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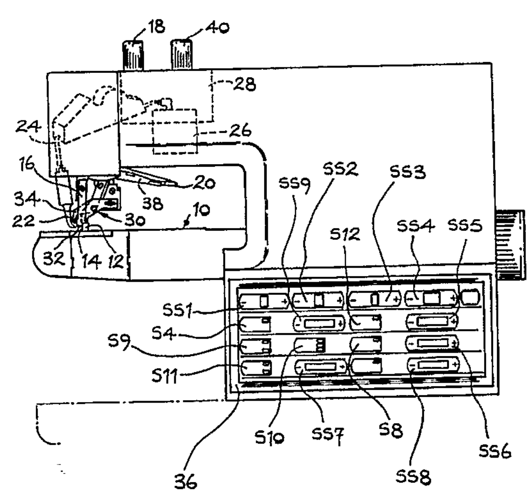
(54) Folding machines.

(57) The workpiece feeding means is operated from a main drive shaft which is driven by a motor (M1) in response to drive signals supplied by computer control means, the value of which signals depends upon the value of a signal supplied to a computer control means by a transducer (T) incorporated in a foot treadle. Moreover, in order to ensure that the actual speed matches the desired speed, the rotation of the drive shaft is monitored and any appropriate compensation then made by the computer control means. Provision is also made for varying the range of speeds within which the machine will operate, such variation also being achieved by the computer control means such that, for any given setting of the transducer, the particular feed speed will be varied proportionally; this means that the overall travel of the treadle will be constant regardless of the width of the speed band. Provision is further made for setting, through the computer control means, feed lengths for "normal", "snipping" and "pleating" operations and for storing a combination of selected feeds lengths as a style pattern for subsequent recall. In addition, for varying the feed length during a cycle of operation a stepping motor (SM1) is provided and the computer control means is effective to "phase in" any feed length over a pre-determined number of rotations of the main drive shaft. Any variation of the feed length from the "normal" setting, furthermore, serves to vary the adhesive supply rate by a proportion determined by the relationship between the selected feed length and the "normal" feed length as set.

Fig_1



EP 0 413 445 A2

FOLDING MACHINES

This invention is concerned with improvements in or relating to folding machines, more particularly so-called thermo-cementing and folding machines.

One such machine is described in EP-A 0110591 and comprises a main drive shaft driven by a motor, folding instrumentalities 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 to be folded through the operating locality, operator-controlled feed speed variation means for varying the speed of rotation of the main drive shaft, and feed length variation means for varying the distance through which a workpiece is fed by the workpiece feeding means for each rotation of the main drive shaft.

In said machine the motor by which the main drive shaft is driven incorporates an integral clutch-and-brake arrangement together with an electronic control, whereby the output speed of the motor can be accurately controlled, and the operation of the motor is under the control of the operator via a foot treadle connected to the motor, and more specifically to the electronic control arrangement therefor, by a mechanical linkage. Apart from the fact that such a motor arrangement is relatively expensive, in addition the degree of control of the speed of rotation of the main drive shaft is not especially high, in so far such control relies solely upon the manipulation of the foot treadle. For example, in the case of an inexperienced operator wishing to operate the machine at less than full speed, such operator has to control the reduced speed range using only that amount of travel of the foot treadle to which the desired speed range relates, so that in effect the control of the rotational speed becomes more coarse over the reduced speed range than is the case where the more experienced operator is using the full speed range. Clearly, therefore, the speed control arrangement in this case acts against the inexperienced operator when it would be preferable for the speed control arrangement to accommodate the learning cycle. Again, in other circumstances it may be desirable to operate the machine at a constant feed in circumstances where, because of the size of the workpiece, the operator is unable to actuate the foot treadle, but clearly the feed speed (and thus the rotational speed of the main drive shaft) will have to be set appropriately to the workpiece and will certainly not always be the maximum feed speed of the machine. To cater for such circumstances, therefore, a higher degree of control of the rotational speed of the main drive shaft is again desirable.

It is thus the object of the invention to provide an improved folding machine in which a higher degree of control of the speed of rotation of the main drive shaft is achieved without additional expenditure on the speed control arrangement, but preferable rather with a cost reduction in this regard.

The invention thus provides, in one of its several aspects, a folding machine comprising a main drive shaft driver by a motor, folding instrumentalities 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 to be folded through the operating locality, and operator-controlled feed speed variation means for varying the speed of rotation of the main drive shaft, feed length variation means is provided for varying the distance through which a workpiece is fed by the workpiece feeding means for each rotation of the main drive shaft, characterised in that computer control means is provided by which a drive signal is supplied to the motor for the main drive shaft, and in that the feed speed variation means comprises a transducer which supplies a signal to the computer control means, the value of said signal being varied according to the setting of the transducer under the control of the operator, the arrangement being such that the drive signal to the motor, and thus the speed of rotation of the main drive shaft, is dependent upon the value of the signal supplied by the transducer.

It will thus be appreciated that in the machine in accordance with the invention the speed of rotation of the main drive shaft is now controlled by the computer control means, thereby providing the facility not only for greater speed control, as will be discussed in greater detail hereinafter, but also enabling the speed control arrangement to be integrated into the main control system of the machine. At the same time, by replacing the clutch-and-brake arrangement of the earlier machine with a simple transducer, which can of course be incorporated within the foot treadle, a simpler and less expensive operator-actuatable control is achieved.

In the machine in accordance with the invention, conveniently the motor utilised is an a.c. induction motor, which is relatively inexpensive to purchase and to maintain, together with an inverter which receives a control signal from the computer control means and in response thereto drives the motor. As is conventional with such arrangements, the signal supplied to the inverter will be a voltage, and in response the inverter, which is supplied with an a.c. supply from which it first creates a smoothed d.c. supply, converts the latter to an a.c. supply for the motor, the frequency of which is determined according to the value of the control signal received from the computer control means.

One advantage of utilising the computer control means to control the speed of rotation of the main drive shaft is that the possibility of a feedback arises and preferably in accordance with the invention monitoring means is provided whereby the speed of rotation of the main drive shaft is monitored, and more particularly the drive signal supplied to the motor for the drive shaft by the computer control means is modified by the latter means if and to the extent that the actual speed of rotation as monitored does not match the notional speed which corresponds to the particular setting of the transducer, such modification being such as to effect matching of said actual speed with said notional speed.

It will of course be appreciated that the invention is also applicable to so-called thermo-cementing and folding machines, more particularly of the aforementioned type comprising also adhesive supply means, including a gear pump driven by an n.c. motor, for supplying adhesive to portions of a workpiece to be folded as it is fed through the operating locality of the machine by the workpiece feeding means. In accordance with the invention, furthermore, in such a machine the computer control means also causes a drive signal to be supplied to the n.c. motor of the adhesive supply means, which signal is dependent upon the speed of rotation of the main drive shaft and operational state of the feed length variation means.

For facilitating control of the workpiece feed, furthermore speed range variation means may be provided whereby the speed range, within which the speed of rotation of the main drive shaft can be varied under the control of the operator as aforesaid, can be varied, the variation being proportional in respect of any setting of the feed speed variation means such that for a given such setting the speed of rotation of the main drive shaft will vary in accordance with the proportion set by the speed range variation means. Such a machine, it will be appreciated, thus enables not only the maximum operational speed of the machine to be pre-set, which can in itself be advantageous, but further, by proportionally varying all the speeds within the selected speed range, enables the selected speed range to be controlled in response to the whole of the allowed travel of the feed speed variation means, so that the degree of control afforded by the foot treadle or the like is not rendered coarser by reason of a reduction in the maximum operational speed.

This aspect of the present invention is especially advantageous where computer control means is provided by which a drive signal is supplied to the motor for the main drive shaft and also the feed speed variation means comprises a transducer which supplies a signal to the computer control means, as described above, the arrangement in such case being that the value of said signal is varied according to the setting of the transducer under the control of the operator and further varied in accordance with the proportion set by the speed range variation means, such that the drive signal to the motor and thus the speed of rotation of the main drive shaft is dependent upon the value of the signal supplied by the transducer but varied as aforesaid.

In such a machine, furthermore, conveniently setting means is provided for setting a maximum speed range within which the speed of rotation of the main drive shaft can be varied by the feed speed variation means, the speed range variation means being effective in such a case to select a speed range which represents a proportion of the thus set maximum. In a preferred embodiment the setting means forms part of the computer control means and is used to ensure that the machine cannot be used at a maximum speed which is considered to be beyond the optimum for a folding operation to take place reliably and satisfactorily. It is generally considered that an optimum maximum operational speed is in the order of 2,400 rpm.

As in the case of the machine described in EP-A 0110591, preferably in the machine in accordance with the invention operator-actuatable means is also provided for setting the rate of adhesive supply. In the machine in accordance with the invention, furthermore, preferably said means is effective to supply a signal, the value of which varies according to the selected setting, to the computer control means which in turn supplies the drive signal to the n.c. motor for the gear pump, the value of said drive signal being dependent also upon the value of the signal supplied by the adhesive supply rate setting means. In this way, therefore, the drive signal to the n.c. motor can be varied not only according to the feed speed, as detected by the monitoring of the main drive shaft rotation, but also proportionally with the value of the signal applied by the adhesive supply rate setting means, so that an even deposition of adhesive can be achieved regardless of the feed speed and the rate of adhesive supply required.

In the machine in accordance with the invention, furthermore, conveniently feed length variation means is provided for varying the distance through which a workpiece is fed by the workpiece feeding means for each rotation of the main drive shaft together with operator-actuatable means whereby a plurality of pre-settings can be made for the feed length for selection according to the contour of the workpiece edge to be folded, the arrangement being such that the feed length variation means is effective to set the feed length in accordance with a selected one of such settings upon receipt of an appropriate signal from the computer control means. This feature was of course provided in the machine described in EP-A 0110591, but in that machine the control was mechanical, whereas preferably in the machine in accordance with the invention the control is by an n.c. motor operable under the control of the computer control means. Moreover, in the machine in accordance with the invention a variation of the feed length in the aforementioned manner is effective to cause the rate of adhesive supply to be varied, the arrangement being such that one of the pre-set feed lengths is used as a standard and selection thereof is ineffective to vary the rate of adhesive supply as set by the operator-actuatable adhesive supply rate setting means, but the selection of another of the presettings is effective to cause said rate to be varied, such variation being proportional to the difference between the standard and the selected pre-set feed lengths. In practice, furthermore, preferably the "standard" pre-set feed length is the feed length which is used when a straight portion (i.e. a portion without significant edge curvature) of the workpiece is being processed, while the other pre-set feed lengths are introduced when portions of significant curvature, usually referred to as "outside" or "inside" corners of the workpiece, are being treated. By an "outside" corner, where referred to herein, 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 refers to an edge portion of curvature the centre of which lies outside the main 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 onto 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 and it is necessary often to "snip" the folded edge in order to distribute it evenly.

As in the machine disclosed in EP-A 0110591 preferably the workpiece detecting devices are disposed at or adjacent the operating locality of the machine and serve to detect the presence of a workpiece and also the approach of both "outside" and "inside" corners (as hereinbefore defined) to the operating locality as the workpiece is being fed therethrough, the arrangement being such that detection of an approaching corner serves to cause an appropriate one of the pre-set feed lengths to be selected while the "workpiece present" detecting device causes the supply of adhesive to be initiated when the presence of a workpiece is detected thereby. Moreover, in the machine in accordance with the invention conveniently operator-actuatable means is provided for disabling the feed speed variation means and for enabling the "workpiece present" detecting device to initiate also operation of the workpiece feeding means when the presence of a workpiece is detected thereby. In such a case the speed of rotation of the main drive shaft is set at the maximum within the selected speed range and the various pre-set feed lengths are selected according to the contour of the workpiece edge as detected by the detecting devices. In this way, it will be appreciated, the operator can control the operation of the machine without accessing the transducer, it being of course desirable that the maximum feed speed as set is appropriate to the edge contour of the workpiece being operated upon.

It will thus be appreciated that, in using the machine in accordance with the invention, a greater degree of control over not only the feed speed (or speed of rotation of the main drive shaft) is obtained but also a greater control over the adhesive supply and other operating functions of the machine.

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 thermocementing 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. 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 supplies corresponding control signals, also in the form of a voltage,to 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 transducer T (Figure 2). In addition, a second treadle (also not shown) is provided by means of which, by selectively depressing respectively the toeward and heelward portions thereof, two switches S6, S7 can be actuated under operator control. Again as will 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-aft for each revolution of the main drive shaft (hereinafter referred to as the "feed length") is varied thus to effect pleating of the folded 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 or device is thus capable of selecting a feed length in a range 0 to 9. The first selector device SS1 is utilised to set the feed length for "normal" 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 can be set up for each operation of the machine, but a further selector device SS4 is also provided on the control panel. This further device incorporates a twin digital display and serves to enable a double-digit style number to be allocated to each combination of feed lengths selected, the style number providing access, via the computer control means, to a memory in which information relating to the feed lengths is stored at an address accessed by the style number.

The machine has a "mains on/off" switch S1, a "motor on/off" S2, a "work lamp on/off" switch S3 and so-called knee-switch 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:

Switch S8, by which the second treadle is enabled/disabled:

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:

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;

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.

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;

Device SS7, by which, as will be described in detail hereinafter, the range of speeds over which the machine will operate up to a pre-set maximum can be selected;

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.

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 first sensing means of the machine) by which the supply of adhesive is controlled, four emitters E3, E4, E5, E6 (constituting third sensing means of the machine) 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, and a further emitter E7 (constituting second 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 SM1, which drives the gear pump and also to stepper motor SM2, by which a feed length control lever is operated; this lever is displaceable under the action of the stepper motor, such displacement causing the feed length to be varied. (This arrangement is well known in folding machines.) 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 (electrically 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 data bus I/OB, each time a mains interrupt signal is 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 indicating 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, i.e. at the start of a 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 re-actuated 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 Fig. 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 48, 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 is checked for, as set by selector device SS9 and, in accordance with the current speed of rotation of the main drive shaft, as checked 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 Figures 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 SM2 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 SM2. 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 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) 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 space of station of main drive shaft from encoder
762 Calculate stepping rate 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 to be folded through the operating locality, and
operator-controlled feed speed variation means (T) for varying the speed of rotation of the main drive shaft,
characterised in that computer control means is provided by which a drive signal is supplied to the motor (M1) for the main drive shaft,
and in that the feed speed variation means (T) comprises a transducer (T) which supplies a signal to the computer control means, the value of said signal being varied according to the setting of the transducer under the control of the operator, the arrangement being such that the drive signal to the motor (M1), and thus the speed of rotation of the main drive shaft, is dependent upon the value of the signal supplied by the transducer (T).
2. Machine according to Claim 1 characterised in that the motor (M1) is an a.c. induction motor provided with an inverter (I) which receives the

drive signal from the computer control means and in response thereto the motor (M1).

3. Machine according to Claim 1 or Claim 2 wherein monitoring means (E) is provided whereby the speed of rotation of the main drive shaft is monitored, characterised in that the drive signal supplied to the motor (M1) for the drive shaft by the computer control means is modified by the monitoring means (E) if and to the extent that the actual speed of rotation as monitored does not match the notional speed which corresponds to the particular setting of the transducer (T), such modification being such as to effect matching of said actual speed with said notional speed.

4. Machine according to Claims 1, 2 or 3 characterised by speed range variation means (SS7) whereby the speed range, within which the speed of rotation of the main drive shaft can be varied under the control of the operator as aforesaid, can be varied, the variation being proportional in respect of any setting of the feed speed variation means such that for a given such setting the speed of rotation of the main drive shaft will vary in accordance with the proportion set by the speed range variation means.

5. Machine according to Claim 4 wherein a maximum speed is set for the output speed of the motor (M1) and thus for the rotation of the main drive shaft, characterised in that the speed range variation means is effective to select a speed range having a maximum which represents a proportion of the thus set maximum.

6. Machine according to any one of the preceding Claims wherein feed length variation means is provided for varying the distance through which a workpiece is fed by the workpiece feeding means for each rotation of the main drive shaft,
characterised in that the feed length variation means comprises an n.c. motor (SM1) operation of which is effective, in response to control signals supplied by the computer control means, to displace a feed length control lever whereby to cause the feed length to be varied, and in that the computer control means calculates the rate at which a feed length variation is to take place based upon the required displacement of said lever to achieve a desired feed length variation and also the speed of rotation of the main drive shaft.

7. Machine according to any one of Claims 1, 2, 3, 4, 5 and 6 further comprising
adhesive supply means (SM2, 22 to 28), including a gear pump (26) driven by an n.c. motor (SM2), for supplying adhesive to portions of a workpiece to be folded as it is fed through the operating locality by the workpiece feeding means, the computer control means supplying a drive signal to said n.c. motor (SM2) dependent upon the speed of rotation of the main drive shaft and the operational state of the feed speed variation means (-, SM1),
characterised in that said drive signal, and thus the rate of adhesive supply, is dependent upon the signal supplied to the computer control means by the transducer (T).

8. Machine according to Claim 4 comprising adhesive supply means (SM2, 22 to 28), including a gear pump (26) driven by an n.c. motor (SM2), for supplying adhesive to portions of a workpiece to be folded as it is fed through the operating locality by the workpiece feeding means, the computer control means supplying a drive signal to said n.c. motor (SM2) dependent upon the speed of rotation of the main drive shaft and the operational state of the feed speed variation means (-, SM1),
characterised in that said drive signal, and thus the rate of adhesive supply, is dependent upon the signal supplied to the computer control means but modified in accordance with the proportion set by the speed range variation means (T).

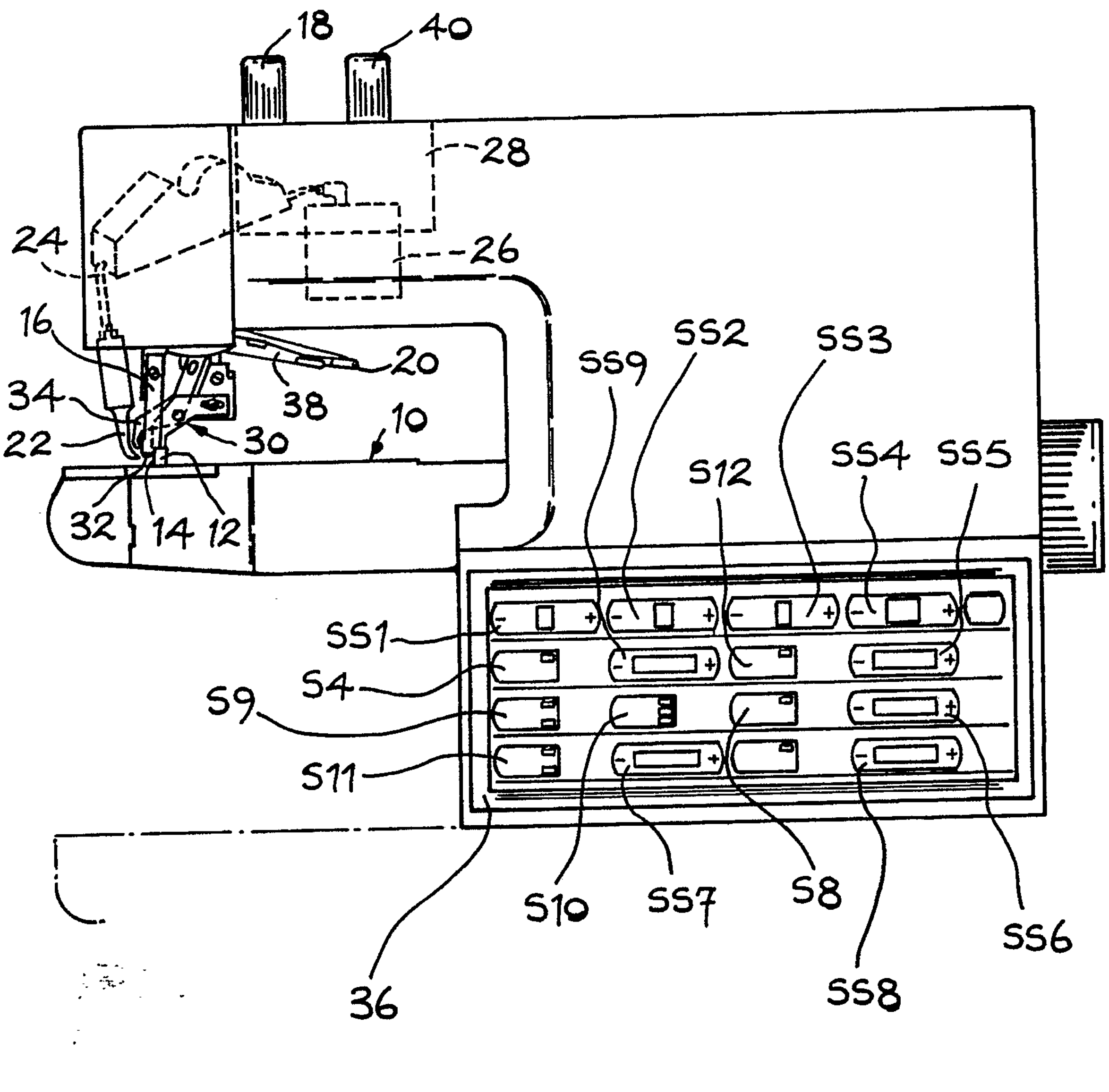
9. Machine according to any one of Claims 7 or 8 wherein operator-actuatable means (SS9) is provided for setting the rate of adhesive supply, characterised in that said means (SS9) is effective to supply a signal, the value of which varies according to the selected setting, to the computer control means which in turn supplies the drive signal to the n.c. motor (SM2) for the gear pump (26), the value of said drive signal being dependent also upon the value of the signal supplied by the adhesive supply rate setting means (SS9).

10. Machine according to Claim 9 wherein operator-actuatable means (SS1, SS2, SS3) is provided whereby a plurality of pre-settings can be made for the feed length for selection according to the contour of the workpiece edge to be folded, the arrangement being such that the feed length variation means (-, SM1) is effective to set the feed length in accordance with a selected one of such settings upon receipt of an appropriate signal from the computer control means,
characterised in that one of the pre-set feed lengths is used as a standard and selection thereof is ineffective to vary the rate of adhesive supply as set by the operator-actuatable adhesive supply rate setting means (SS9), but the selection of another of the pre-settings is effective to cause said rate to be varied, such variation being proportional to the difference between the standard and the selected pre-set feed lengths.

11. Machine according to Claim 10 when tied to Claim 5 wherein workpiece detecting devices (E1 to E7) are disposed at or adjacent the operating locality of the machine and serve to detect the presence of a workpiece and also the approach of both "outside" and "inside" corners (as hereinbefore defined) to the operating locality as the

workpiece is being fed therethrough, the arrangement being such that detection of an approaching corner serves to cause an appropriate one of the pre-set feed lengths to be selected while the "workpiece present" detecting device (E1, E2) causes the supply of adhesive to be initiated when the presence of a workpiece is detected thereby, characterised in that operator-actuatable means (S11) is provided for disabling the feed speed variation means(T) and for enabling the "workpiece present" detecting device(E1, E2) to initiate also operation of the workpiece feeding means when the presence of a workpiece is detected thereby, the speed of rotation of the main drive shaft being set at the maximum within the selectively set speed range and the various pre-set feed lengths being selected according to the contour of the workpiece edge as detected by the detecting devices (E3 to E7).

Fig_1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30
10
32
14
12
SS9
SS2
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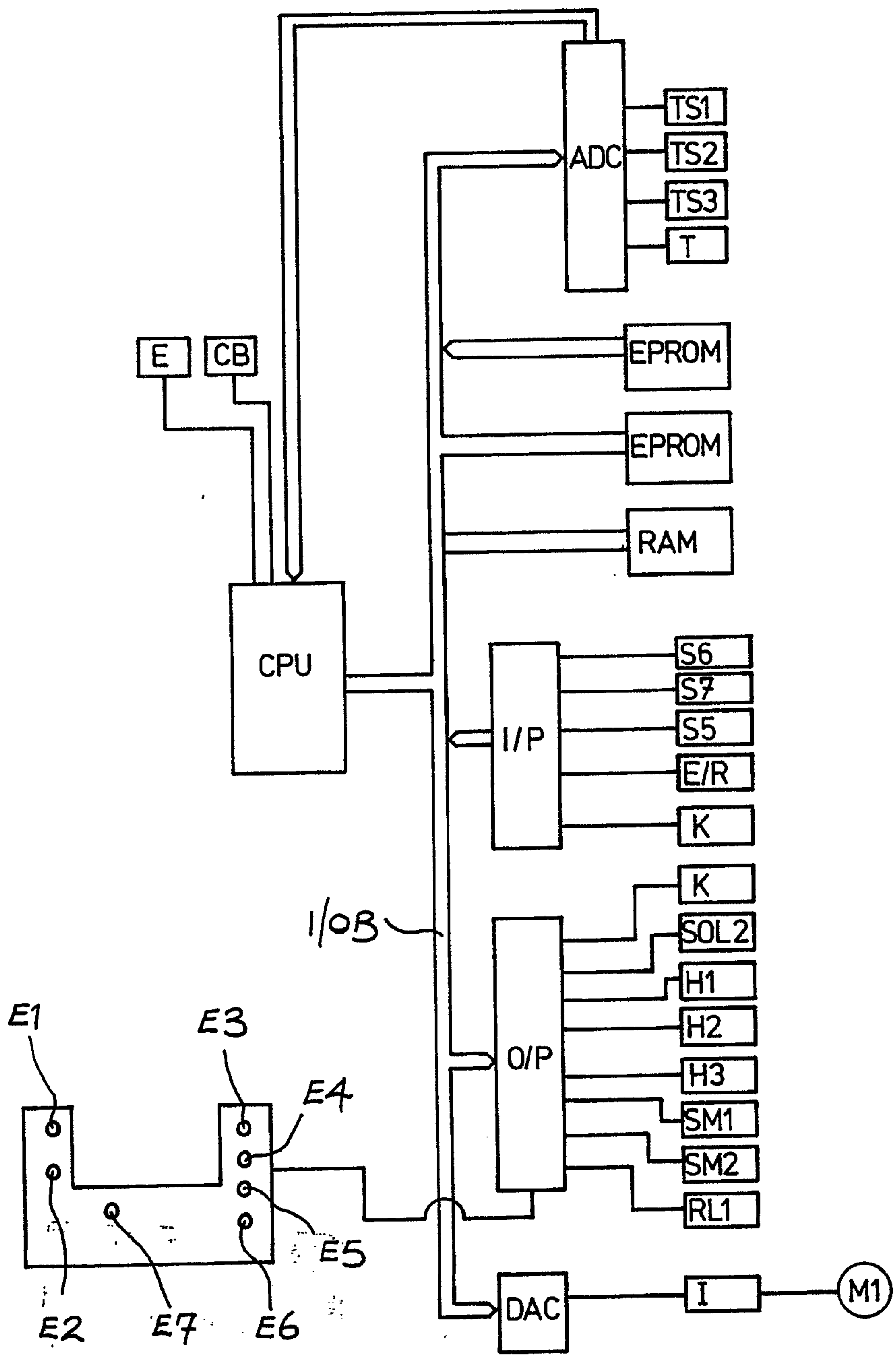
S8
SS6
36
SS8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K
SOL2
H1
H2
H3
SM1
SM2
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I/OB
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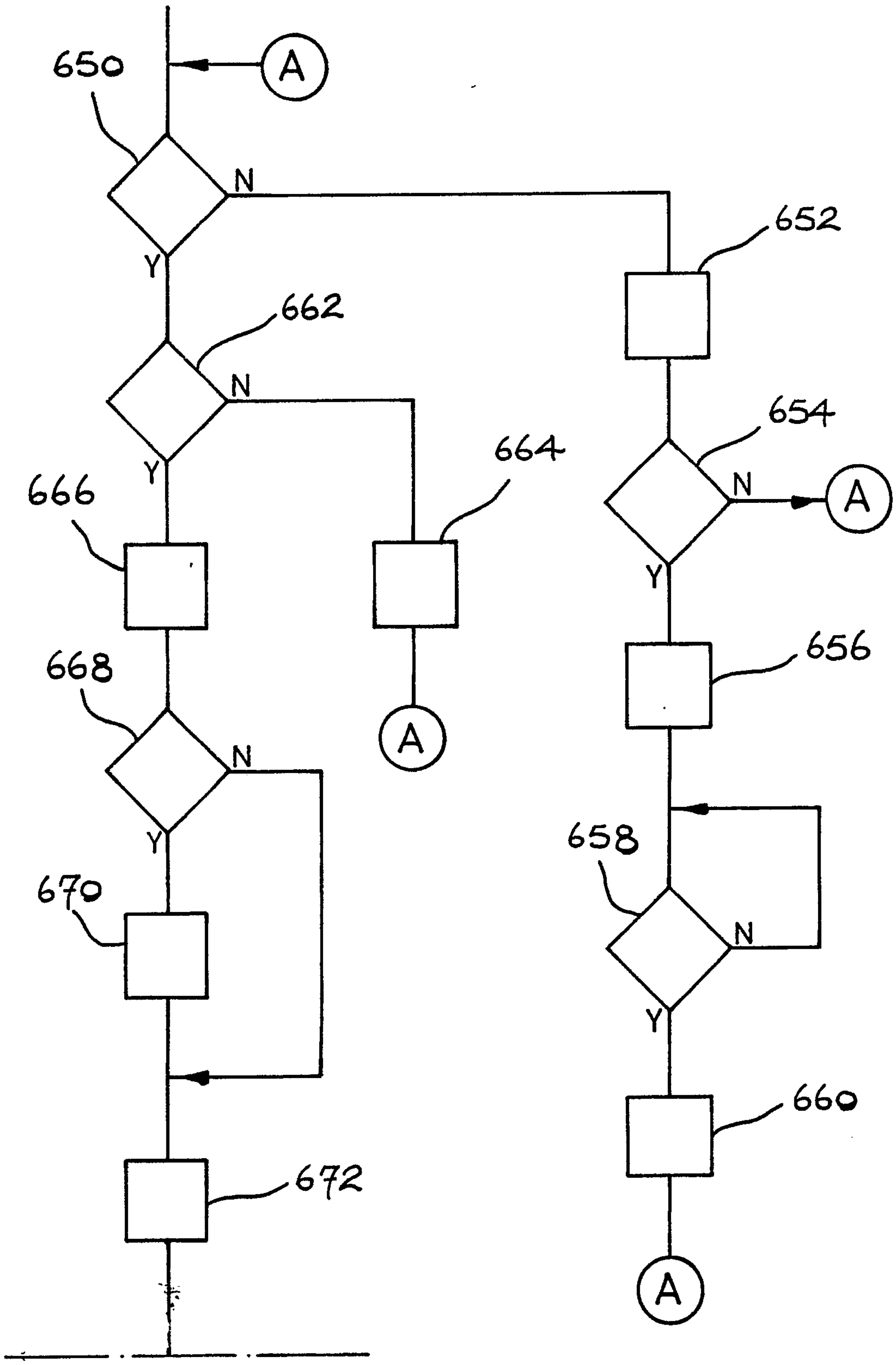
E3
E4
E5
E2
E7
E6
DAC
I
M1

Fig-2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672
660
A

Fig-3A

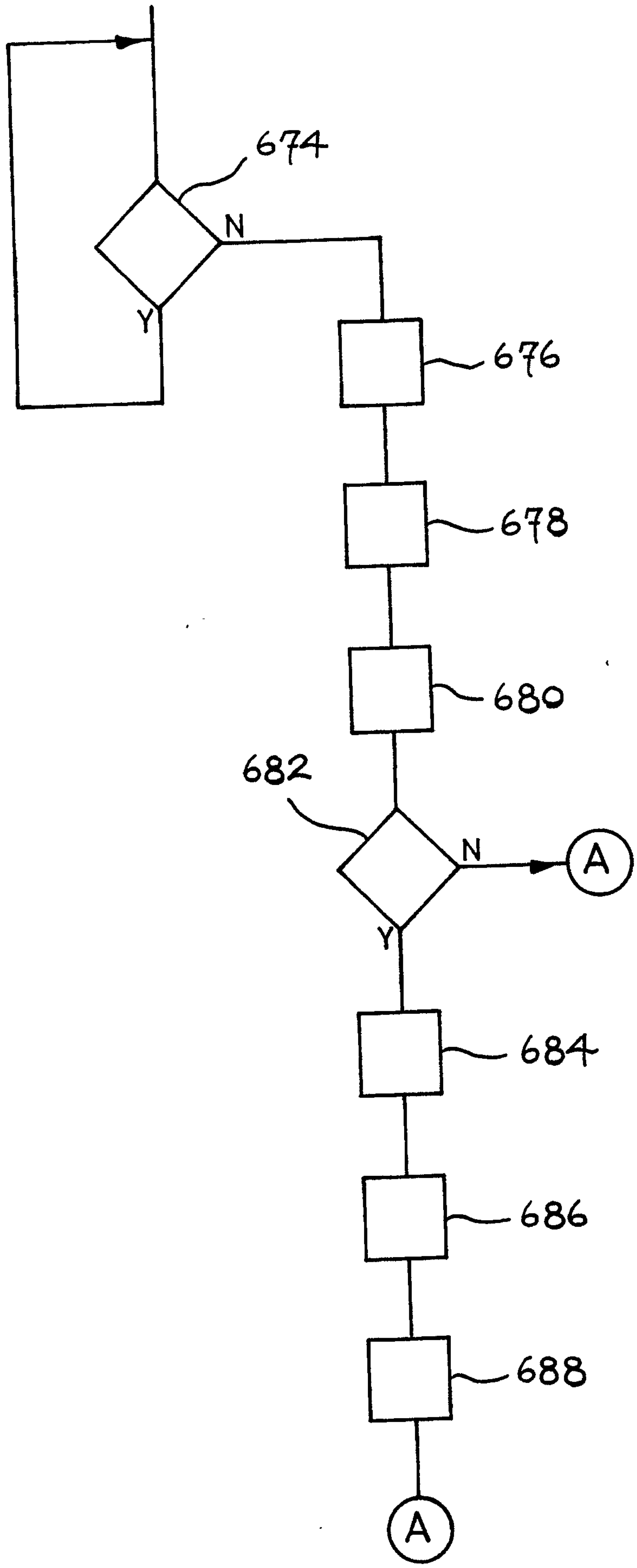

Fig-3B

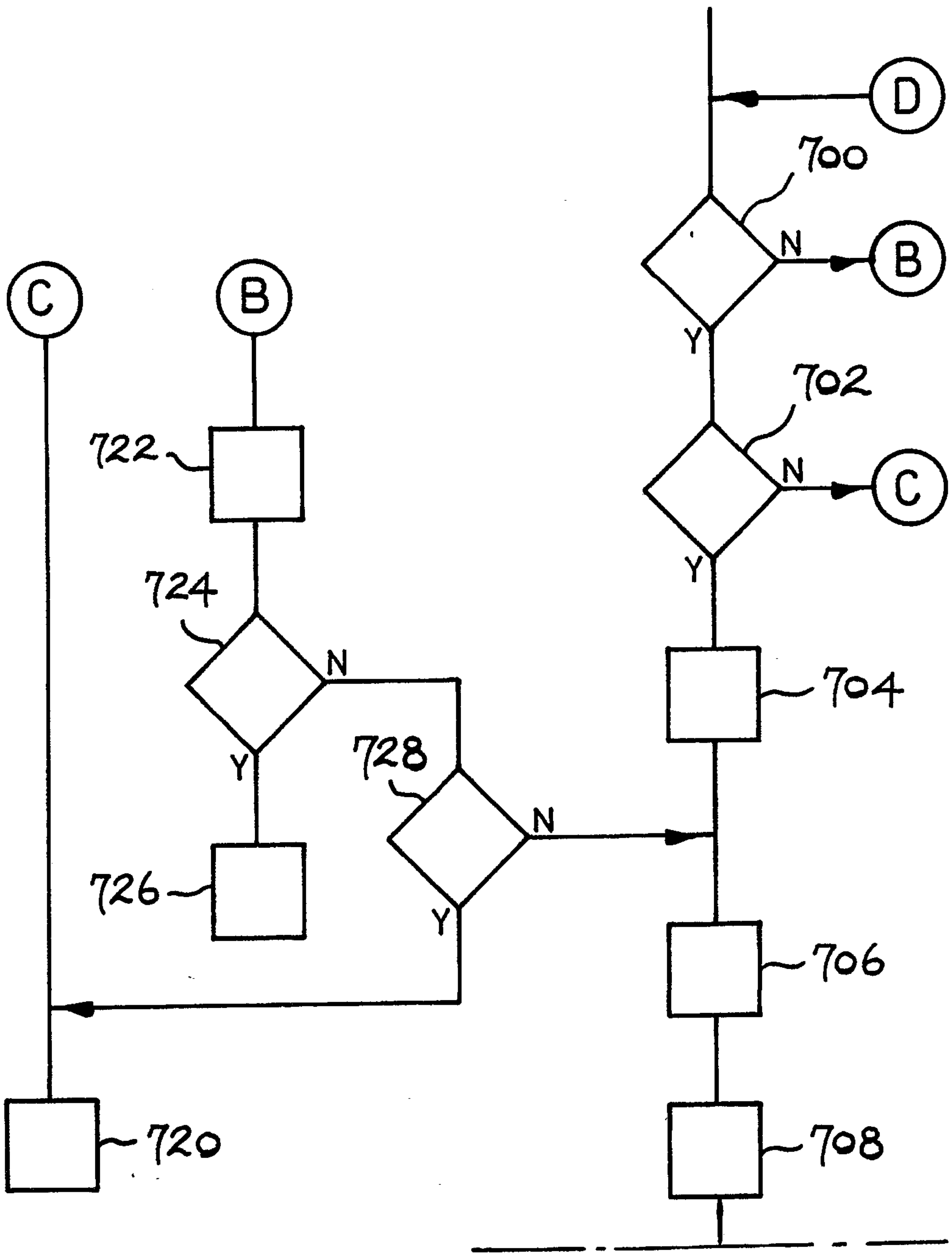

Fig. 4A

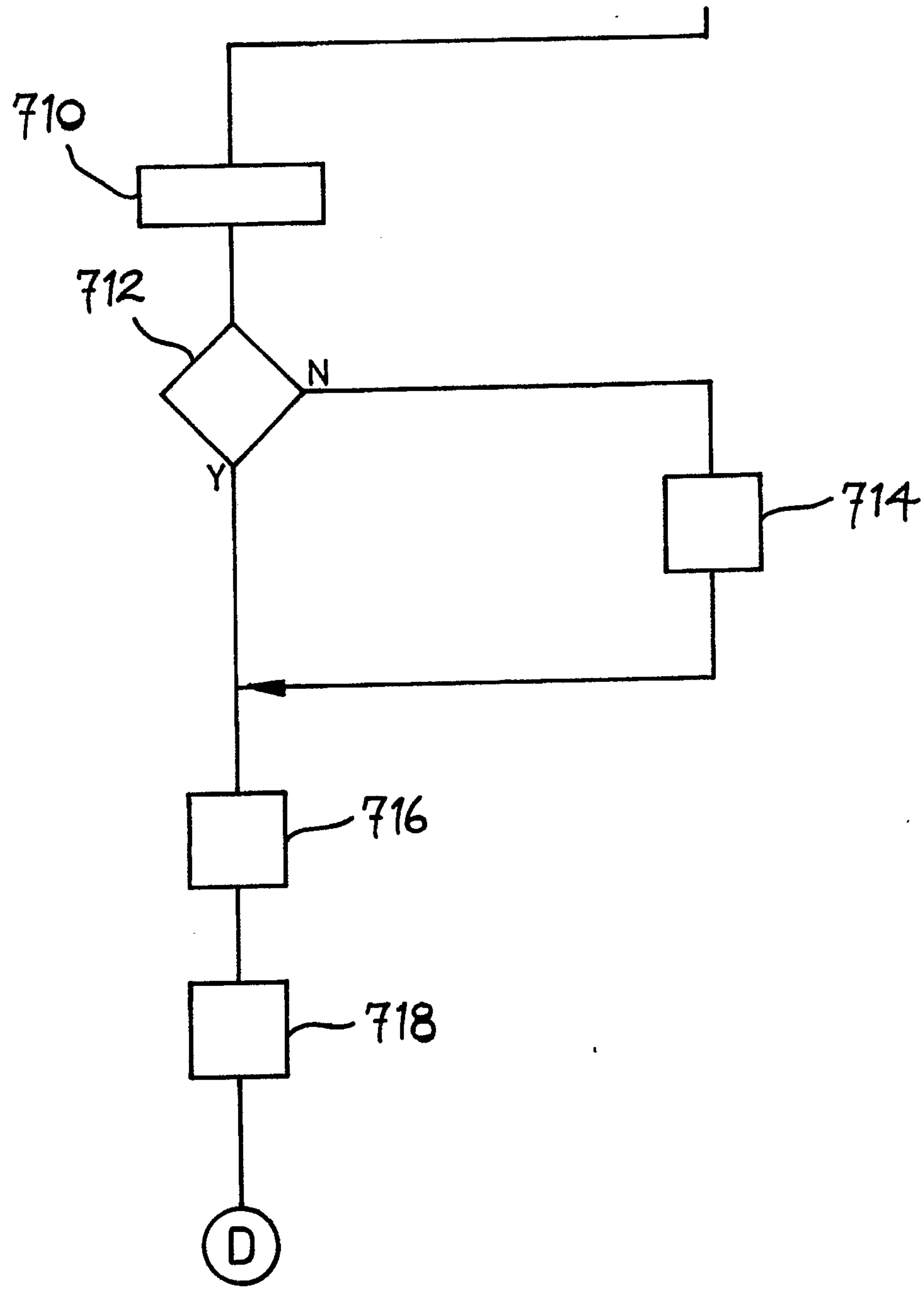

Fig-4B

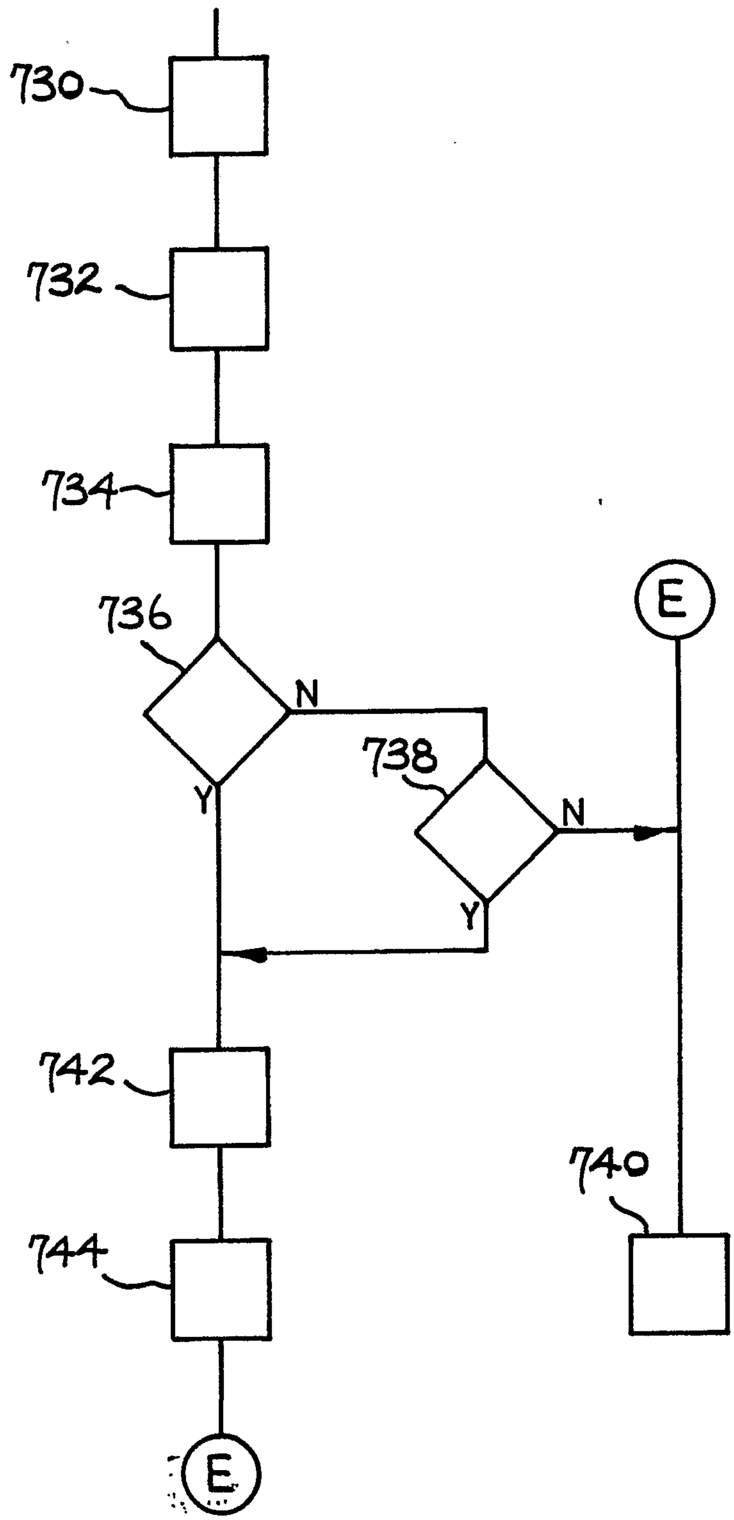

Fig_5

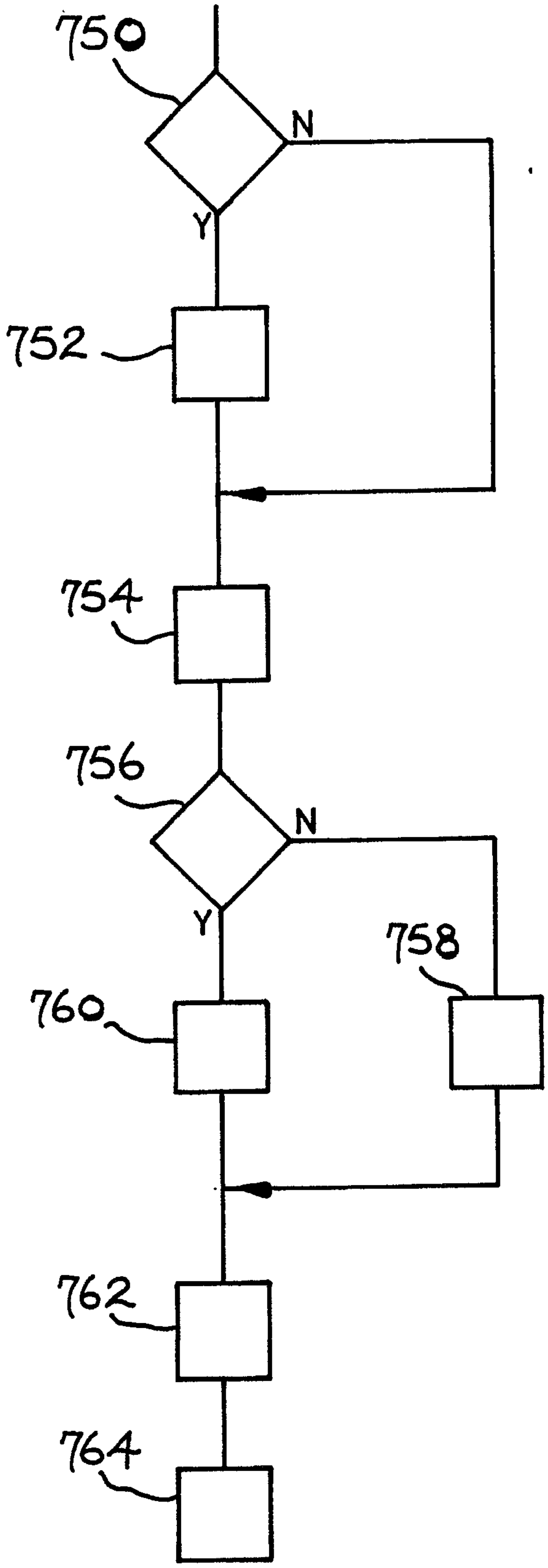

Fig. 6