

May 14, 1963

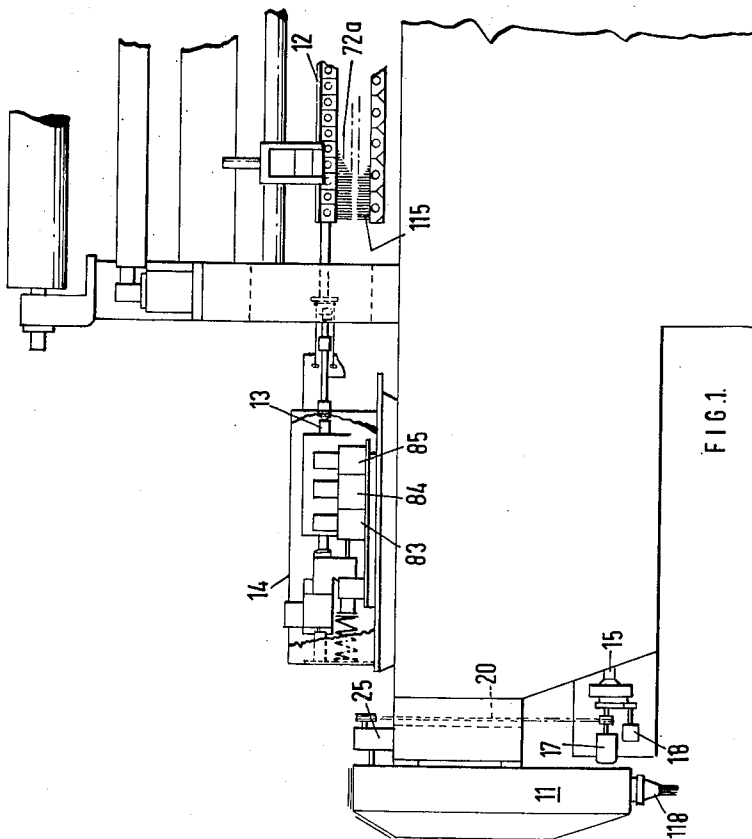
D. M. BRUCE ET AL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 1



DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY
Frederick Bratenfeld
ATTORNEY

May 14, 1963

D. M. BRUCE ET AL
AUTOMATIC MACHINERY

3,089,322

Filed Sept. 12, 1960

10 Sheets-Sheet 2

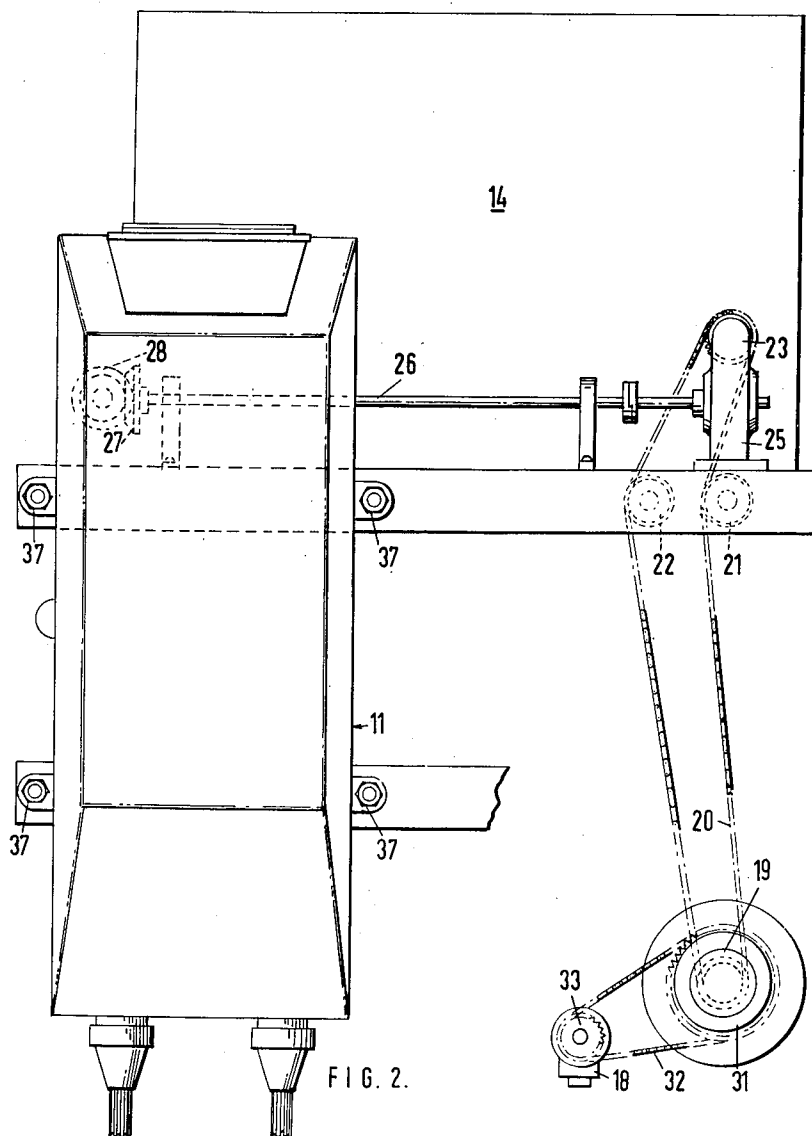


FIG. 2.

DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY

Frederick Breitenfeld
Attorney

May 14, 1963

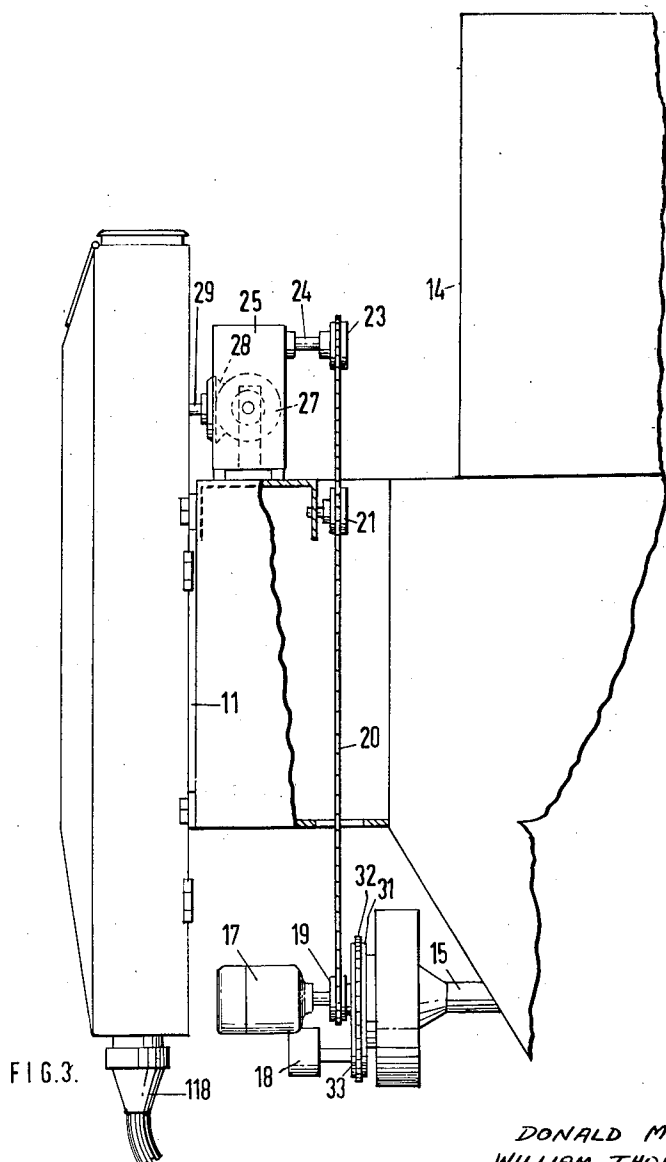
D. M. BRUCE ET AL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 3



DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY

Frederick Brestenfeld
Attorney

May 14, 1963

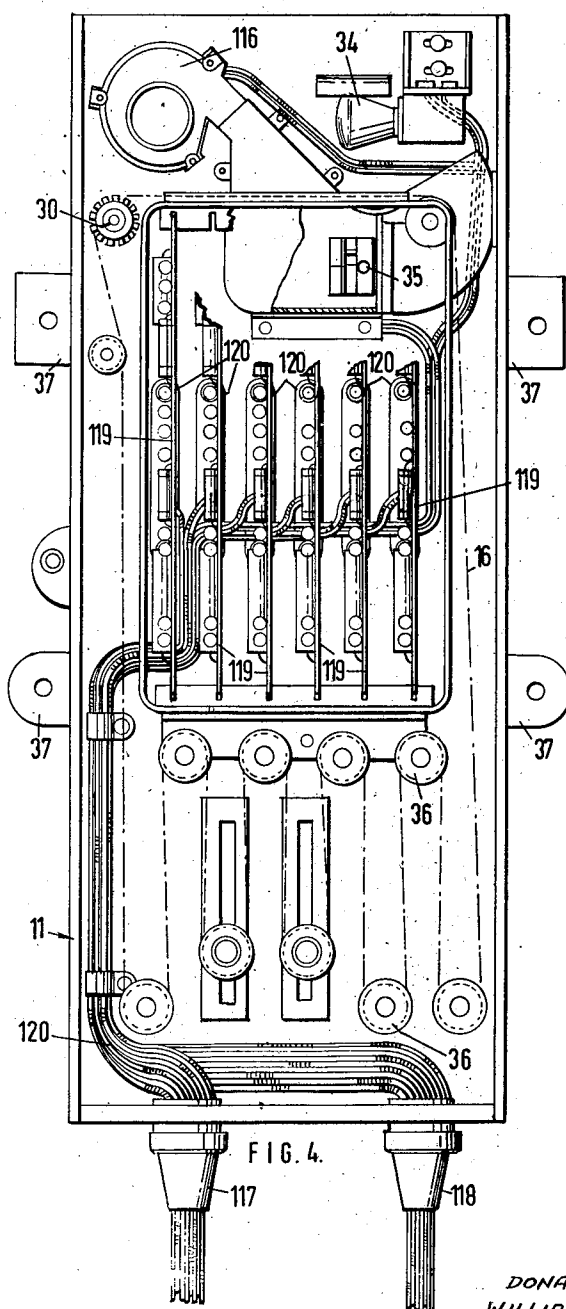
D. M. BRUCE ET AL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 4



DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY
Frederick Breitenfeld
ATTORNEY

May 14, 1963

D. M. BRUCE ETAL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 5

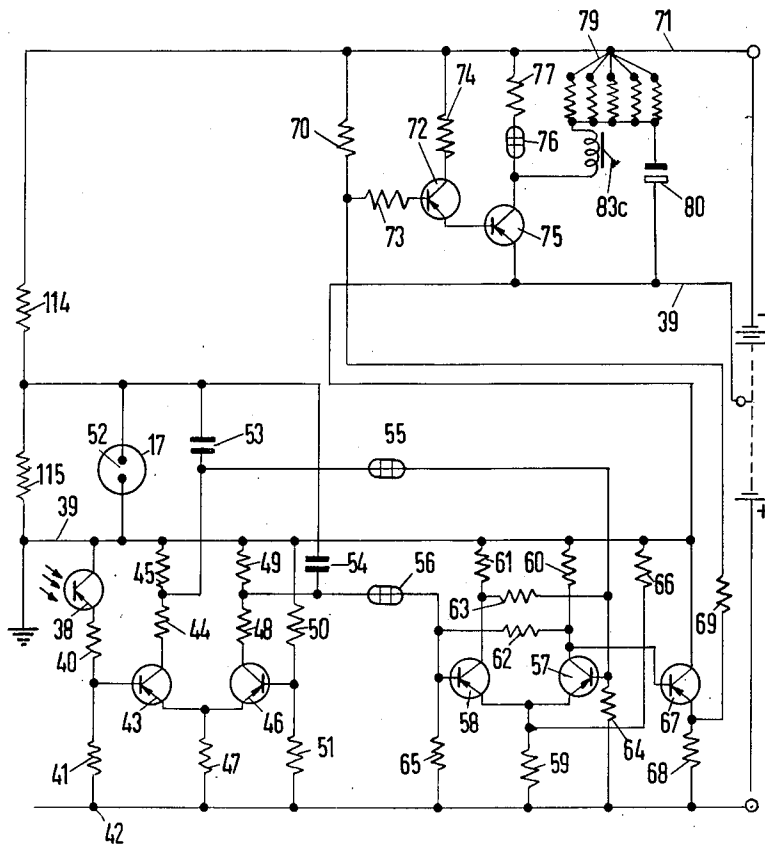


FIG. 5.

DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
Inventors

By.

Frederick Breitfeldt
Attorney

May 14, 1963

D. M. BRUCE ETAL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 6

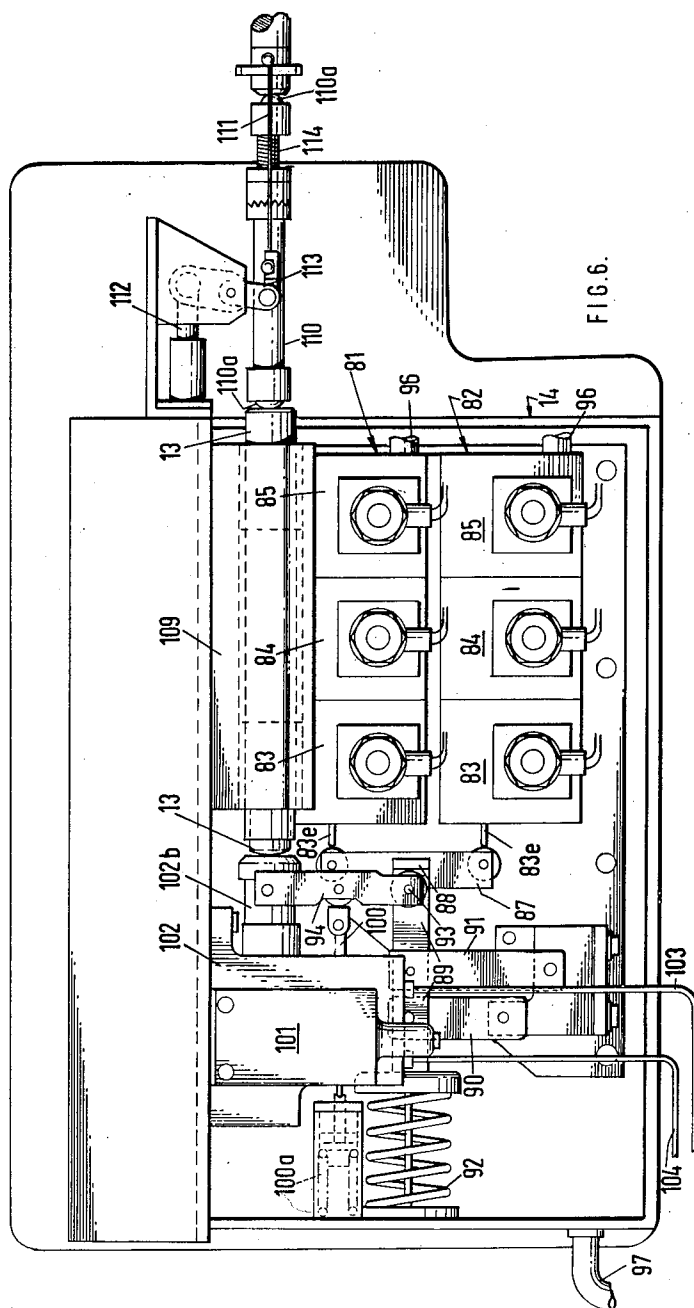


FIG. 6.

INVENTORS
DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
BY

Frederick Braitenfeld
Attorney

May 14, 1963

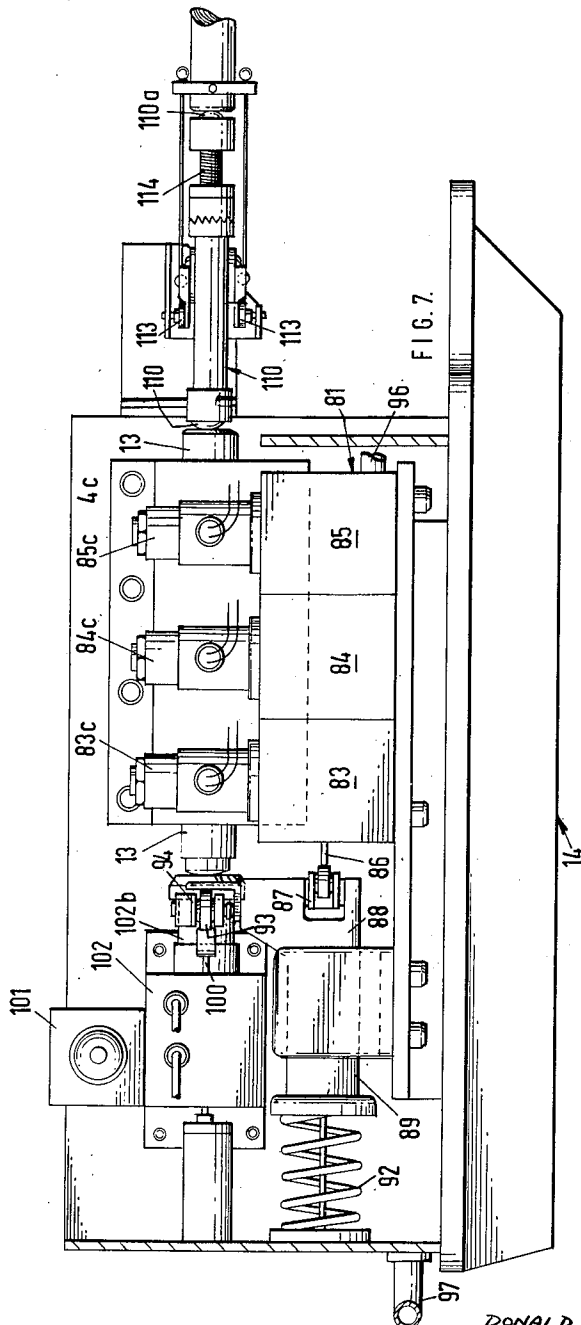
D. M. BRUCE ET AL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 7



DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY
Frederick Brestfeld
ATTORNEY

May 14, 1963

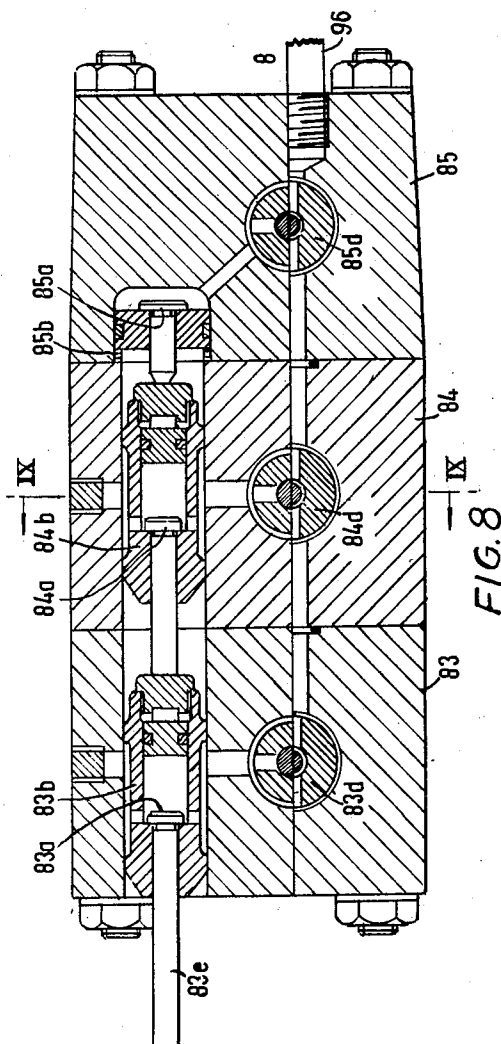
D. M. BRUCE ETAL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 8



DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY
Frederick Breitenfeld
Attorney

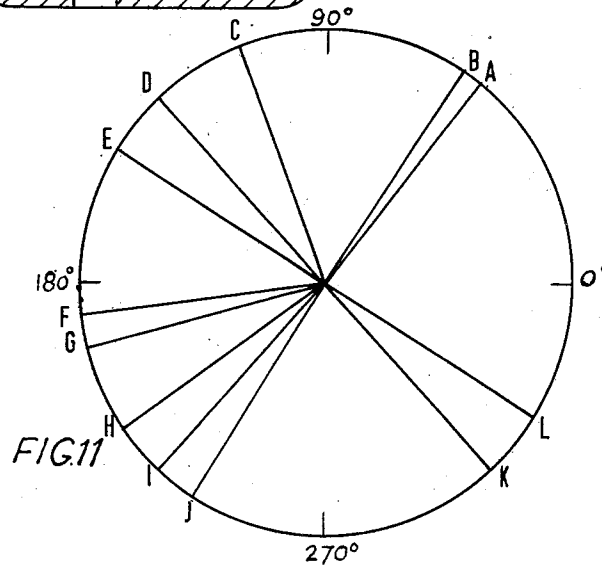
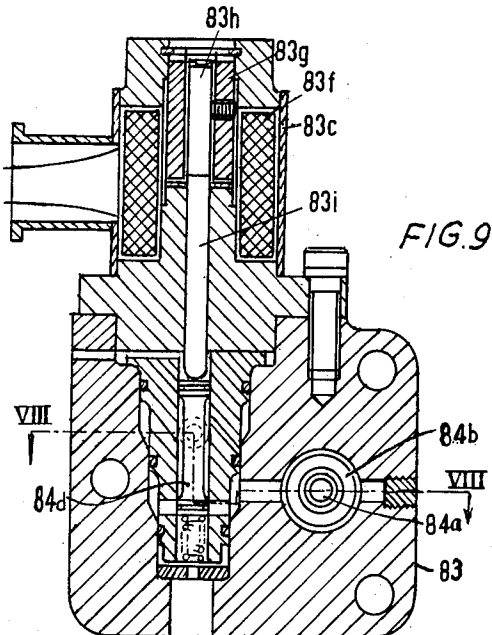
May 14, 1963

D. M. BRUCE ET AL
AUTOMATIC MACHINERY

3,089,322

Filed Sept. 12, 1960

10 Sheets-Sheet 9



DONALD MARSH BRUCE
WILLIAM THOMAS COWHIG
KENNETH JAMES BUTLER
INVENTORS

BY

Frederick Breitenfeld
Attorney

May 14, 1963

D. M. BRUCE ET AL

3,089,322

AUTOMATIC MACHINERY

Filed Sept. 12, 1960

10 Sheets-Sheet 10

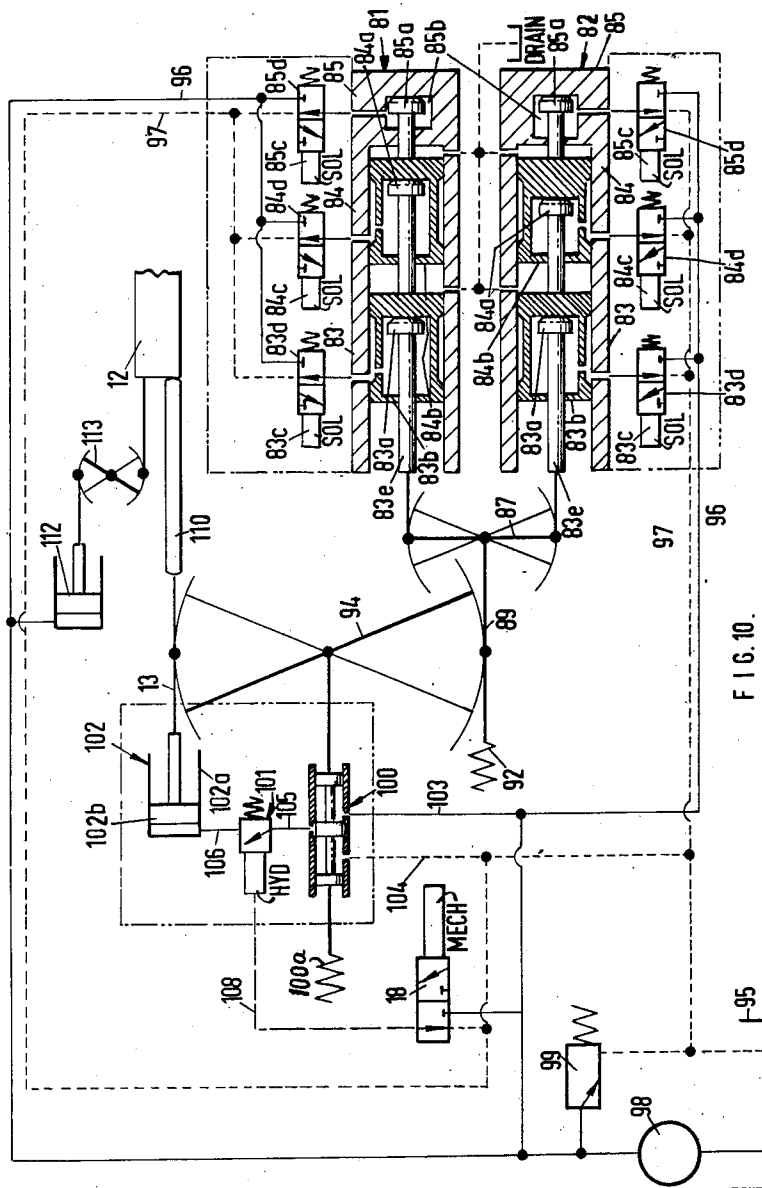


FIG. 10.

INVENTORS:
DONALD MARSH BRUCE
WILLIAM THOMAS CONNIG
KENNETH JAMES BUTLER
BY

Frederick Breitenfeld
Attorney

1

3,089,322

AUTOMATIC MACHINERY

Donald Marsh Bruce, Grappenhall, Warrington, William Thomas Cowhig, Sale, and Kenneth James Butler, Didsbury, Manchester, England, assignors, by mesne assignments, to The Cotton Silk and Man-Made Fibres Research Association, Shirley Institute, Didsbury, Manchester, England

Filed Sept. 12, 1960, Ser. No. 55,400

Claims priority, application Great Britain Aug. 20, 1958

11 Claims. (Cl. 66—154)

This invention concerns automatic machinery, especially high speed warp knitting machines with compound tubular needles, and the present application is a continuation-in-part application of our co-pending application Serial No. 834,996, filed August 20, 1959, now abandoned.

The movements of warp yarns in conventional warp knitting machines are controlled by guide bar means. There are normally two guide bars at least, each guide bar controlling the movements of a set of warps relative to the needles of the machines. In known machines the longitudinal movements of the guide bars are in turn controlled by cam means against which the respective guide bars are spring loaded. The cam means are located at one end of the machine and operate directly against the ends of the respective guide bars. Normally there is provided, for each guide bar a rotary cam which may be in the form of a wheel with the cam surface formed on the periphery thereof, or having engaged on its periphery a chain, the links of which constitute the cam surface. Thus, for a particular pattern, a particular wheel or a particular chain is needed, and when it is desired to knit a different pattern, the wheel or cam (usually for each guide bar) must be changed. Also in the case of a wheel with the cam surface formed on the periphery thereof, the length of the repeat in the pattern is limited by the circumference of the wheel, and, where a chain is used, by the length of the chain.

It will, therefore, be appreciated that whilst the arrangements just described are fairly simple in construction and operation, they lead, where pattern changes are frequent, to substantial expense due to the necessity of providing a multiplicity of different wheels or chains, and to limitations of patterns corresponding to the limitation of length of repeat.

It is the principal object of the present invention to provide apparatus for controlling the guide bar movements on a warp knitting machine which enables changes of pattern to be made at little additional expense, and all such patterns not to be subject to any serious limitations as regards length of pattern repeat. The broad object of the invention, however, is to provide new and improved operating means for automatic machinery.

According to the present invention, to achieve this broad object there is provided apparatus suitable for imparting a predetermined sequence of movements to at least one machine part which comprises in combination hydraulically operable movement imparting means therefor, hydraulically operable control means which includes hydraulically operable movement summation-subtraction mechanism as herein defined and negative feed-back type mechanism which are arranged to control the hydraulic operation of said movement imparting means for the purpose of moving the movement imparting means to and locating it in any one of a multiplicity of positions, electrically operable control means for controlling the hydraulic operation of said summation-subtraction mechanism, the said electrically operable control means being arranged for operation by a combination of change of energy states, said changes of energy states corresponding

2

with a source of recorded information, the apparatus being so arranged that, when connected to the said machine and to sources of electrical and hydraulic power and supplied from a prepared source with recorded information, corresponding changes of energy state occur, and the apparatus is capable of imparting said predetermined sequence of movements to at least one operative part of said machine.

More particularly according to the present invention there is provided apparatus suitable for imparting a pre-selected sequence of cyclic movements to at least one operative part of a cyclically operable machine which comprises in combination hydraulically operable movement imparting means therefor, hydraulically operable control means which includes hydraulically operable movement summation-subtraction mechanism as herein defined and negative feed-back type mechanism which are arranged to control the hydraulic operation of said movement imparting means for the purpose of moving the movement imparting means to and locating it in any one of a multiplicity of positions, electrically operable control means for controlling the hydraulic operation of said summation-subtraction mechanism, the said electrically operable control means being arranged for operation by a combination of change of energy states in pre-selected sequence corresponding with a source of recorded information and cyclic changes of energy states corresponding with a cyclic operating frequency of said machine causing changes of energy state in correspondence with said recorded information, and feeding same to said electrically operable control means, means for imparting cyclic changes of energy state to the said electrically operable control means in synchronism with said cyclic operating frequency of said machine, the apparatus being so arranged that when connected to the said cyclically operable machine, and to sources of electrical and hydraulic power and supplied from a prepared source, with recorded information corresponding changes of energy state occur, and the apparatus is capable of imparting said sequence of pre-selected cyclic movements at least one operative part of said machine in synchronism with said cyclic operating frequency.

The machine may be a textile machine, and especially a high speed warp-knitting machine with compound tubular needles, the apparatus being arranged to control the movements of one or more guide bars.

Furthermore, the invention includes within its scope operating means for a guide bar of a warp-knitting machine which consists of means for progressing a source of recorded information corresponding to a desired sequence of guide bar movements, for the guide bar, relative to an electronic means for producing electrical signals corresponding to said information, basically hydraulic mechanism for moving the guide bar of the machine sequentially into its appropriate discrete positions, means forming part of said mechanism which is adapted to move to one of a number of discrete positions in accordance with a number of simultaneous signals from the program reader, the presence or absence of a particular signal causing the presence or absence of a particular displacement in the controlling mechanism, the final discrete position corresponding to the sum of the displacements due to the particular signals present, and means operable in synchronism with the machine and adapted to ensure that the movements are transmitted to the guide bar only at the appropriate times.

By "movement summation-subtraction" mechanism we mean a mechanism including a plurality of elements each adapted when energised to be displaced by a given amount from a datum position which it occupies when not energised and an output member which is displaced by an

amount equal to or proportional to the sum of the displacements of said elements.

The invention will now be described further with reference to one particular embodiment, suitable for use, inter alia, on a high speed warp knitting machine with compound tubular needles.

This embodiment is illustrated in the accompanying drawings, in which:

FIGURE 1 is a schematic front elevation of a high speed warp knitting machine with compound tubular needles, only the left-hand end fitted with electronic and electro-hydraulic control means according to the invention, and part of one guide bar, with its associated guides and needles being shown;

FIGURE 2 is an end elevation of the end of the machine illustrated schematically in FIGURE 1;

FIGURE 3 is a front elevation corresponding to FIGURE 2;

FIGURE 4 is a view of electronic control means with the front cover removed;

FIGURE 5 is a diagram of one of the electrical circuits used in the electronic control means;

FIGURE 6 is a plan view of the electro-hydraulic control means for operating the guide bar;

FIGURE 7 is a front elevation corresponding to FIGURE 6 except that the front wall of the enclosing casting is omitted;

FIGURE 8 is a large scale sectional plan view on the line VIII—VIII of FIGURE 9, of a bank of indexing jacks forming part of the electro-hydraulic control means;

FIGURE 9 is a sectional end view of the line IX—IX of FIGURE 8;

FIGURE 10 illustrates diagrammatically with the use of conventional symbols the electro-hydraulic control means of FIGURES 6-9.

FIGURE 11 is a timing diagram of the machine.

GENERAL ARRANGEMENT OF PARTS

Referring firstly to FIGURE 1, there is shown the left-hand end of a two guide bar high speed warp knitting machine with compound tubular needles. The machine is conventional in all respects, except that apparatus according to the invention is provided for operating the guide bars. In the figure only one guide bar and its associated apparatus is illustrated, it being understood that like apparatus will be associated with the other guide bar.

Mounted on conventional parts of, or extensions to, the frame of the machine are box 11, housing pattern control means, and electro-hydraulic guide bar movement control means 14 associated therewith and operated thereby. It will be understood that in FIGURE 1, which is provided to indicate the general arrangement, and relative disposition of the various main parts of the control apparatus according to the invention and the machine, does not include all the detail components or all the electrical and hydraulic connections, these being adequately indicated in certain of the remaining figures. Nor have the majority of the conventional and well-known parts of the knitting machine per se been described or indicated by reference numerals since a person skilled in the knitting machine art is perfectly familiar with these.

The box 11 houses mechanical means for progressing an endless tape, having holes punched therein as later described in a sequence and arrangement according to the desired movements of guide bar 12 and its yarn guides 72a, relative to needles 115, and electronic means capable of sensing the presence or absence of the punched holes and controlling the action of two banks of hydraulic jacks 83, 84, 85 (through the agency of solenoids 83a, 84b, 85c) which in turn control the movement of a push rod 13, and therefore guide bar 12, accordingly. The detailed construction and operation of the control means are more particularly described hereinafter. The mechanical means for progressing the tape is driven from the main shaft 15

of the machine through gearing as will later be described more fully.

Referring now more particularly to FIGURES 2 and 3 the main shaft 15 of the machine is arranged to provide the drive for progressing the punched tape 16 (FIGURE 4) previously referred to, for a contact breaker 17, of the conventional automobile type, adapted to provide electrical pulses for a purpose shortly to be described, and for mechanically, for example, cam operated auxiliary timing valve 18, also for a purpose shortly to be described, all in synchronism with the cyclical movements of the knitting machine parts.

At the end of the main shaft 15 are fitted two chain wheels 19, 31. The smaller chain wheel 19 is enabled to transmit the drive, by means of chain 20 passing over two idlers 21, 22 and chain wheels 23 on the end of a worm shaft 24 forming part of a reduction gear 25, to a shaft 26, and then by bevel gears 27, 28 to a spindle 29, which carries, within the control box 11, a sprocket 30 (FIGURE 4) for driving the tape 16.

The contact breaker 17 is mounted on the extended end of the main shaft 15.

The end of the main shaft 15 also carries a larger chain wheel 31 and from this the drive is transmitted via a chain 32 to another chain wheel 33, rotation of which is adapted to operate timing valve 18.

The Pattern Control Means

There will now be described, in detail, and with particular reference to FIGURES 4 and 5, a particular form of box 11 which has been found to operate very satisfactorily. This device is the subject of co-pending U.S. patent application Serial No. 6,928 in the name of J. E. Marshall.

Referring firstly to FIGURE 4, the box 11 accommodates an endless opaque tape 16, which is punched with holes, pre-arranged in a number of longitudinally extending channels in accordance with the desired pattern of fabric to be produced by the warp-knitting machine. The nature of the pattern is determined by the presence or absence of holes which occur at a fixed pitch in the longitudinal plane of the tape, in a manner as will later be described in more detail. The tape 16 is carried between a lamp 34 and a block 35 of photo-transistors 38, which are air cooled by air drawn from outside the case 11 by means of a fan 116, and which are each connected to a circuit, the nature of which is as fully described later in connection with FIGURE 5. There is one circuit for each channel (in the present machine six) of holes punched in the tape, and the components of each circuit form part of printed circuit panel 119 which slides into a socket 120 therefor. Of course, it may well be that certain of the circuit components shown in the drawings as forming part of the printed circuit are of such a nature as to be unsuitable for mounting on such panels and in this case it is a perfectly simple matter to mount them outside the box 11, in a suitable auxiliary box, for example. Such an arrangement however, is well within the scope of a skilled electrician and it has not been thought necessary to elaborate any further, but in the interests of clarity to treat each circuit as though it were comprised by its respective panel 119.

The power input to the box and the output to the electro-hydraulic means 14 are via the plug 117 and the socket 118 respectively, and within the box appropriate cable runs 121 are provided leading from the input and output connexions to the printed circuit sockets 120, the fan 116, the lamp 34 and photo-transistor bank 35.

The tape is mounted on pulleys 36 and is driven by the sprocket wheel 30, rotatable by the rotary shaft 29 of the machine. The control box 11 is attached to the machine by means of lugs and brackets 37.

Referring now to FIGURE 5, each electrical circuit includes a photo-transistor 38, which is one of those held

5

in the block 35 shown in FIGURE 4. The base of the photo-transistor 38 is left as an open circuit and the collector is taken directly to an earthed conductor 39. Two resistors 40 and 41 are connected in series between a positive conductor 42 and the emitter of the photo-transistor 38. The junction between the resistors 40 and 41 is connected to the base of a transistor 43. Resistors 44 and 45 are connected between the collector of transistor 43 and the earthed conductor 39. A second transistor 46 has its emitter connected to the emitter of transistor 43 and also connected to the positive conductor 42 through a resistor 47. The collector of transistor 46 is connected to the earthed conductor 39 through resistors 48 and 49. Resistors 50 and 51 are connected in series between the earthed and positive conductors. The junction of the resistors 50 and 51 is connected to the base of the transistor 46. The part of the circuit which has just been described will be referred to as a "saturated differential amplifier."

The contact breaker 17 has a pair of contacts 52 one contact being earthed. The other contact is connected via resistor 114 to the negative conductor and via resistor 115 to the earthed conductor. Condensers 53 and 54 are also connected to this last contact 52 and to the junction between the resistors 44 and 45, connected to the transistor 43 and to the junction of the resistors 48 and 49, connected to the transistor 46 respectively. The anode of a diode 55 is connected to the junction between the condenser 53 and the resistor 44 and 45 and the anode of a similar diode 56 is connected to the junction between the condenser 54 and the resistors 48 and 49. The cathodes of the diodes 55 and 56 are taken to the bases of transistors 57 and 58 respectively. The condenser 53 and the diode 55 and the condenser 54 and the diode 56 each form an "AND" gate, in known manner.

The emitter of transistors 57 and 58 are connected to a resistor 59 which is connected to the positive conductor 42. Resistors 60 and 61 are connected between the collectors of transistors 57 and 58 and the earth conductor 39 respectively. Resistors 62 and 63 are connected between the collectors of transistors 57 and 58 and the bases of transistors 58 and 57 respectively. Resistors 64 and 65 are connected between the bases of the transistors 57 and 58 and the positive conductor 42. A resistor 66 is connected between the earth conductor 39 and the emitters of transistors 57 and 58. The part of the circuit which has just been described, including the transistors 57 and 58 will be referred to as a "bi-stable circuit," such as are well-known to those skilled in the art.

The base of a further transistor 67 is connected to the collector of transistor 57. The collector of transistor 67 is connected to the earthed conductor 39. The emitter of the transistor 67 is connected to the positive conductor 42 by a resistor 68. This part of the circuit including the transistor 67 forms an "emitter follower" or "buffer stage."

The emitter of transistor 67 is connected through series resistors 69 and 70 to a negative conductor 71. The junction of resistors 69 and 70 is connected to the base of a transistor 72 via a resistor 73. A resistor 74 connects the collector of transistor 72 to the negative conductor 71. The emitter of a transistor 75 is connected to the earthed conductor 39. The collector of transistor 75 is connected to the negative conductor 71 via a diode 76 and a resistor 77 in series. The cathode of the diode 76 is connected to the collector of the transistor 75, which is connected in series with one of the jack solenoids, says 83c (see also FIGURE 9) of a relay of an actuating member and a resistor 79. A condenser 80 is connected between the earthed conductor 39 and the junction of the resistor 79 and the solenoid 83c. The resistor 79 is connected to the negative conductor 71. The part of the circuit which has just been described, includ-

6

ing the transistors 72 and 75 will be referred to as the "relay driving amplifier."

The operation of a circuit will now be described.

When a hole in an opaque tape 16 (FIGURE 4) appears between the lamp 34 and a photo-transistor 38, light from the lamp falls on the photo-transistor and causes an increased current flow through the photo-transistor. An increased voltage is thus produced across resistors 40 and 41. This voltage across resistor 41 makes the base of transistor 43 more negative than its emitter and causes transistor 43 to conduct—the transistor previously being cut off due to the absence of a hole in the opaque tape. The base of transistor 46 is held at a fixed potential by potential divider resistors 50 and 51 and the voltage produced across resistor 47 by the emitter current of transistor 43 makes the emitter voltage of transistor 46 more negative than its base and the transistor 46 is cut off.

This stage is thus a differential amplifier and since the input light is sufficient to saturate the transistor 43, may be, as previously stated, described as a "saturated differential amplifier."

Conversely when light from the lamp 34 does not fall on the photocell 38 due to the absence of a hole in the opaque tape 16 there is only a very small voltage across resistor 41 due to leakage current and transistor 43 will not conduct due to the voltage on the common emitters point of transistors 43 and 46 being more negative than the voltage on the junction of resistor 41 and the base of transistor 43. The value of resistors 50 and 51 are such that transistor 46 will conduct under this no-light condition. Thus light falling on transistor 38 via the opaque tape will cause transistor 43 to conduct and transistor 46 to be cut-off and absence of light will cause transistor 43 to be cut-off and transistor 46 to be conducting.

The voltage produced across resistor 41 when the light falls on the photo-transistor 38 will appear amplified and inverted at the collector of transistor 43 and will appear amplified but not inverted at the collector of transistor 46. The voltage changes at these two collections will not, however, affect the bias conditions of the following bi-stable circuit due to the presence of the AND gate.

The contact breaker 17 is, as previously stated, rotated in synchronism with the rotary main shaft 15 of the warp knitting machine.

The contacts 52 are short-circuited for most of the time that the contact breaker 17 is rotating and are open circuited only briefly during the rotation. The common point of resistors 114 and 115 is thus connected via the contacts 52 to the earthed conductor for most of the time during which the contact breaker 17 is rotating. When the contacts 52 are open-circuited the common point of resistors 114 and 115 is raised to some negative potential and then returned to earth when the contacts 52 are short circuited again. This change in potential producing a negative pulse will be referred to as the "synchronising pulse."

The synchronising of the contact breaker contacts 52 to the rotary main shaft 15 is such that the contacts close during the fixed period when a hole or the absence of a hole occurs. The trailing edge of the negative going synchronising pulse is the important part of the pulse as is obvious to those skilled in the art and the trailing edge of the synchronising pulse occupies much less time than the time taken for the hole in the opaque tape to move over the photo-transistor.

When the guide bar is required to be moved to a different position the contacts 52 of the contact breaker 17 are synchronised to close and a positive edge of the synchronising pulse is thus applied to the condensers 53 and 54 of the AND gates. Depending upon which of the transistors 43 and 46 is conducting one of the AND gates will open and a voltage large enough to change the bi-

stable circuit state will be supplied to one of the bases of the transistors 57 and 58 in the bi-stable circuit.

If light from the lamp 34 is falling, through a hole in the opaque tape 16, on to the photo-transistor 38 then transistor 43 will be conducting and the junction of resistors 44 and 45 will be at its maximum positive limit as determined by the circuit values. This positive excursion in conjunction with the positive edge of the synchronising pulse will open the AND gate comprising condensers 53 and diode 55. This will cause the voltage at the base of transistor 57 to rise to its maximum positive limit as determined by its circuit values.

Transistor 57 will thus be cut-off and its collector voltage will change to a more negative voltage limited by the circuit values. The resistor 62 and 65 form a potential divider chain and since they are connected to the base of transistor 58, the base of this transistor will become more negative than it was. The emitters of transistors 57 and 58 are held at a fixed potential by the potential divider chain comprising resistors 59 and 66 and the values are such that when the base of transistor 58 is driven negative by transistor 57 being cut-off, transistor 58 will conduct. Its collector voltage then becomes more positive than it was and the base of transistor 57 is held at its maximum positive excursion via potential divider resistors 63 and 64. This tends to drive transistor 57 even further into cut-off and is a stable state.

Conversely if light is not falling on to the photo-transistor 38 due to the absence of a hole in the opaque tape, transistor 43 is cut-off and transistor 46 will be conducting. In the presence of a synchronising pulse at the AND gates, the AND gate comprising condenser 54 and diode 56 will open and the positive voltage will cause transistor 58 to cut-off.

When this happens, the collector voltage will change to its maximum negative limit as determined by its circuit values and the base of transistor 57 will be driven negatively via potential divider chain resistors 63 and 64. The base voltage will then be more negative than the emitter voltage of transistor 57 and the transistor will conduct.

On conduction the collector voltage of transistor 57 will change to its maximum positive limit and the base of transistor 58 will be driven positively via potential divider chain resistor 62 and 65. This voltage will tend to cut-off transistor 58 even further and is the second stable state of the bi-stable circuit.

If a synchronising pulse appears and the "saturated differential" amplifier has not changed its potentials due to the presence or absence of a series of holes the voltage applied will obviously not affect the bi-stable circuit.

In other words, when a synchronising pulse appears at the contact 52, the transistor 43 and 58 operate similarly and the transistors 46 and 57 operate similarly. As the transistors of the bi-stable circuit will only change their state in the presence of a synchronising pulse, the circuit only responds at required intervals to the information recorded on the opaque tape.

The voltage at the base of the transistor 67 is that voltage at the collector of transistor 57, the two being connected together. When the transistor 57 is cut-off, i.e. when light falls on photo-transistor 38 due to the presence of a hole in the opaque tape, the voltage at the base of transistor 67 is sufficiently negative compared with the voltage on the emitter of transistor 67 to cause transistor 67 to conduct. The voltage at the emitter of the transistor therefore changes to its maximum negative limit as determined by the circuit values.

This transistor 67 in emitter follower configuration provides sufficient power to operate transistors 72 and 75 and prevents loading on the transistor 57 upsetting the symmetry of the bi-stable circuit.

The voltage at the base of transistor 72, being connected to transistor 67 via resistors 69 and 73 also changes to its maximum negative limit as determined by its circuit

values. This limit is such as to cause transistor 72 to conduct and thus cause transistor 75 to conduct as can be seen by those skilled in the art. When transistor 75 conducts the collector current energises the solenoid relay 83C which operates the respective jack 83.

Conversely, in the absence of a hole in the opaque tape and in the presence of a synchronising pulse, transistors 43 and 58 will be cut-off and transistors 46 and 57 conducting. The voltage at the base of transistor 67 will be at its maximum positive limit as determined by the circuit values and the voltage at the base of transistor 72 will be such as to cut-off the transistor 72. This will cause transistor 75 to be cutoff as can be seen by those skilled in the art. No collector current is drawn through the solenoid relay 83C. In other words, presence of a hole in the opaque tape and a synchronising pulse will cause operation of the solenoid relay 83C and its jack 83 and absence of a hole in the presence of a synchronising pulse will cause the solenoid relay 83C to be de-energised, and non-operation of its jack 83.

Diode 76 prevents a high reverse collector voltage damaging the transistor 75 during switch off and resistor 77 prevents a high peak current through the diode. Resistor 79 and capacitor 80 speed up the pull in time of the solenoid relay 83C as is general practice.

The bi-stable circuit, comprising the transistors 57 and 58 and the resistors 59 to 66 also acts as a memory device and its state represents the information, i.e. "hole" or "no hole" in the opaque tape, when the last synchronising pulse was applied. The state of this device is maintained until the further synchronising pulse is applied to the terminals 52. The bi-stable circuit will also retain its state after the negative conductor 71 has been disconnected from the power supply. This is useful, as it enables the relay driving amplifier which is the part of the circuit drawing the most power from the electrical supply to be disconnected, while the bi-stable circuit still maintains its same state. The bi-stable circuit can, if desired, be independently energised so that on any interruption of the supply to the remainder of the equipment the bi-stable circuit retains its electrical state. This enables the machine to be switched off, for maintenance, adjustment, or other purpose without interfering with the continuity of the pattern. One push-button for each channel, enabling all electrical supplies to be disconnected, may be provided so that each bi-stable circuit can be triggered into the correct state, determined by visual examination of the opaque tape.

The presence of the transistor 67 acts as a buffer and prevents interaction between the relay driving amplifier and the bi-stable circuit.

Each photo-transistor 38 and its associated circuit, as shown in FIGURE 5, controls one solenoid. The number of relays is equal to the number of channels in a tape. The relays form part of the electro-hydraulic means 14 which is arranged to actuate the guide bar 12 of the warp-knitting machine, the guide bar 12 being common to all channels of the tape.

The Electro-Hydraulic Guide Bar Movement Control Means

Reference will now be made more particularly to FIGURES 6 to 10 wherein is illustrated the details of the electro-hydraulic means 14.

FIGURES 6 to 9 show the actual spatial arrangements of the various components (corresponding to FIGURE 4 in the case of the electronic control means) whilst FIGURE 10 is a diagram showing the operative lay-out of the electro-hydraulic means 14 (corresponding to FIGURE 5 in the case of the electronic control means). FIGURE 10 uses the conventional symbols used in showing hydraulic systems, and the size and relationship of the various components correspond in general, but not in detail, to the components as shown in FIGURES 6 to 9, this being for easier understanding of FIGURE 10. In-

deed, some components, the showing of which could be superfluous, have been omitted in FIGURE 10. Also, some of the parts (especially the valves 100, 101 and 102) are not shown in detail in FIGURES 6 to 9; these parts are of known type, and their nature is adequately shown in FIGURE 10.

The main part of the electro-hydraulic means 14 consists of two banks of indexing jacks 81, 82. Each bank comprises three jacks 83, 84, 85, the three jacks of each bank being arranged in nose-to-tail disposition so that the total displacement of the system consisting of pistons 83a, 84a, 85a, and cylinders 83b, 84b, 85b, are manifested by the rod 83e of piston 83a. At the upper parts of the respective jacks are the solenoids 83c, 84c, 85c, which are operated by the appropriate photo-transistor 38 and its associated circuit, as previously explained.

The banks 81, 82 are mounted side-by-side in a shallow oil bath in a suitable casting fixed to the machine frame, and a floating averaging lever 87 bridges the push-rods 83e. The mid point of lever 87 is freely and pivotally mounted in a bracket 88 at the end of a bar 89 supported by parallel links 90, 91 and loaded by a compression spring 92, so that there is a returning force on the jack pistons 83a, 84a, and 85a. The upper part of the bracket 88 provides a contact surface for a roller 93, freely mounted in the end of a floating feed back or servo lever 94, so that the displacement of the lever 94 is proportional to the displacement of the rods 83e and thus to the sum of the displacement of the six indexing jacks. The system is therefore a movement summation-subtraction system as hereinbefore defined.

The principal hydraulic circuit (FIGURE 10) comprises a tank 95, for hydraulic fluid, feed and return piping 96, 97, to and from the banks of jacks 81, 82, a motor driven delivery pump 98 and a relief valve 99. The solenoid 83c, 84c, 85c, of each jack operates a valve 83d, 84d, 85d, so as to connect the cylinder of the jack either to supply pressure to extend the jack or to tank to allow the jack to retract under the influence of the spring 92, according to whether the particular solenoid is energised or not. Each solenoid comprises a coil 83f suitably mounted in a housing, and an armature 83g, an adjustable screw 83h, and push rod 83i.

An auxiliary hydraulic circuit comprises a servo control valve 100, a timing valve 101, a main jack 102, feed and return piping 103, 104 to and from the supply to the servo valve 100, connection 105 between the servo valve 100 and the timing valve 101, and connection 106 between timing valve 101 and the main jack 102.

The main jack 102 consists of a fixed cylinder 102a with a lapped piston 102b connected to the other end of lever 94 and bearing on the guide bar push rod 13. The servo valve 100 operates on the mid-point of the lever 94 and is designed and arranged so that for a given condition of the indexing jacks 83, 84, 85 the movement of the main jack 102 caused by any flow through the valve 100 will be in such direction as to close the valve 100, the equilibrium being reached when the valve 100 is in its neutral position. The floating feed back lever 94 will effectively pivot about the valve 100 in the neutral position of the latter and main jack 102 thus moves by an amount equal to the integrated displacement of the indexing jacks, although the latter will only have to supply a load sufficient to move the servo control valve 100. This system therefore may be described as a negative feed-back type mechanism.

The timing valve 101 is operated by the auxiliary timing valve 18 on the machine in such a manner as to shut or open the fluid connection between the servo valve 100 and the main jack 102 as necessary. For example, a cam mounted on the same shaft as chain wheel 33 (FIGURE 2) may be in operative relationship with auxiliary timing valve 18 and by virtue of a pipe connection 108 between valve 18 and valve 101 the necessary action of the latter valve is obtained. In this manner it is provided that al-

though the indexing jacks 83, 84, 85 will operate whenever a signal is received, the main jack 102 will remain locked except during periods when movement of the guide bar is appropriate (i.e. when the guide bars are clear of the needles).

As has previously been mentioned, the main jack 102 operates a push rod 13 which extends through a robust bearing 109. The push rod 13 operates, through the medium of a connecting rod 110, the guide bar 12. It is necessary to provide a returning force for the guide bar 12 and also to accommodate the swinging transverse movement of the guide bar. The connecting rod 110 is therefore provided with ball ends 110a which bear against the push rod 13 and the guide bar 12 and straining wires 111 are subject to the returning force exerted by a hydraulic piston 112, exerted through a stirrup lever 113, this force being arranged to be constant at a value half that capable of being exerted by the main jack 102. The connecting rod 110 has a turnbuckle portion 114 to enable it to be adjusted to length.

It will be noted from FIGURE 10 and other FIGURES that the cylinders 83b, 84b and 85b do not all have the same internal lengths. In bank 81, cylinder 83b has an internal length of seven units, cylinder 84b seven units, and cylinder 85b one unit. In bank 82, the cylinders 83b, 84b, 85b have internal length respectively of seven, four and two units. It will be recalled that whether each jack extended or closed depends basically on whether there is a hole in the corresponding channel of the tape 16. By arranging the lengths of the six cylinders in the above manner and by providing holes across the tape only in the appropriate channels, any desired total of jack movement from 1 unit to 28 units may be obtained.

General Operation of the Machine

Reference will now be made to FIGURE 11 to describe in some detail the manner of operation of the machine.

The diagram represents one cycle, i.e. the knitting of one course during one revolution of the main shaft 15.

At 0°, the needles 115 (FIGURE 1) are at their lowest position. At this point the shogging motion is in progress. The extent of this motion is not, of course, fixed, but will vary in extent according to the pattern, and for this reason the termination of the shog is not indicated. At position A the timing valve 101 closes thus causing the guide bar to be retained in the position it had reached at the end of the shog. Immediately afterwards, the contact breaker 17 which has broken makes to apply a pulse at position B to the terminals 52 and thus to allow the jacks 83, 84 and 85 to be operated according to the number of holes in the various channels across the tape. At position C, the guides enter the needles and at position D the guides are clear of and behind the needles and the timing valve 101 is opened under the influence of auxiliary timing valve 18. This allows the servo valve 100 to operate and cause the jack movements previously referred to manifest themselves at the main jack 102. Thus, at position E the lap, which is usually fixed to extend over a given number of needles, starts. The lap finishes at position F. At position G, the guides re-enter the needles and at position H clear the needles. Position I indicates the position at which the timing valve 101 closes to cause the guide bar 12 to be locked in position again. Immediately thereafter, at position J the contact breaker 17 operates again to allow the program reader to move the jacks 83, 84, 85 according to the required shog, and at position K the timing valve 101 opens again to allow the shog to commence, at position L. It will, of course, be apparent that the auxiliary timing valve 18 and the contact breaker 17 must be rotated at twice the revolutions of the main shaft 15, and suitable gearing is provided to ensure this.

Thus, in operation, it will be appreciated that a selected number of jacks will be moved prior to each shog or lap according to the number of holes in the tape channels between the lamp 34 and the photo-transistor bank 35 at

the time, so that the guide bar is moved to the desired position. The preparation of different tapes for different patterns can be effected fairly readily, and the pattern repeat can be of substantial length.

In order to operate continuously at economical speeds (e.g. at least 800 cycles per minute, involving a response rate of the hydraulic system of less than .05 second), the apparatus will need to be carefully designed and made. The solenoid valves in particular will need to conform to a stringent specification and be supplied with adequate current to ensure the necessary rapid operation. The pump, the jacks, and other valves must also be capable of sustained and rapid operation over prolonged periods. Care must be exercised to avoid excessive acceleration and deceleration of the guide bars so that excessive shock and vibration do not occur.

It will be noted that careful provision to ensure the correct timing of the operation of the apparatus has been made and the importance of this at high speeds will be appreciated. An additional precaution which would with advantage be incorporated would be a mechanical interlock to prevent movement of a guide bar when the needles lie in the path of movement of the guides.

Although the invention as applied to a high speed warp-knitting machine with compound tubular needles has been described with reference to only one guide bar, it will be appreciated that there will always be at least two guide bars. Therefore, as stated, the jack system and the associated hydraulic arrangement will need to be duplicated for each guide bar. More than one guide bar, however, could be controlled from the same tape and tape-reading device, but additional tapes and such devices could be used if desired.

Although the invention has been illustrated with reference to a warp-knitting machine, it may be practised in association with other machines of various types, such as profile milling and grinding machines, looms for weaving and so on.

We claim:

1. Apparatus suitable for imparting a pre-determined sequence of movements to at least one machine member, comprising in combination, an element having a succession of regions prepared in accordance with said pre-determined sequence of movements whereby to constitute a source of recorded information as to the nature of said movements; electrically operable control means associated with said member and including a plurality of control circuits sensitive to said recorded information; means for moving said source of recorded information relative to said electrically operable control means whereby to energize and de-energize parts at least of said control circuit in a sequence corresponding to said sequence of movements; hydraulically operable control means associated with said member and including a plurality of members each adapted to be displaced or not by a fixed amount from a datum position, according to the state of a respective control circuit at a given time, a single displaceable member, a linkage connecting said plurality of members and said single displaceable member whereby said single displaceable member is displaced by an amount corresponding to the sum of the displacements of said plurality of members, and a negative feed-back mechanism associated with said single displaceable member; a hydraulically operable movement imparting means for said member actuated by said single displaceable member through said negative feed-back mechanism; a source of electrical power for said electrically operable control means; and a source of hydraulic power for said hydraulically operable control means and said hydraulically operable movement imparting means.

2. Apparatus suitable for imparting a pre-determined sequence of movements to at least one operative member of a cyclically operable machine, comprising in combination, an element having a succession of regions prepared in accordance with said pre-determined sequence of move-

ments whereby to constitute a source of recorded information as to the nature of said movements; electrically operable control means associated with said member, and including means for generating electrical pulses in synchronism with the cyclical operation of said machine and a plurality of control circuits sensitive to said source of recorded information and said pulses; means for moving said source of recorded information relative to said electrically operable control means whereby to energize and de-energize parts at least of said control circuits in a sequence corresponding to said sequence of movements and in timed relationship with said pulses; hydraulically operable control means associated with said member and including a plurality of members each adapted to be displaced or not by a fixed amount from a datum position, according to the state of a respective one of said control circuits at a given time, a single displaceable member, a linkage connecting said plurality of members and said single displaceable member whereby said single displaceable member is displaced by an amount corresponding to the sum of the displacements of said plurality of members, and a negative feed-back mechanism associated with said single displaceable member; a hydraulically operable movement imparting means for said member actuated by said single displaceable member through said negative feed-back mechanism; a source of electrical power for said electrically operable control means; and a source of hydraulic power for said hydraulically operable control means and said hydraulically operable movement imparting means.

3. Apparatus as claimed in claim 2 in which said hydraulically operable movement imparting means is based on a piston-cylinder assembly.

4. Apparatus as claimed in claim 2 in which each of said plurality of members is an indexing jack based on a piston-cylinder assembly.

5. Apparatus as claimed in claim 2 in which said hydraulically operable movement imparting means is based on a piston-cylinder assembly, in which each of said plurality of members is an indexing jack based on a piston-cylinder assembly, and in which said negative feed-back mechanism includes a floating feed-back lever directly connected at one point to said single displaceable member and at another point with the moving part of said hydraulically operable movement imparting means, and a servo-valve connected to a further point on said lever intermediate said one point and said other point, said servo-valve being adapted on flow of fluid there-through to cause movement of said hydraulically operable movement imparting means to be itself moved in the direction of closure.

6. Apparatus as claimed in claim 5 further comprising a solenoid, and a valve operated thereby, associated with each said indexing jack, said solenoids forming part of the respective control circuits and whereby the actual operation of said jacks is directly controlled.

7. Apparatus as claimed in claim 5 further comprising means adapted to prevent movement of said hydraulically operable movement imparting means except at least one preselected point in the cycle of operation of said machine.

8. Apparatus as claimed in claim 7 in which said movement preventing means comprises a valve between said servo-valve and said hydraulically operable movement imparting means, and means operable in synchronism with said machine and adapted to cause said valve to open only at each preselected point.

9. Apparatus according to claim 2 in which said element is an endless tape, said information being recorded thereon by the punching of various combinations of holes at intervals longitudinally thereof.

10. Apparatus as claimed in claim 9 further comprising a photo-transistor in each said control circuit; sensitive to light passing through holes, at one transverse

region of said tape, a source of light at the opposite side of said tape to said photo-transistors, and means for progressing the tape between said photo-transistors and said source of light at a speed related to the frequency of said electrical pulses entering said control circuits.

5

11. Apparatus as claimed in claim 2 in which said machine is a high speed warp-knitting machine with compound tubular needles, and in which said member is a guide bar thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

691,692	Zweigbergk	Jan. 21, 1902
2,416,933	Lynam et al.	Mar. 4, 1947
2,699,757	Tornkvist	Jan. 18, 1955
3,035,426	McQueen	May 22, 1962

FOREIGN PATENTS

1,135,985	France	Dec. 22, 1956
-----------	--------	---------------