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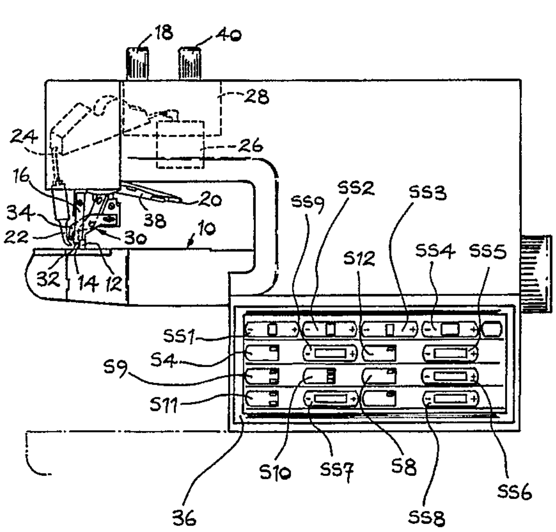
(54) Folding machines.

(57) The workpiece feeding means comprises a conventional hammer-and-anvil arrangement driven at a speed under operator control (T) and with variable feed length for "normal", "snipping" and "pleating" operations. For each workpiece shape a set of settings of these three feed lengths (SS1, SS2 and SS3) is stored in computer memory under an identification (SS4) by which such set can subsequently be accessed. The set may also include other style-sensitive settings, e.g. rate of adhesive flow (SS9), delay in supplying adhesive (SS5), "density" of snipping (SS6), for subsequent recall with the feed length settings. Provision is also made for certain operator-sensitive settings, e.g. maximum feed speed for the particular operator (SS7) as a proportion of the overall maximum for the machine; this enables the operator control (T) to be fully used over its whole range and thus to maintain the sensitivity of control it provides regardless of the maximum speed set. Provision is also made for certain adhesive-sensitive settings, e.g. creaser foot temperature (SS8). The operator- and adhesive-sensitive settings do not form part of the set of settings for a particular workpiece.

Fig_1



FOLDING MACHINES

This invention is conerned with folding machines of the type comprising a main drive shaft driven by a motor, folding instrumentalities arranged at an operating locality of the machine, workpiece feeding means operable in time relation with the rotation of the main drive shaft for feeding a workpiece through the operating locality, and feed speed variation means for varying the speed of rotation of the main drive shaft.

One such machine is described in EP-A 0110591. In this machine the maximum for the speed of rotation of the main drive shaft, and thus for the feed speed as controlled by the feed speed variation means, is not under the control of the operator, but rather is determined merely by the maximum output speed of the motor. It will however be appreciated that the speed at which the main drive shaft is rotated, and thus the feed speed of a workpiece through the operating locality, depends to a large extent upon the skill and dexterity of the operator, subject to the overall maximum. Conventionally the feed speed variation means is operator-controlled and moreover is conventionally constituted by an infinitely variable switch, usually treadle-operated. The amount of travel of such switch thus covers a range of settings from zero up to the overall maximum. It will thus be appreciated that an operator who is able to operate only at, say, 75% of the overall maximum will utilise only 75% of the switch travel and the lower the rate at which the operator feels confident to work, the less the amount of switch travel available to her and thus the coarser the variation of the rate under her control. It is acknowledged that proposals have been made to set different maxima for the different conditions referred to above, but in such proposals the effect of the settings is merely to render further travel of the switch after a set maximum is reached ineffective to increase the rate further, so that the same disadvantages of coarseness of operator control apply.

It is the object of the present invention to provide an improved folding machine in which the disadvantages referred to above are overcome.

This object is resolved in accordance with the present invention, in a machine as set out in the first paragraph above, the computer control means is provided by which a drive signal is supplied to the motor, and in that the feed speed variation means comprises a variable output signalling device which supplies a signal to the computer control means, the value of said drive signal supplied by the computer control means varying according to the value of the signal supplied by the variable output signalliing device, such that the speed of rotation of the main drive shaft is dependent upon the value of the output signal supplied.

A setting of the maximum for the speed of rotation of the main drive shaft can be regarded as being an "operator-sensitive" setting. In using a folding machine of the aforementioned type, however, other settings, e.g. "style-sensitive" and "adhesive-sensitive" settings are also frequently made. For example, in the machine described in EP-A. 0110591 pre-selected "feed length" settings can be made by mechanical means, more particularly by the setting of physical stops representing maximum and minimum positions only. In this way, moreover, it will be appreciated, only two settings are available. In the folding of workpiece edges, however, three distinct conditions are met, namely "straight" edges, "inside" corners and "outside" corners. By "straight" in this context is to be understood "without significant curvature", while by an "outside" corner is to be understood an edge portion having a curvature the centre of which lies within the body of the workpiece, and an "inside" corner an edge portion where the centre of curvature lies outside the body of the workpiece. It will be appreciated that in folding an outside corner, in general an amount of material is folded over which is in excess of the material on to which it is being folded so that it is necessary to "pleat" the folded edge, while in the case of an inside corner less material is being folded over so that it is often necessary to "snip" the folded edge, using snipping means provided, in order to distribute the material evenly. Thus in the case of pleating the minimum setting is concerned this often has to be a compromise between the needs of inside corners and those of straight feeding. Using physical stops along the provision of separate settings for these two different functions is achievable only by a more complicated arrangement.

Using such a machine, it will be appreciated, it is necessary for the pre-selection of the settings to be reviewed each time there is a change of workpiece shape being operated upon if the machine is to be used to its optimum effectiveness. Moreover, where the operator has a variety of workpiece shapes to process in the course of a working shift and she is thus required to re-set the machine relatively frequently, she must either memorise the settings she initially decides upon for each shape or re-set the machine ab initio each time the shape changes. Either way this is demanding upon the operator and/or time-consuming, but failure to make the appropriate changes may prove detrimental to the finished product, and in any event there will always be a tendency to compromise on the settings selected.

In accordance with the present invention, in such a machine comprising means for sensing features of the position of a workpiece approaching the operating locality as the workpiece is fed as aforesaid, and feed length variation means for varying the distance through which a workpiece is so fed by the workpiece feeding means for each rotation of the main drive shaft, such variation being effected, in accordance with pre-selected "feed length" settings, automatically in response to the sensing of said workpiece features by the sensing means said machine being characterised by means for storing sets of such pre-settings, each set comprising a plurality of settings, to be associated each with a sensed workpiece feature, and each set having an identification by which it can be recalled and thus rendered operational, and further characterised in that the setting of the maximum for the rotation of the main drive shaft is stored as a value which is applicable regardless of which set of "feed length" pre-settings is recalled and rendered operational.

It will be appreciated that by such an arrangement the operator is now able to make appropriate settings for each workpiece shape and store them for subsequent recall each time she has to process a workpiece of that shape. Alternatively the settings may be made by a different operator, e.g. a more experienced operator, for use by the less skilled operator, until such time as the latter herself has acquired the desired level of skill. Moreover, in this latter situation the less skilled operator will be able readily to select a slower maximum feed rate at which to operate while nevertheless retaining the same degree of control through the signalling device as enjoyed by the more skilled operator operating at the higher rate, and of course as the skill of the less experienced operator increases, she will be able to increase the feed rate maximum without having to vary the settings previously made.

It will of course be appreciated that whereas "style-sensitive" settings will normally be required for each style of workpiece being processed, operator-space and adhesive-sensitive settings of the machine will not need to be varied with changes in style (or shape) of the workpieces being processed.

As is conventional in machines of the type referred to as thermo-cementing and folding machines, conveniently the folding instrumentalities include a creaser foot about which folding of the workpiece is effected and adhesive is supplied into the fold thus formed through an outlet provided in the creaser foot. In accordance with the present invention, furthermore, preferably means is provided for setting a value for the temperature of the creaser foot, heating means being also provided for heating said foot to and maintaining it at or close to the temperature corresponding to the value set, and said value also being stored as a fixed value, unless varied by the foot temperature value setting means, and being applicable whichever set of pre-settings is recalled and rendered operational. It will of course be appreciated that this setting is an adhesive-sensitive setting, as referred to above, and thus also will be unlikely to require variation by reason of changes in workpiece shape only.

In order to render the machine more efficient, furthermore, other style-sensitive pre-settings may also be made and stored as part of the set of settings for a particular shape of workpiece, to be subsequently recalled and rendered operational as aforesaid. For example, in the case of a thermo-cementing and folding machine comprising adhesive supply means, first selector means for selecting whether or not adhesive is to be supplied, and second selector means for setting the rate at which adhesive is to be supplied, said rate as set also being variable proportionately with the workpiece feed rate as controlled by the rate control means, a first value corresponding to the status of the first selector means and a second value corresponding to the selected adhesive flow rate may also be stored as part of the set for subsequent recall as aforesaid.

Similarly, in such a machine delay selection means may be provided whereby a delay in the initiation of the flow of adhesive at the start of a cycle of operation of the machine can be set and a third value corresponding to the selected delay may also be stored as aforesaid. Again, where the sensing means is effective to sense the approach to the operating locality of "inside" corners (as herein defined) in the edge of a workpiece being fed as aforesaid and also the approach of "outside" corners (as herein defined) in such edge, first inhibit means may be provided for rendering ineffective signals supplied by the sensing means by which "inside" corners are sensed and second inhibit means for rendering ineffective signals supplied by the sensing means by which "outside" corners are sensed, and further a value for each of said inhibit means corresponding to the status thereof may be stored as part of the set for subsequent recall as aforesaid.

In machines of the aforementioned type disabling means may be provided for rendering the sensing means ineffective to control the operation of the workpiece feed rate varying means and operator-actuatable means may then be provided for selecting the appropriate pre-selected settings forming part of the particular operational set of settings. In this case too a value corresponding to the status of the disabling means may be stored as part of the set for subsequent recall as aforesaid. In addition, further disabling means may also be provided for disabling said operator-actuatable means and a value corresponding to the status of said further disabling means may also be stored as aforesaid.

Conveniently, furthermore, the sensing means is also effective to initiate the supply of adhesive when the approach of a workpiece to the operating locality of the machine is sensed thereby and further operator-actutable means may be provided for initiating the supply of adhesive if the sensing means is rendered ineffective as aforesaid.

As previously mentioned, in machines of this type conventionally the folding instrumentalities include snipping means by which the portion of the workpiece being folded can be snipped to facilitate the folding thereof. In accordance with the invention, furthermore, operator-actuatable inhibit means may be provided for inhibiting under operator control either the adhesive supply or the operation of the snipping means, function selection means being provided for selecting which of the two latter-mentioned inhibit functions is to be operative and a value corresponding to the status of said function selection means being stored for subsequent recall as aforesaid.

Again, where the folding instrumentalities include snipping means, means may also be provided for setting the rate at which snipping operations are effected, said rate being proportional to the workpiece feed rate as controlled by the rate control means, a value corresponding to the setting of the snipping rate setting means is stored as part of said set for subsequent recall as aforesaid. In one embodiment of the invention conveniently the snipping feed rate setting means constitutes the first inhibit means when the rate set by said setting means is zero.

There now follows a detailed description to be read with reference to the accompanying drawings, of one machine in accordance with the invention, which machine has been selected for description merely by way of exemplification of the invention and not by way of limitation thereof.

In the accompanying drawings:-

Figure 1 is a front view of the machine in accordance with the invention;

Figure 2 is a block diagram of an electronic control circuit of said machine;

Figures 3A and 3B constitute a flow chart relating to the control of the general operation of the machine;

Figures 4A and 4B constitute a flow chart indicating the control of the speed of rotation of a main drive shaft of the machine;

Figure 5 is a flow chart indicating the control of the rate of adhesive supply; and

Figure 6 is a flow chart indicating the manner in which a feed length adjustment takes place.

The machine in accordance with the invention now to be described is a so-called a thermo-cementing and folding machine, which finds use in the shoe industry and allied trades and is generally similar, except as hereinafter described, to the machine described in GB-A 2141968, itself a modification of the machine described in EP-A 0110591. The machine thus comprises a work table 10 on which a workpiece can be supported at an operating locality of the machine, at which conventional folding instrumentalities are located, comprising a fold-initiating block 12 having an upwardly curved work-guiding surface 14, a gauge finger 16, a creaser foot 22 and a lip turner (not shown), which completes the fold of the workpiece edge over the creaser foot. During folding, adhesive can be applied to the workpiece edge through an outlet in the creaser foot, to which adhesive is supplied via a delivery tube 24 from a melt chamber 28 under the action of a gear pump 26, which is driven by a stepping motor SM2. The melt chamber 28, delivery tube 24 and creaser foot 22 are heated respectively by heaters H1, H2, H3. Other features of the folding instrumentalities are shown in Figure 1.

"Downstream" of the folding instrumentalities are located conventional edge snipping means generally designated 30, comprising a fixed and movable blade 32, 34, and conventional workpiece feeding means in the form of an orbitally moving hammer-and-anvil arrangement (not shown), which also serves to consolidate the fold. A work release clamp (not shown) is also provided for clamping the work against the under-side of the creaser foot during the return movement of the hammer-and-anvil arrangement.

The hammer-and-anvil arrangement is driven through a main drive shaft (not shown) by means of an electric motor M1 operation of which is controlled in turn by computer control means (see Figures 2 to 6) through an inverter I. The inverter receives drive signals from the computer control means in the form of a voltage and in response thereto drives the electric motor. The electric motor is in this case an a.c. induction motor. As will be hereinafter described in detail, the motor and more particularly the speed of the motor, and thus the speed of rotation of the main drive shaft (hereinafter referred to as the "feed speed") may be controlled either automatically or by the operator using a first treadle (not shown), which incorporates a variable output signalling device in the form of a transducer T (Figure 2), forming part of operator-controlled feed speed variation means for varying the speed of rotation of the main drive shaft and thus the speed at which workpieces are fed through the operating locality of the machine. In addition, a second treadle (also not shown) is provided by means of which, in a "manual" mode of operation of the machine, by selectively depressing respectively the toeward and heelward portions of the treadle, two switches S6, S7, can be actuated under operator control. To this end, as will also be described in detail hereinafter, switch S6 actuates a stepping motor SM1 by which, through a mechanical arrangement including a feed length control lever (not shown), the amount through which the hammer-and-anvil arrangement moves fore-and-after for each revolution of the main drive shaft (hereinafter referred to as the "feed length"), is varied thus to effect pleating of the folding over margin of the workpiece. Similarly switch S7 operates a solenoid SOL2 which causes the edge snipping means 30 to operate and at the same time operates the motor SM1 to vary the feed length according to the appropriate setting. For determining the feed length provision is made in the form of three selector devices SS1, SS2, SS3 on a control panel 36 of the machine. Each selector device comprises a digital display and means for scrolling up or down the displayed numerical indicator; each selector device is thus capable of selecting a feed length in a range 0 to 9, the selected "feed length" representing a value for a signal which is supplied to the stepping motor SM1. The first selector device SS1 is utilised to set the feed length for "normal"(i.e. straight line) operation, the second SS2 for a snipping operation (which will normally occur when an "inside" corner is passing through the operating locality), and the third SS3 for a pleating operation (which will usually occur when an "outside" corner is passing through the operating locality). It is to be understood that in general, as is common in folding machines, the pleating feed length is likely to be relatively short, in order to enable pleating to be effected, while the "snipping" feed length will normally be somewhat longer, in order to avoid mere fraying of the edge by too many snips being made in the fold. The feed length settings are thus made for each workpiece to be processed. These are then stored in computer memory and are recallable and thus rendered operational using an identification in the form of a two-digit code. To this end a further selector device SS4 is also provided on the control panel incorporating a two-digit display and serving to enable the code (or style number) to be allocated to each set of feed length settings selected, the style number providing access, via the computer control means, to the memory in which information relating to the feed lengths is stored at an address accessed by the style number. For causing the settings to be stored, an "enter" button E is also provided on the control panel.

The machine has a "mains on/off" switch S1, a "motor on/off" S2, a "work lamp on/off" switch S3 and a so-called knee-switoh S5 for purposes which will be described later.

The control panel 36 of the machine also has the following switches for the purposes set out hereinafter:

Switch S4, which is an "adhesive supply" on/off switch incorporating a first pilot light, indicating "on", a second pilot light which, as the adhesive is heating, flashes to indicate adhesive is not available for supply, but which, when the temperature of the adhesive has been reached, is continuously illuminated to indicate that the adhesive supply is available, and a third light which indicates that the adhesive is in fact being supplied. (This switch thus constitutes first selector means of the machine.

Switch S8, by which the second treadle is enabled/disabled (said switch thus constituting further disabling means of the machine);

Switch S9, by which selectively snipping, pleating and adhesive on/off functions can be effected automatically or under operator control, pilot lights being provided for indicating which mode has been selected (said switch thus constituting disabling means for rendering the sensing means ineffective to control the workpiece feed length variation means of the machine);

Switch S10, which is a three-position pre-selector switch by which the operator can selectively utilise the knee-switch S5 when the machine is operating in its "automatic" operating mode (as selected by switch S9). More specifically, switch S10 can be switched between "off", in which the knee-switch S5 is not effective, an "adhesive inhibit" position, in which, when the knee-switch S5 is held operated, the supply of adhesive to the creaser foot 22 is inhibited, and a "snip inhibit" position, in which the edge snipping means is disabled while the knee-switch S5 is held operated. (This switch thus constitutes function selection means of the machine);

Switch S11, by which the control of the motor is selectively achieved automatically or under operator control, pilot lamps being provided for indicating which selection has been made; and

Switch S12, by which the selection of a "pleating" feed length can be prevented (this switch thus constituting second inhibit means of the machine).

Also on the control panel 36 are further selector devices, each of which comprises a plurality of bars which can be illuminated to indicate a progressive incrementing or decrementing of a value, selector buttons (+ and -) being provided for effecting such incrementing and decrementing:

Device SS5, by which the supply of adhesive at the start of a cycle of operation of the machine may be delayed;

Device SS6, by which, the density of "snipping" can be selected by the operator, generally in the manner set out in GB-A 2148541. (This switch, if set at zero, serves also as first inhibit means of the machine);

Device SS7, by which, as will be described in detail hereinafter, a maximum for the speed of rotation of the main drive shaft ("feed speed") can be set;

Device SS8, by which the temperature of the creaser foot 22 can be varied; and

Device SS9 serves to control the operating speed of the stepping motor SM2 by which the rate of adhesive supply can be controlled as will be described hereinafter (said switch thus constituting second selector means of the machine).

From the foregoing it will be appreciated that a number of pre-selections may be made, in addition to the three feed length settings, according to the shape of workpiece being operated upon (the "style-sensitive" settings); these comprise those made using switches S4, S8, S9, S10, S12, SS5, SS6 and SS9. In the machine in accordance with the invention operation of the enter button E will be effective to store appropriate values for the status of each of these switches as part of the set of settings selected for the particular workpiece shape and all these settings, together with the feed length settings, are recallable and rendered operational by the operation of switch SS4. The setting made using switch SS7, on the other hand, is operator-sensitive and thus remains fixed, regardless of workpiece shape, unless and until altered by the operator. Similarly the setting made using switch SS8 is adhesive-sensitive and will remain unchanged for style changes unless and until altered by the operator.

When the machine is in an automatic mode of operation (selected by switch S9), the control of adhesive supply (on/off function) and the selection of feed length is effected using a sensing arrangement including two emitters E1, E2 (constituting further sensing means of the machine) by which the supply of adhesive is controlled, four emitters E3, E4, E5, E6 by which an approaching "inside" corner in the edge contour of the workpiece being operated upon is sensed and which control solenoid SOL2 and also serve to select the "snipping" feed length, through stepping motor SM1 driving the feed length control lever, as hereinbefore referred to, and a further emitters E7 (the emitters E3-E7 constituting sensing means of the machine) by which an approaching "outside" corner in the workpiece edge contour is sensed and the "pleating" feed length selected.

In the machine in accordance with the invention, when switch S1 is switched on, mains power is supplied sequentially to heaters H1, H2 and H3 such that the various integers heated thereby reach operating temperature at essentially the same time. When the temperature of each integer is reached, then, assuming that switch S4 is switch "on", the appropriate lamp indicates that adhesive is available and that the machine is ready for operation. At the same time, power is supplied to solenoid SOL2, which, in response to appropriate signals, controls the edge snipping arrangement 30, and also to a transformer (not shown) which steps down the voltage to 12 volts for supply to a work lamp circuit which includes the "worklamp" switch S3. The 12 volt circuit is an a.c. supply, but from this is derived an unsmoothed 12 volts d.c. circuit which supplies power to a mains-controlled control box CB supplying a "mains interrupt" signal, to be referred to hereinafter. In addition, there is derived from the 12 volt a.c. circuit a smoothed 12 volt d.c. circuit which supplies power to stepper motor SM2, which drives the gear pump, and also to stepper motor SM1, by which the feed length control lever is operated. From the smoothed 12 volt d.c. circuit, furthermore, is derived a 5 volts circuit, which drives a central processor unit CPU and associated circuits and also provides power to the various switches and integers of the electrical and electronic circuits of the machine.

The central processor unit CPU, which controls the machine, is constituted by a single-chip 8-bit micro-computer (in casu, a Zilog Z8681 which, in addition to a microprocessor, also incorporates a random access memory/scratch pad RAM (shown separately in Figure 2); this microprocessor is obtainable from Zilog Inc). For the internal timing of the CPU a system clock C, comprising a free-running 12 MHz crystal, is provided. The CPU is connected via input-output bus I/OB with input and output ports IP, OP, a non-volatile memory in the form of an EPROM (erasable programmable read-only memory), which is accessed by the CPU via the I/OB for instructions to execute, and an EEPROM (electrical eraseable programmable read-only memory) for the storage of style and "machine status" information. In addition, an analogue-to-digital converter ADC is provided, to which signals are supplied by the various integers shown in Figure 2, including thermisters TS1, TS2, TS3 (which sense the temperatures of the components heated by heaters H1, H2, H3) and the various switches and selector devices. The ADC is interrogated by the CPU, via the I/OBus, each time a mains interrupt signalis supplied to the CPU by the control box CB. More particularly the various channels of the ADC are interrogated in turn, one in response to each mains interrupt in a so-called "wrap around" sequence. The ADC supplies information as to the state of the interrogated channel via the input port IP. The various switches and selector devices supply information as to the state of the interrogated channel via the data bus I/OB. In addition a digital-to-analogue converter DAC is provided which supplies analogue control signals to the inverter I for driving the motor M1, in accordance with digital signals received from the CPU. The control circuit also comprises a re-set sub-circuit R which is directly connected into the CPU and by which, upon starting up of the machine, the CPU is enabled to set the controls to their correct state in a rapid manner. A shaft encoder E driven by the main drive shaft is also provided having a direct "interrupt" input to the CPU. In response to the various signals thus supplied to the CPU, the CPU supplies outputs OP via the data bus I/OB to sub-circuits controlling the heaters H1, H2, H3, the solenoid SOL2, drives for stepper motors SM1,SM2, emitters E1 to E7 and relay RL1 as well as to the inverter I as already referred to. The relay RL1 serves as a "watch dog" over the whole of the control circuit. To this end, it is maintained in a "made" condition during normal operation of the machine by a control sub-circuit which is "refreshed" at regular intervals, failure to refresh the sub-circuit causing the relay RL1 to drop out. More particularly, the sub-circuit receives a signal at each mains interrupt, the signal serving to change the state of the circuit between "1" and "0", the arrangement being such that switching to the "1" state constituting the "refresh" signal.The sub-circuit is arranged to become de-energised, in the absence of a refresh signal, after a time interval which is greater than the interval between two "1" signals.

De-energisation of the sub-circuit of course switches off the relay, thereby terminating the power supply to the machine.

In the machine in accordance with the invention the emitters, constituting the various sensing means, are actuated in response to control pulses supplied by the CPU sequentially thereto at each system clock interrupt and emit pulses of infra-red radiation, which are separately received by the receiver E/R located in the machine head above the emitters. In other machines in accordance with the invention other types of sensing means may of course be utilised.

Figures 3 to 6 constitute flow charts illustrating various functions of the software by which the machine in accordance with the invention is controlled. It will be noted that there are no inscriptions within any of the boxes of the flow charts, but rather a full description of each step is appended to this specification.

Referring now to Figures 3A and 3B which relate to the general running of the machine, at the first step 650 the status of switch S9 is checked to determine whether the adhesive supply (on/off), snipping and pleating functions are to be controlled automatically, namely through the emitters E1 to E7, or under operator control, using the knee-switch S5 and treadles; the machine in this regard operates in the same manner as described in GB-A 2141968. If a "No" is, obtained, indicating that "manual" has been selected, at step 652 a command is issued to ensure that the motor will not operate in "automatic"mode, and at step 654 the status of knee-switch S5 is monitored. If the machine is not switched on, then the software loops back to step 650, but in the event that the knee-switch is actuated, adhesive is supplied, initially, ie at the start of a cycle of operation of the machine, with a "fast forward" cycle of operation of the machine, with a "fast forward" operation of the motor to give a surge, generally as described in EP-A 0110591 (Step 656).The control of the rate of adhesive supply will be described hereinafter in connection with Figure 5. The status of knee switch S5 continues to be monitored at step 658; it will be recalled that as described in GB-A 2141968, the knee switch must be released by the operator and reactuated in order to switch off the adhesive flow. When such flow is switched off, the operation of the stepping motor SM2 is stopped and reversed to provide for suck-back of the adhesive, both initially and thereafter intermittently, as described in detail in EP-A 0154441 (step 660).

It is also to be noted that throughout the operation as set out above, the various switches and selector devices, e.g. those relating to the control of the snipping and pleating functions are regularly and frequently monitored and any signals therefrom processed.

In the event that "automatic" operation is selected at step 650, then the status of emitters E1, E2 is interrogated (step 662). In the event that the emitters are uncovered, then a command is issued to ensure that the motor will not operate in "automatic" mode (step 664) and the circuit loops back to step 650. Where the emitters E1, E2 are covered, indicating that a workpiece is present then any delay in the initiation of adhesive supply, as selected by selector device SS5 is executed (step 666) and thereafter the status of switch S11 is interrogated, to determine whether the motor M1 is to be controlled automatically or by the operator using the right hand treadle. In the case of "automatic" selection, the motor M1 is switched on (step 670). If the "manual" operation is selected, on the other hand, then a signal is awaited from transducer T associated with the right hand treadle; this will described in greater detail with reference to Figure 6. At step 674 the supply of adhesive is initiated, in the same manner as described previously with reference to step 656 and this continues until the emitters E1, E2 are once more uncovered (step 674). Upon the uncovering of the emitters, indicating that a workpiece is no longer present, a delay in switching off the adhesive supply is calculated (step 676), on the basis of rotations of the main drive shaft between the uncovering of the first emitter and that of the second; it will be appreciated that the two emitters lie one after the other in the general feed direction. The calculated delay is then implemented at step 678 and thereafter the adhesive supply is switched off (step 680), in the same manner as described with reference to step 660.

At step 682 the status of switch S11 is once more interrogated, essentially to ensure that the workpiece is fed completely out of the operating locality, the arrangement being such that if "automatic" operation has been selected, a delay, based upon the current feed length selected by one of selected devices SS1, SS2, SS3, is calculated and implemented (684 and 686) prior to the motor M1 being switched off (step 688). In the event that "manual" operation has been selected, then it is assumed that the operator will ensure that the workpiece has been fed from the operation locality. Thereafter the circuit loops back to step 650.

As described in detail in GB-A 2141968, when "automatic" is selected at step 650, then in the event that switch S10 is appropriately set, the knee-switch may serve to inhibit either "snipping" or the adhesive supply when actuated. On the other hand, when "automatic" operation is selected by means of switch S11, operation of the knee-switch S5 acts as an emergency stop.

Referring now to Figures 4A and 4B, which relate to the control of the motor M1 and more particularly to the operation of the machine depending upon the selection made by switch S11, at step 700 the status of said switch is interrogated. If "automatic" operation is selected then at step 702 the status of the emitters E1, E2 is interrogated, that is to say the presence of a workpiece is checked for. If a workpiece is present then at step 704 the "basic speed" of the motor is set at 2,400 rpm; this is in fact a function of the software itself, the particular speed being assessed as being the optimum for the operation of a machine of this kind. At step 706 thereafter the status of selector device SS7, by which a proportional value of the set speed (in this case 2,400 rpm) is selected by the application of a reduction factor and at step 708 the software then calculates, e.g. by look-up tables, the value of the drive signal to be supplied to the motor M1 to achieve the desired speed and the drive signal is supplied accordingly. At step 710 the actual speed of rotation of the main drive shaft, which is monitored by the shaft encoder E, is calculated from the output of the encoder and at step 712 the difference between the calculated and the actual speed is determined and compared with a pre-set tolerance. If the difference does not lie within the given tolerance, then the drive signal supplied to the motor M1, as previously calculated at step 708, is modified according to a feedback factor (step 714), said factor being calculated so as to bring actual speed of rotation of the shaft up to the desired speed and this feedback factor is then applied to the drive signal value (step 716). The feedback factor is thereafter stored and is applied, without further modification, provided that the difference between the desired and actual speed of rotation of the main drive shaft remains within the tolerance. The appropriate drive signal is thus applied to motor M1 (step 718) and the circuit then loops once more back to step 700.

In the event that at step 702 the emitters E1, E2 become uncovered, indicating that a workpiece is no longer present, then, bearing in mind that this circuit is continuously looping, at step 720 a signal to stop the operation of motor M1 is supplied.

In the case where at step 700 a "manual" operation has been selected, then at step 722 the status of the signal from the transducer associated with the right hand treadle is interrogated, in particular, the treadle will either indicate a "stop" condition or a "drive" condition, in which latter case the value of the signal from the transducer will be converted proportionally to a motor speed. The transducer is also able to provide a further signal, namely by the operator depressing the treadle with her heel to signal a requirement that the machine is brought to a stop with the hammer-and-anvil arrangement in a closed condition; this may be desirable where a workpiece has not been completely processed but rather it is desirable to carry out some intermediate operation on the workpiece part-way through a cycle of operation. At step 724, therefore, this condition of the transducer is sought and in the event that a corresponding signal is provided, then at step 726 the motor M1 is switched off with the hammer-and-anvil arrangement in closed condition. Otherwise if no such signal has been provided, then at step 728 the status of the transducer is interrogated as to whether it is in a "stop" or "drive" condition. If "stop" has been selected, then the circuit leads to step 720 and the motor M1 is switched off, this time with the hammer-and-anvil arrangement in an open condition. In the event that "drive" has been selected, then steps 706 and subsequent steps are followed as described above; that is to say the reduction factor which is set by device SS7 is applied to the motor speed set according to the position of the transducer in "drive" mode and drive signals are supplied to the motor M1 as aforesaid.

Figure 5 relates to the operation of the adhesive supply means, more particularly the signalling supplied to stepping motor Sm2. Thus, at step 730 the required adhesive supply rate, as set by selector device SS9, is ascertained and, in accordance with the current speed of rotation of the main drive shaft, as ascertained from the shaft encoder (step 732), the requested adhesive supply rate is modified proportionally, namely by dividing the actual speed of rotation of the main drive shaft by 2,400 and thus arriving at a proportion to be applied to the requested adhesive rate (step 734). At step 736 and 738 the question of whether a snipping or pleating operation respectively has been selected is posed. To this end, in "automatic" mode the status of the various emitters E3 to E7 will be addressed, whereas in "manual" mode the status of the left hand treadle is interrogated. In the event that neither a snipping nor a pleating operation has been selected then at 740 the appropriate drive signal is supplied to motor SM2 to achieve the adhesive supply rate as determined at step 734. In the event that either a snipping or a pleating operation has been selected, then at step 742 the calculated adhesive supplied rate required is again modified according to the setting of the appropriate one of selector devices SS2 and SS3. In this regard it will be noted that the setting of the desired adhesive supply rate will be applicable whenever "normal" feeding of the workpiece is taken place, as determined by the setting of selector device SS1. The modification of the delivery rate in accordance with the setting of either one of devices SS2 and SS3 will be proportional, in the same ratio as that between the settings of the selected device and device SS1.

Thereafter, at step 744, the adhesive supply rate as determined at step 734 is modified by this further modification factor and thereafter the appropriate drive signal is supplied to motor SM2 (step 740).

Figure 6 indicates further aspects of the software relating to the adjustment of feed length which will take place during the operating cycle of the machine. It will thus be appreciated that, as with the sections of software to which Figs. 4 and 5 also relate, these sub-programs are access regularly and frequently during the general operation of the machine as set out in Figure 3. The particular sub-program is brought into effect only if a change in feed length is indicated, either by a signal from the emitters E3 to E7 or a signal from the left hand treadle, depending on the particular mode of operation of the machine. In the event that a new feed length is indicated then at step 750 the question is posed as to whether a feed length change is currently taking place. If so, then at step 752 an instruction to wait for the current change to be completed is supplied. At step 754 the displacement of the feed length control lever necessary to bring about the required change of feed length is calculated in terms of steps of stepping motor SM1 by which the position of the lever is varied. It is the intention that any change of feed length which takes place during the operating cycle of the machine, i.e. when the machine is actually running, is effected smoothly as opposed to previous machines in which the change has been effectively instantaneous, leading to "snatching" of the workpiece as the change takes place. If, however, the motor M1 is not in fact operating at the time of the feed length change, as checked at step 756, then the feed length change can be promptly executed and to this end at step 758 the motor feed speed is treated as at the maximum so that the change of feed length is effected in the quickest possible time. In the event that the machine is operating at the time then the actual speed of rotation of the main drive shaft is calculated using shaft encoder E (step 760). Whichever information is thus supplied, at step 762 the stepping rate of stepping motor SM1 required to displace the feed length control lever through the appropriate distance within a pre-set number of, e.g. 3, revolutions of the main drive shaft (which will give an allowed time dependent upon the speed of rotation of the drive shaft as calculated at step 760 or set at step 758) is calculated, such calculation being of course dependent upon the maximum stepping rate limit for the motor SM1. In the event that the stepping motor cannot achieve the stepping rate required, then it will be operated at a maximum speed to achieve the change of feed length in the smallest time commensurate with that speed.

If desired, the change in the rate of adhesive supply corresponding to the feed length change may also be similarly "phased" to achieve a smooth transition.

At step 764 the calculated stepping rate is then implemented and the control lever displaced. It will thus be appreciated that, using the machine in accordance with the invention, significantly greater control over the operation of the various motors incorporated in the machine can be achieved, in particular by the application of computer control techniques.

APPENDIX

650 Switch S9: Is automatic control of adhesive supply, snipping and pleating by sensors (as opposed to operator control) selected?
652 Cancel automatic motor (M1) run request.
654 Is knee-operated adhesive supply control switch S5 actuated (adhesive "on")?

656 Switch motor SM2 to "fast forward" (adhesive surge) and initiate adhesive supply.
658 Is knee-operated adhesive supply control switch S5 actuated (adhesive "off")?
660 Switch motor SM2 to reverse (intermittent suck-back) 662 Are "workpiece present" sensors E1, E2 covered?
664 Switch off motor M1
666 Initiate adhesive supply delay (if any): Selector device SS5
668 Switch 11: Is operation of motor M1 set to automatic?
670 Switch on motor M1
672 Switch motor SM2 to "fast forward" (adhesive surge) and initiate adhesive supply.
674 Are "workpiece present" sensors E1, E2 covered?
676 Calculate delay in switching off the adhesive supply.
678 Implement delay in switching off the adhesive supply
680 Switch motor SM2 to reverse (intermittent suck-back)
682 Switch 11: Is operation of motor M1 set to automatic?
684 Calculate delay in switching off motor M1
686 Implement delay in switching off motor M1
688 Switch off motor M1
700 Switch 11: Is operation of motor M1 set to automatic?
702 Are "workpiece present" sensors E1, E2 covered?
704 Set motor (M1) speed at maximum
706 Apply to maximum set at 704 any selected reduction factor : device SS7
708 Calculate value of drive signal to motor M1 required to achieve desired speed of rotation of main drive shaft
710 Calculate actual speed of rotation of drive shaft from encoder and determine feedback factor
712 Is difference between selected and actual shaft speed within tolerance?
714 Modify feedback factor
716 Apply feedback factor to drive signal value
718 Supply drive signal to motor M1
720 Stop motor M1 when "home" position is sensed
722 Read transducer (T) signal and convert to motor (M1) speed
724 Is "hammer closed" stop position command signalled?
726 Switch off motor M1 in "hammer closed" position
728 Is motor (M1) stop position command signalled?
730 Access required adhesive supply rate (Switch SS4)
732 Calculate actual speed of rotation of main drive shaft from encoder
734 Modify required adhesive supply rate by factor: actual speed (rpm)/2,400
736 Is "snipping" feed length selected?
738 Is "pleating" feed length selected?
740 Supply drive signal to motor SM2 to achieve adhesive supply rate as determined at 734 or 744
742 Calculate modification factor according to selected feed length as a proportion of "straight" feed length
744 Modify by modification factor the adhesive supply rate as determined at 734
750 Is feed length in course of being changed?
752 Wait for completion of current change
754 Calculate (in terms of steps of motor SM1) required displacement of feed length control lever
756 Is motor M1 stopped?
758 Apply maximum value to speed of rotation of main drive shaft
760 Calculate actual speed of rotation of main drive shaft from encoder signal
762 Calculate stepping rate of motor SM1 required to displace feed length control lever in time equivalent to pre-set number of revolutions of main drive shaft (subject to maximum stepping rate limit)
764 Initiate displacement of feed length control lever

Claims

1. Folding machine comprising
a main drive shaft driven by a motor (M1),
folding instrumentalities (12, 14, 16, 22, 30) arranged at an operating locality of the machine,
workpiece feeding means operable in timed relation with the rotation of the main drive shaft for feeding a workpiece through the operating locality, and
feed speed variation means (T) for varying the speed of rotation of the main drive shaft,
characterised in that the feed speed variation means (T) comprises a variable output signalling device (T) which supplies output signals in response to which drive signals are caused to be supplied to the motor driving the main drive shaft, said device (T) having a range of positions between "maximum" and "minimum" end positions,
and in that means (SS7) is provided for setting a maximum for the speed of rotation of the main drive shaft, and thus for the feed speed as controlled by the feed speed variation means (T), the arrangement being such that the value of the output signal appropriate for achieving the set maxi-

mum speed of rotation of the main drive shaft (the "maximum output signal") corresponds to the "maximum" end position of said device, regardless of the setting of said setting means (SS7), and the values of the output signals corresponding to positions intermediate the "maximum" and "minimum" end positions of the device are proportional, over the range of positions, to the value of the maximum output signal.

2. Machine according to Claim 1 further comprising means (E3 to E7) for sensing features of the position of a workpiece approaching the operating locality as the workpiece is fed as aforesaid, and
feed length variation means (SM1) for varying the distance through which a workpiece is so fed by the workpiece feeding means for each rotation of the main drive shaft, such variation being effected, in accordance with pre-selected "feed length" settings, automatically in response to the sensing of said workpiece features by the sensing means,
said machine being characterised by means for storing sets of such pre-settings, each set comprising a plurality of settings, to be associated each with a sensed workpiece feature, and each set having an identification by which it can be recalled and thus rendered operational,
and further characterised in that the setting of the maximum for the rotation of the main drive shaft is stored as a value which is applicable regardless of which set of "feed length" pre-settings is recalled and rendered operational.

3. Machine according to Claim 2 wherein the folding instrumentalities (12, 14, 16, 22) include a creaser foot (22) about which folding of the workpiece is effected, and wherein adhesive is supplied into the fold thus formed through an outlet provided in the creaser foot, and further wherein means (SS8) is provided for setting a value for the temperature of the creaser foot (22), heating means (H3) being also provided for heating said foot to and maintaining at or close to the temperature corresponding to the value set,
characterised in that the temperature setting is stored as a value applicable whichever set of pre-settings is recalled and rendered operational.

4. Machine according to either one of Claims 2 and 3 comprising adhesive supply means (22, 28), first selector means (S4) for selecting whether or not adhesive is to be supplied, and second selector means (SS9) for setting the rate at which adhesive is to be supplied, said rate as set also being variable proportionately with the workpiece feed length as set by the feed length variation means (-, SM1),
characterised in that for each set of pre-settings a first value corresponding to the status of the first selector means (S4) and a second value corresponding to the selected adhesive flow rate are also stored as part of said set and are thus recallable and rendered operational as aforesaid.

5. Machine according to Claim 4 wherein delay selection means (SS5) is provided whereby a delay in the initiation of the flow of adhesive at the start of a cycle of operation of the machine can be set characterised in that for each set of pre-settings a third value corresponding to the selected delay is also stored as part of said set and is thus recallable and rendered operational as aforesaid.

6. Machine according to any one of the preceding Claims wherein the sensing means (E3, E7) is effective to sense the approach to the operating locality of "inside" corners (as herein defined) in the edge of a workpiece being fed as aforesaid and also the approach of "outside" corners (as herein defined) in such edge, and wherein first inhibit means (SS6) is provided for rendering ineffective signals supplied by the sensing means by which "inside" corners are sensed and second inhibit means (S12) for rendering ineffective signals supplied by the sensing means by which "outside" corners are sensed,
characterised in that for each set of pre-settings a value for each of said inhibit means SS6, S12) corresponding to the status thereof is stored as part of said set and each such value is recallable and rendered operational as aforesaid.

7. Machine according to any one of Claims 2, 3, 4 and 5 or to Claim 6 when tied directly or indirectly to any one of Claims 2, 3, 4 and 5 comprising disabling means (S9) for rendering the sensing means (E3-E7) ineffective to control the operation of the feed length variation means (-, SM1) together with operator-actuatable means for selecting the appropriate pre-selected settings forming part of the particular operational set of settings,
characterised in that for each set of pre-settings a value corresponding to the status of the disabling means (S9) is stored as part of said set and is recallable and rendered operational as aforesaid.

8. Machine according to Claim 7 comprising further disabling means (S8) for disabling the operator-actuatable means (S6, S7) for selecting the appropriate settings as aforesaid,
characterised in that for each set of pre-settings a value corresponding to the status of said further disabling means (S8) is stored as part of said set and is recallable and rendered operational as aforesaid.

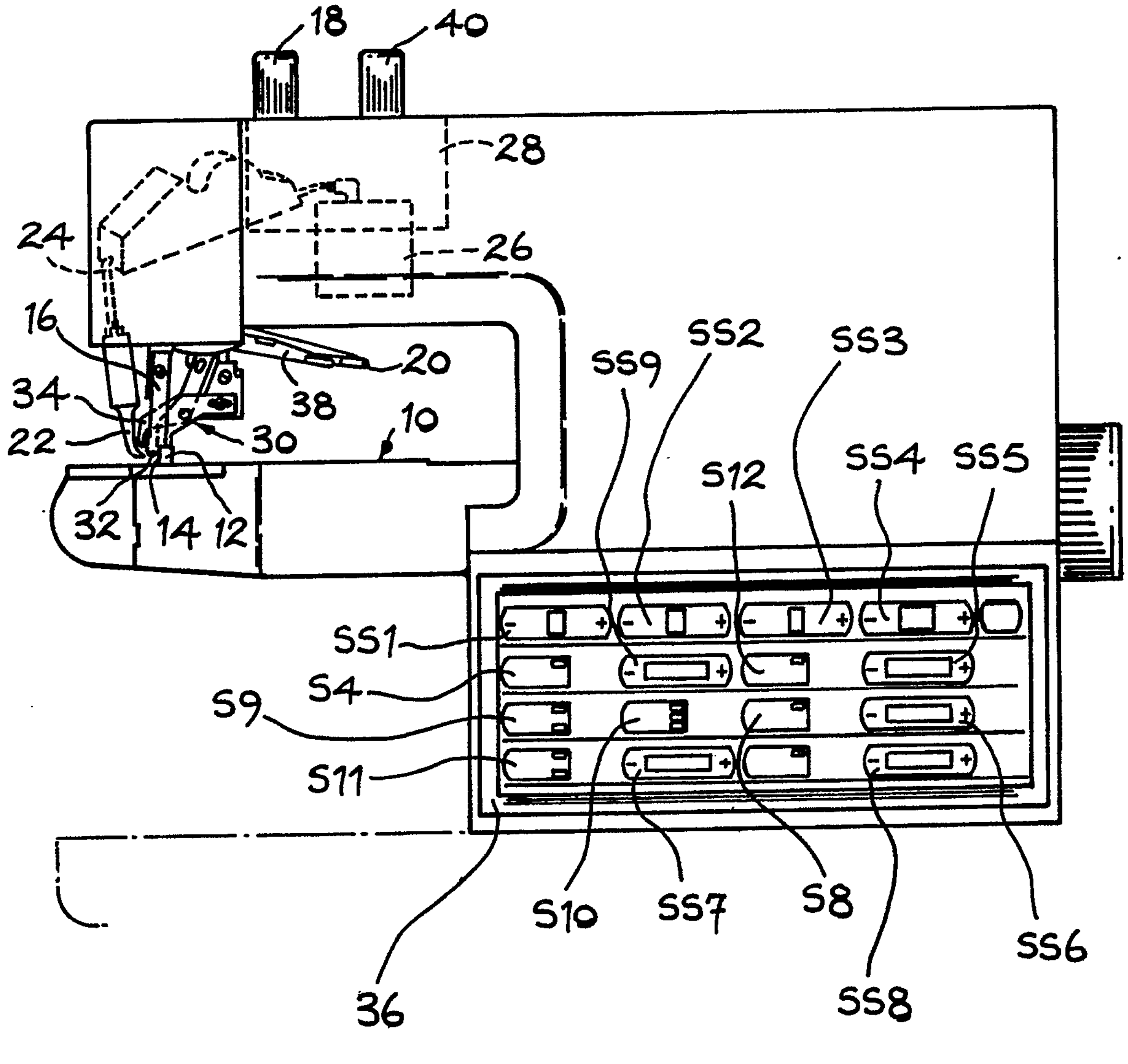
9. Machine according to either one of Claims 7 and 8 when tied directly or indirectly to Claim 4 wherein further sensing means (E1, E2) is provided which is effective to initiate the supply of adhesive when the approach of a workpiece to the operating locality of the machine is sensed thereby,
characterised in that further operator-actutable means (S5) is provided for initiating the supply of

adhesive if the further sensing means (E1, E2) is rendered ineffective as aforesaid.

10. Machine according to Claim 9 or to either one of Claims 7 and 8 when tied directly or indirectly to Claim 4 wherein the folding instrumentalities (12, 14, 16, 22, 30) include snipping means (30) by which the portion of the workpiece being folded can be snipped to facilitate the folding thereof, and wherein operator-actuatable inhibit means (S5) is provided for inhibiting under operator control either the adhesive supply or the operation of the snipping means, function selection means (S10) being provided for selecting which of the two latter-mentioned inhibit functions is to be operative, characterised in that for each set of pre-settings a value corresponding to the status of said function selection means (S10)is stored as part of said set and is recallable and rendered operational as aforesaid.

11. Machine according to any one of Claims 2 to 5, 7, 8 and 9 or to Claim 6 when tied directly or indirectly to any one of Claims 2 to 5 wherein the folding instrumentalities (12, 14, 16, 22, 30) includes snipping means (30) by which the portion of the workpiece being folded can be snipped to facilitate the folding thereof, and wherein means (SS6) is provided for setting the rate at which snipping operations are effected, said rate being proportional to the feed length as controlled by the feed length variation means (-, SM1), characterised in that for each set of pre-settings a value corresponding to the setting of the snipping rate setting means (SS6) is stored as part of said set and is recallable and rendered operational as aforesaid.

Fig_1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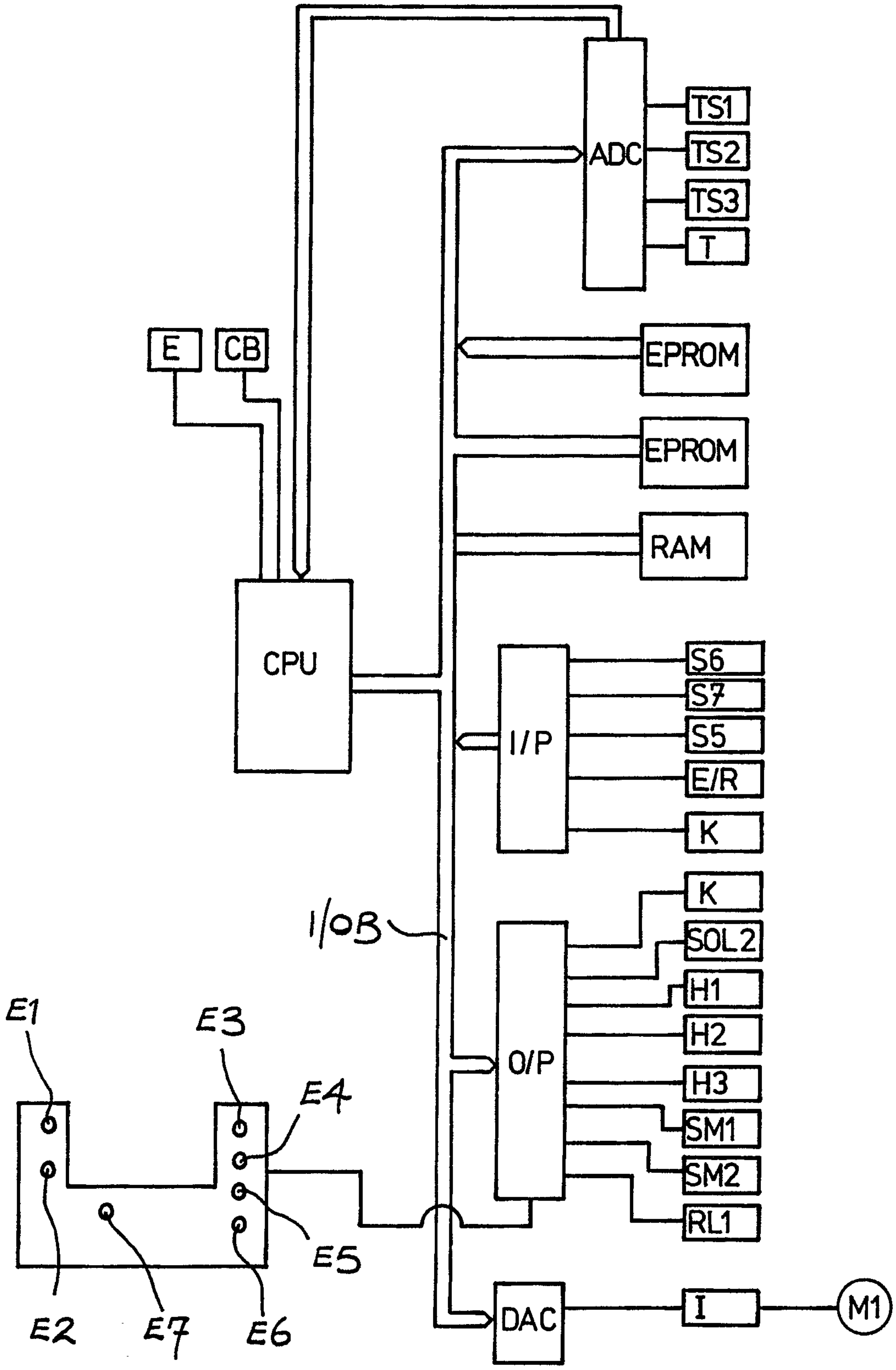
28
24
26
16
20
34
38
22
30
10
32
14
12
SS9
SS2
SS3
S12
SS4
SS5
SS1
S4
S9
S11
36
S10
SS7
S8
SS8
SS6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TS2
TS3
T
E
CB
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EPROM
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CPU
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S6
S7
S5
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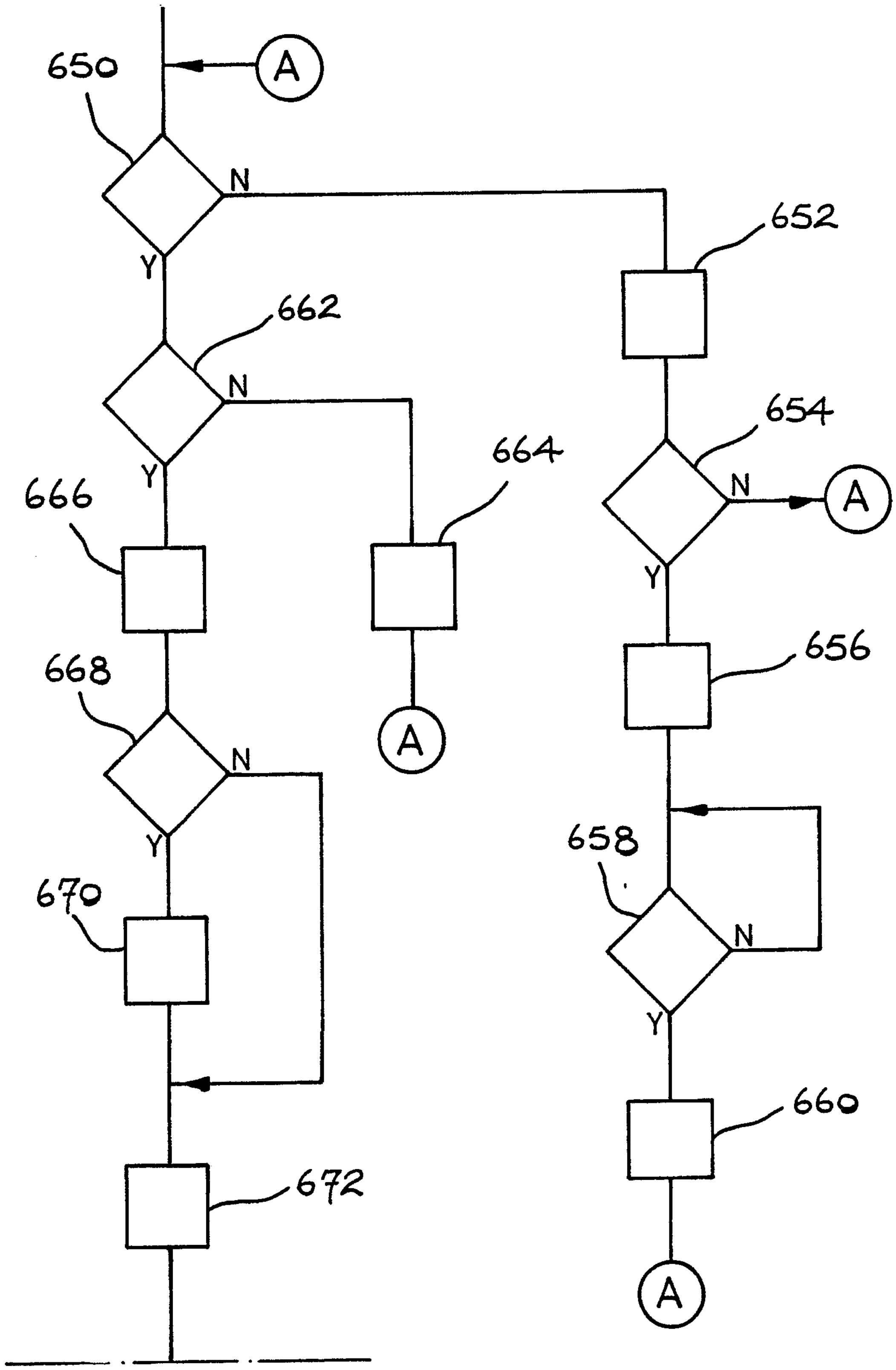
K
K
SOL2
H1
H2
H3
SM1
SM2
RL1
O/P
I/OB
E1
E2
E3
E4
E5
E6
E7
DAC
I
M1

Fig-2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670
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Y
660
672
A

Fig-3A

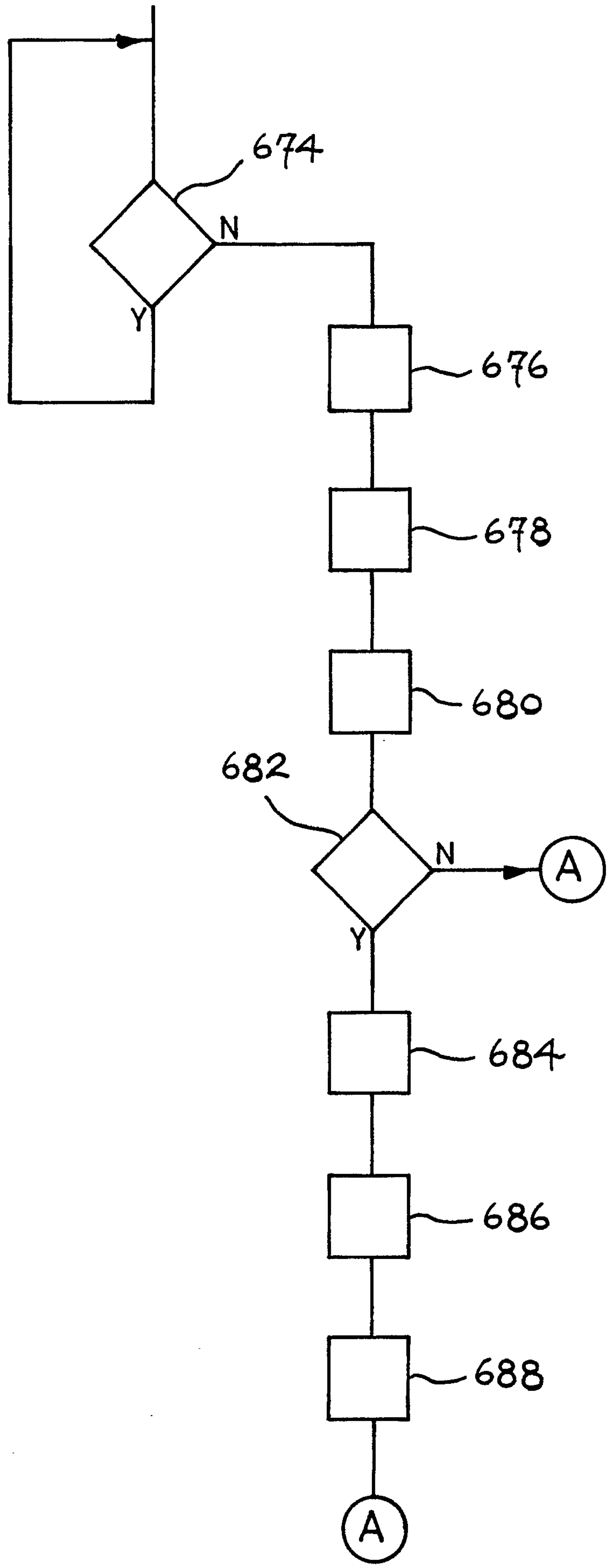

Fig-3B

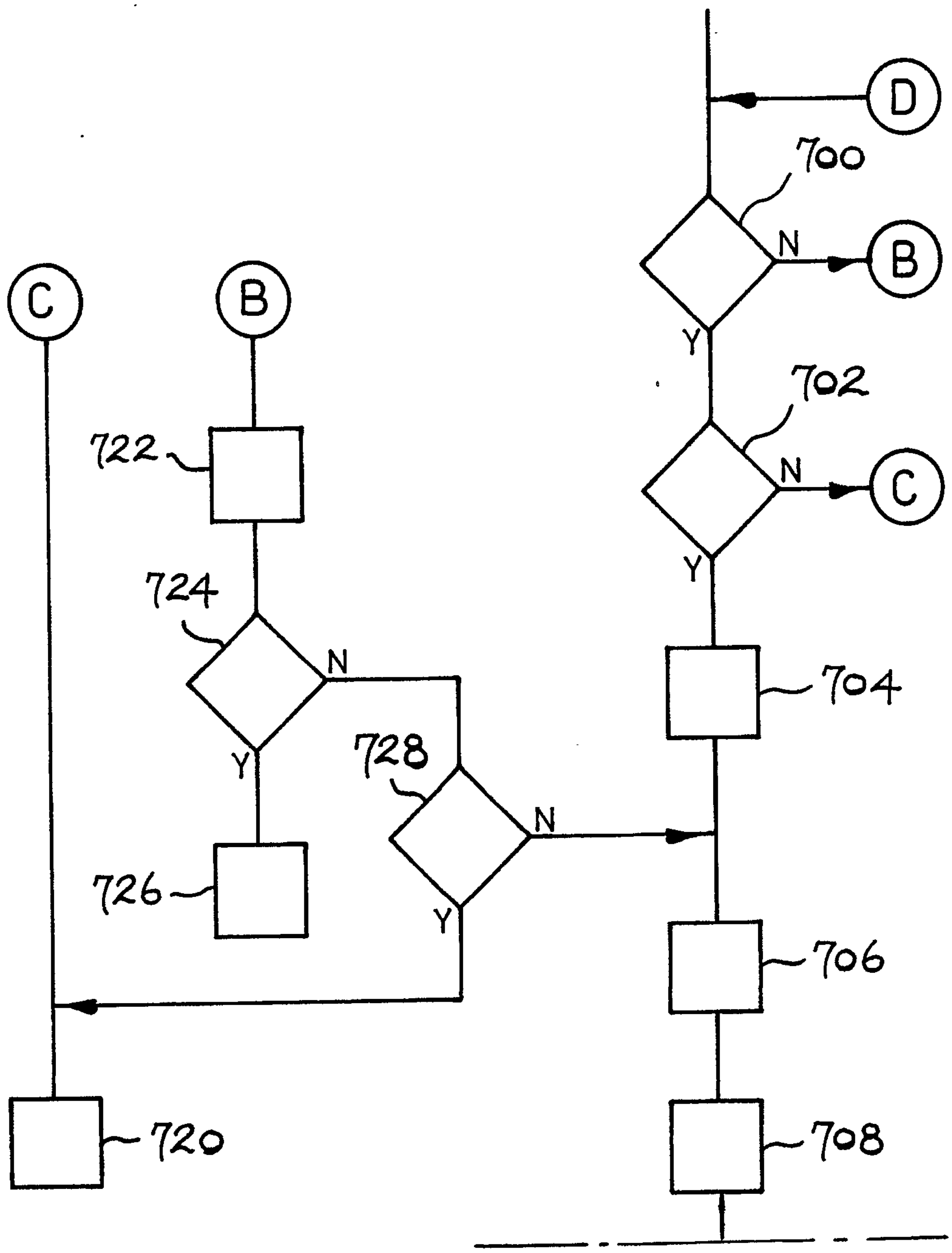

Fig-4A

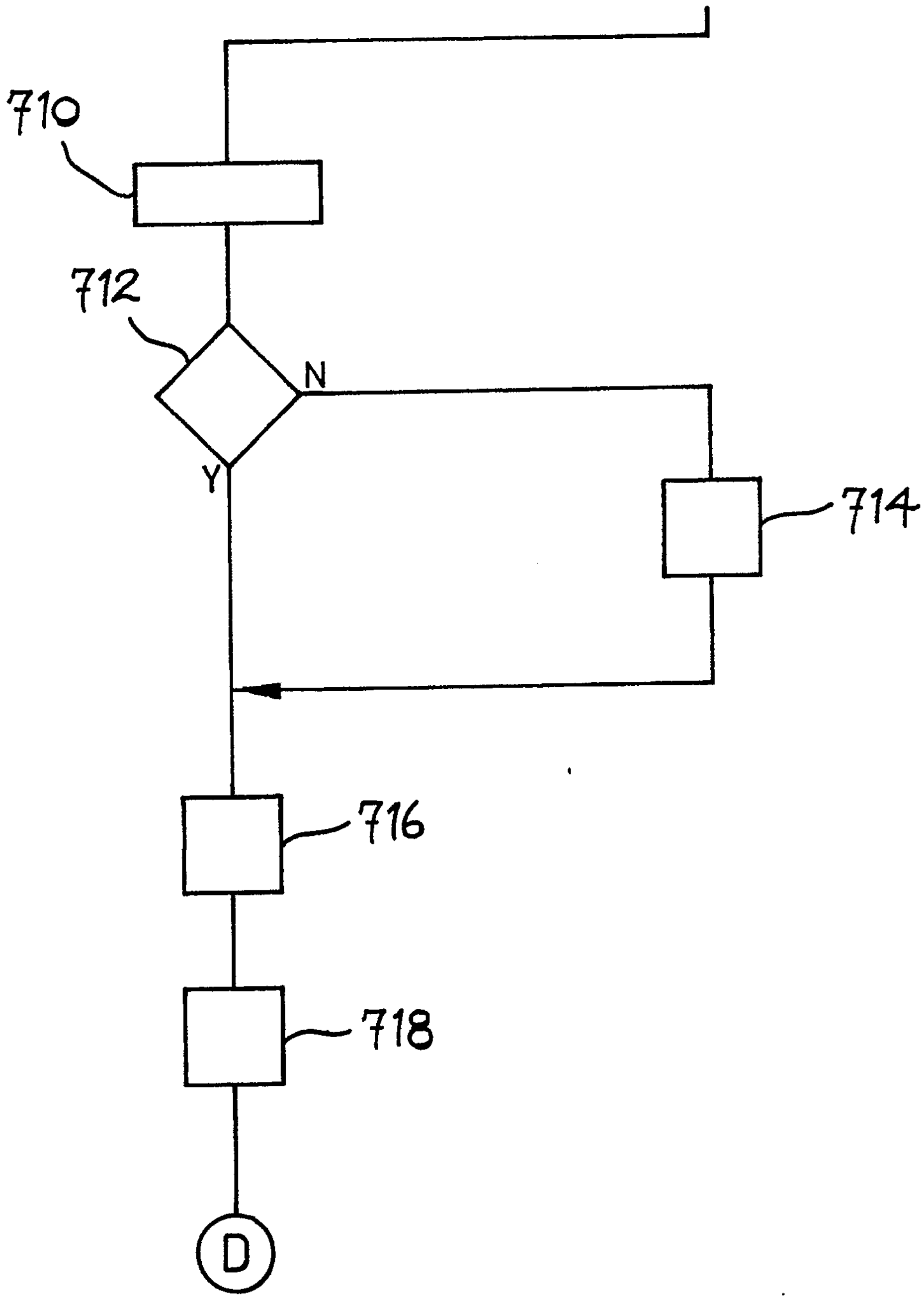

Fig-4B

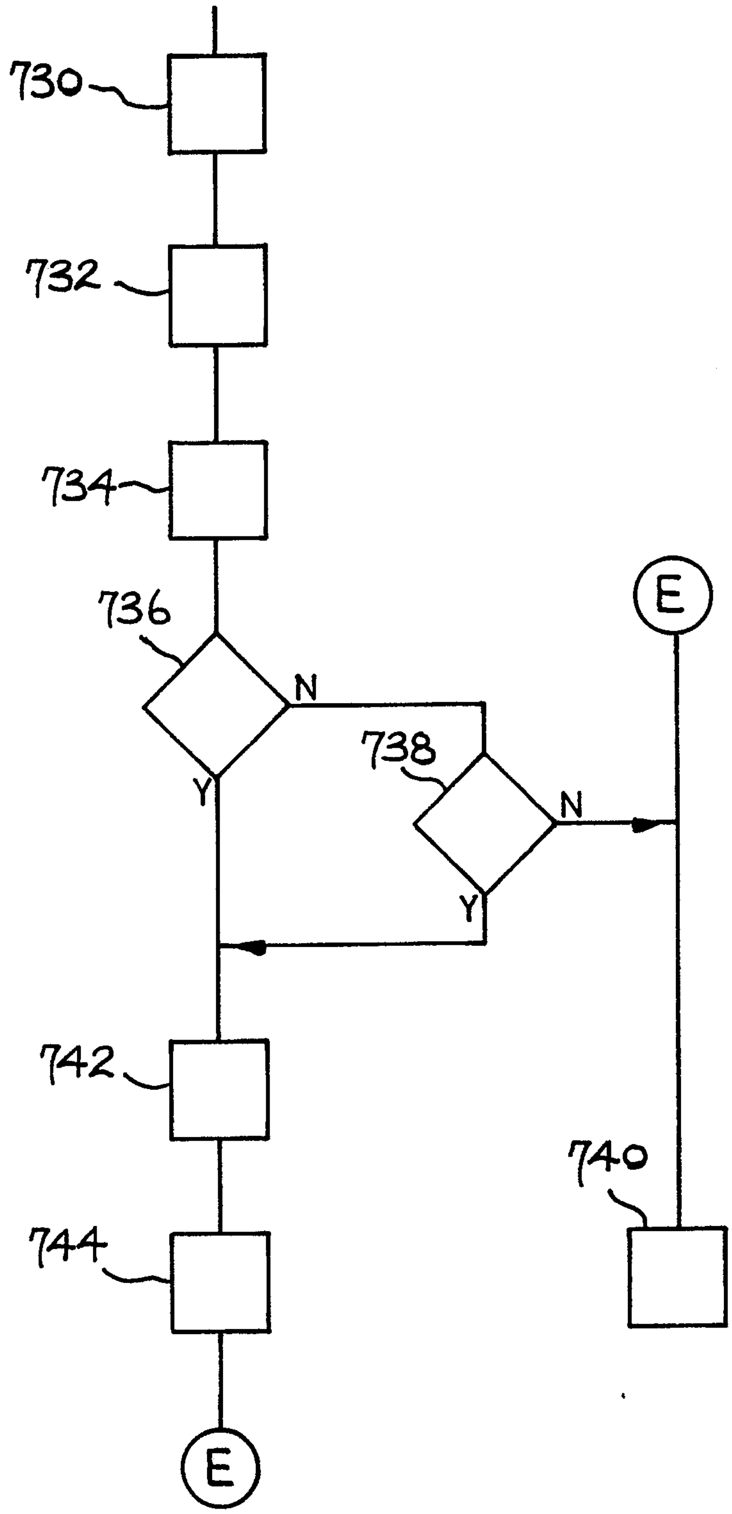

Fig- 5

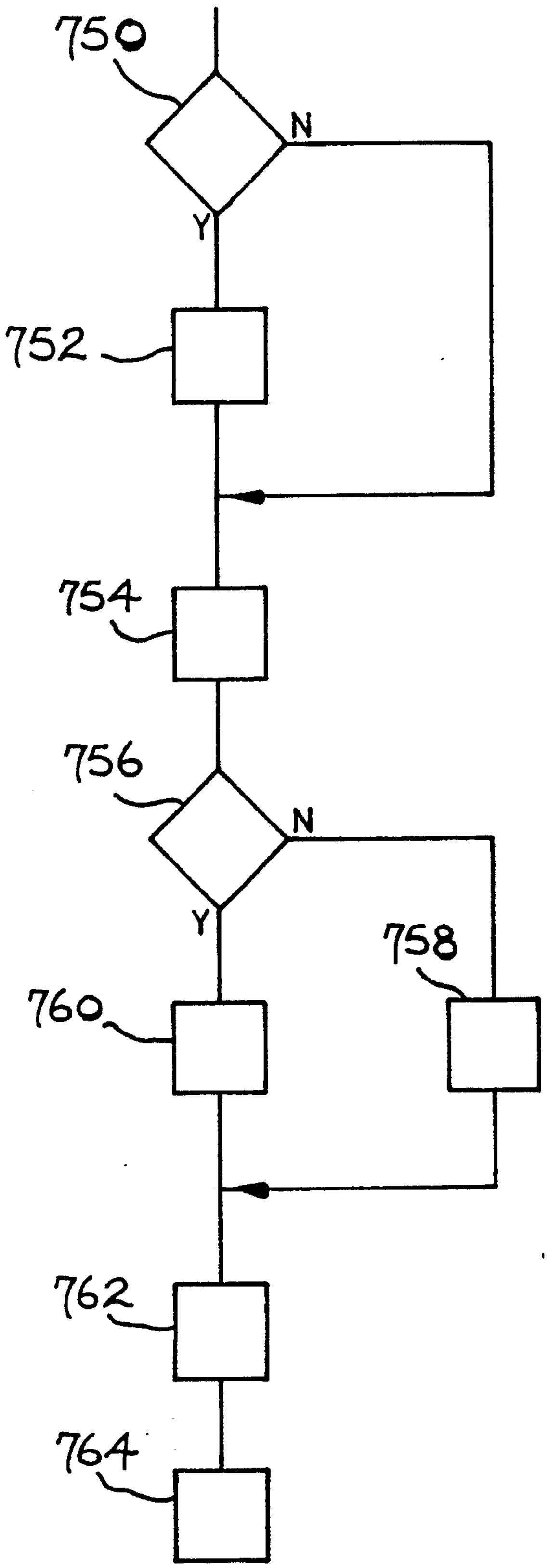

Fig. 6