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APPLICATION OF THYRISTORS IN MULTIPOINT MONITOR CONTROLLER

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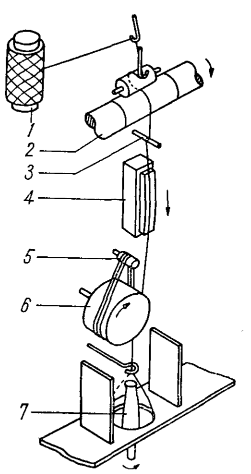
I. INTRODUCTION

Heat processing used in the synthetic fiber and plastics industries require temperature control at a large number of points. Since this control aims at maintaining the same temperature at all of these points, it is essential to have high reliability and accuracy as well as economy. Previously two types of equipment were used for this type of control; scanning control in the form of a multiplex system and an electronic regulator system for individual point control. For heater, in most cases, electric heaters are used. For temperature control, contact relays were used but recently the trend has been to eliminate contacts throughout the equipment and employ thyristors for higher reliability and accuracy.

II. OUTLINE

The multipoint monitor controller described here is used for controlling the temperature of heaters used for the heat processing of synthetic fibers. *Fig. 1* shows this heat processing, known as the drawing process. The aim of this heat processing is drawing and twisting of the fiber. The processing is performed by heaters which apply heat to very thin fibers of 50～100 denier travelling at speeds of about 30 m/min. The processing temperature is 200°C with an accuracy of ±1°C. Generally, one draw-twister processes 100～200 spindles of thread, and the same number of heaters as the number of spindles processed is needed. In one plant there are usually 40～60 such machines, and the control equipment must keep all of this large number of heaters at the same temperature. *Fig. 2* shows the twister. The temperature range in the region of the fiber yield point differs according to the type of fiber but is generally 100～250°C. The control accuracy required within this range is ±1°C. Disturbances such as fiber breaks, fiber run-through, cover opening, power fluctuations and room temperature changes are considered when determining the voltage operating range of the heaters so that all of these disturbances are absorbed within this range. The conditions essential for this control equipment are accuracy, reliability, ease of handling and maintenance, interchangeability, versatility within the temperature range, long service life and economy. An important point in temperature control is to coordinate the voltage operating capacity in respect to external disturbances, the heaters and the regulators. If these three things are not well coordinated during design of the equipment, good control can not be achieved.



1. Delivery bobbin
2. Delivery roll
3. Pin
4. Plate heater
5. Pin heater
6. Roll heater
7. Winding bobbin

Fig. 1 Drawing process

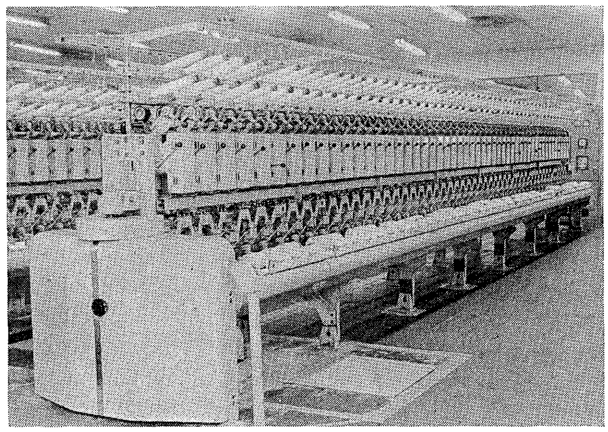


Fig. 2 Twister

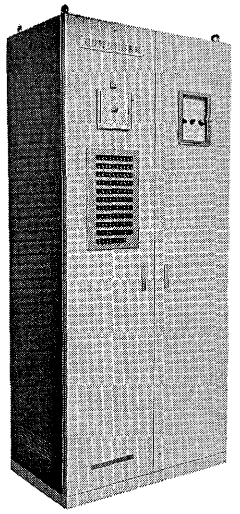


Fig. 3 External view of locker

III. TEMPERATURE CONTROL EQUIPMENT

1. Individual Control System

This system is known as ITOMATIC and one unit employs a common setting for all points in respect to several hundred heaters. With this system all the points are controlled at the same temperature. The controllers are of the plug-in type with one printed board per one controller and the entire system is solid-state. In addition to controlling the temperature at all the points, this equipment also serves to monitor any temperature irregularities. There are separate alarm lamps for each point which give warnings of temperature irregularities and a temperature indicator can also be usep for checking arbitrarily at any of the points.

The ITOMATIC consists of controllers (alarms) (printed board groups), setters, indicators, alarm lamps,

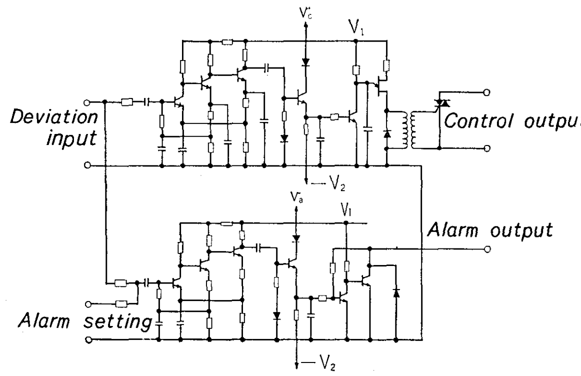


Fig. 5 Principle of control circuit

check circuit, power source and locker to accommodate all these components. Since the controllers are of the printed board plug-in type, the lockers can be much more compact than if usual controllers are used. An external view of the locker is shown in *Fig. 3*.

Fig. 4 is a systematic diagram of the ITOMATIC control system. Signals from the thermometers within each of the heaters are conducted to the respective controllers. The setter is used to establish the control values as well as the upper limit/lower limit alarm values, and is connected in common to all of the controllers. The measured values and the set values are compared, and any deviations are fed to the controllers. The controller operation is based on on/off operation with the output level of the thyristors or triacs. A control output is given in accordance with the input deviations and the heating circuits of the heaters are controlled by means of the thyristors. When required, control can performed in P control action using phase control. In addition to the control circuit, the printed boards also contain an independent alarm circuit. When the input deviation

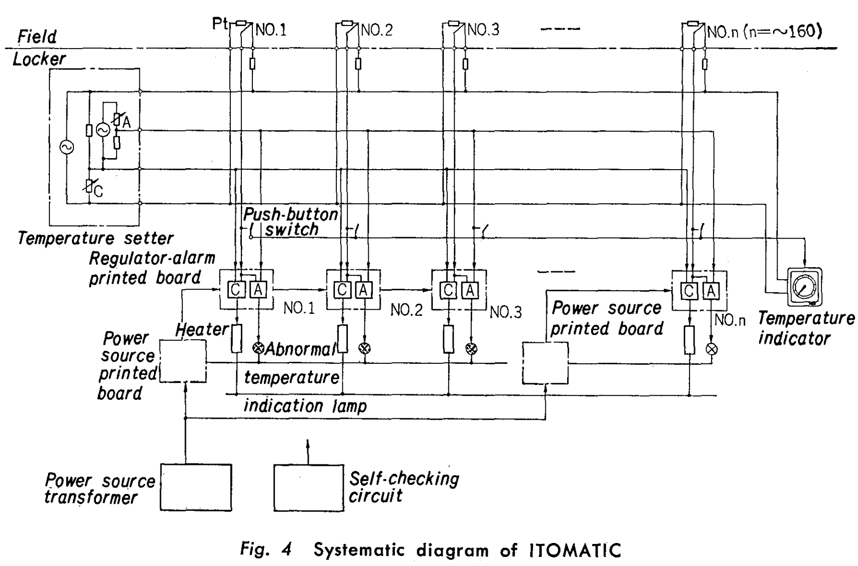


Fig. 4 Systematic diagram of ITOMATIC

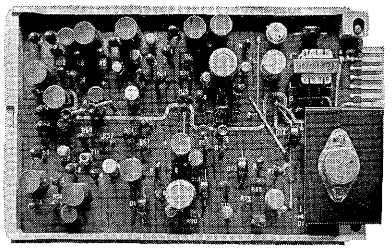


Fig. 6 Controller monitor printed board

exceeds the upper or lower limits of the set alarm temperature values, a temperature abnormality alarm is given by means of this extra circuit. This temperature abnormality signal causes the red alarm lamp for the point in question to be lit on the front surface of the locker.

Each measuring temperature can be selected arbitrarily among the points using push-button switches and indicated on a self-balancing type indicators. The push-button switches contain lamps and are arranged one for each point. Selective indication of abnormal points can be effected immediately with these arrangement. The power source serves to supply stablized power to each device and is constructed in the form of a unit. It supplies power to all the printed boards in common.

The check circuit is used to perform self-checking of all parts of the equipment. Detector abnormalities can be checked in the same way as temperature abnormalities and the results of these checks are indicated by lamps.

The principle of the control/alarm circuits is shown in *Fig. 5*. As is evident from this figure, the control circuit and the alarm circuit are completely insulated. These two circuits are fixed on one printed board, and they are equivalent (1 : 1) for each heater. The contro[circuit consists of a 3-stage ac amplifier, a synchronous rectifier and a thyristor circuit.

Referring to *Fig. 5*, the synchronous rectifier circuit output becomes negative when the input is in the same phase as the standard voltage. A gate pulse is generated by the UJT transistor in the final stage and the thyristor is turned " on ". On the contrary, the deviation input and v_c are antiphase, the output of the synchronous rectifier circuit becomes positive and the thyristor is switched " off ". Up to the synchronized rectifier circuit, the alarm circuit is exactly the same as the control circuit. After the rectifier circuit, there is a switching circuit and the final stage transistor is used to flash the warning indication lamp. In the alarm circuit, operation is switched alternatively as the upper and lower limit circuits every 2 seconds by means of an upper/lower limit switching device which employs a thyristor oscillating circuit.

The control/alarm circuit printed board is shown in *Fig. 6*. In this photo, the control output thyristors are affixed to the printed board. In large current capacity, these thyristors are arranged separately.

Groups of these printed boards are inserted in the locker. The number of control points can be freely increased or decreased and the equipment is functionally interchangeable. The number of boards each locker can accomodated is standardized so that one locker can be used for up to 160 points. One printed board shelf contains 20 printed control boards and one power source board to supply these controllers. The locker can accommodote a maximum of 8 shelf, 160 points. All superintendence, operation, detection and maintenance can be effected at the surface front only.

The locker front surface contains an indicator, setters, push-button switches, lamp monitors and operation devices in easy-to-see arrangement.

2. Scanning Control System

A systematic diagram of the scanner is shown in *Fig. 7*. One controller only is used in this multiple

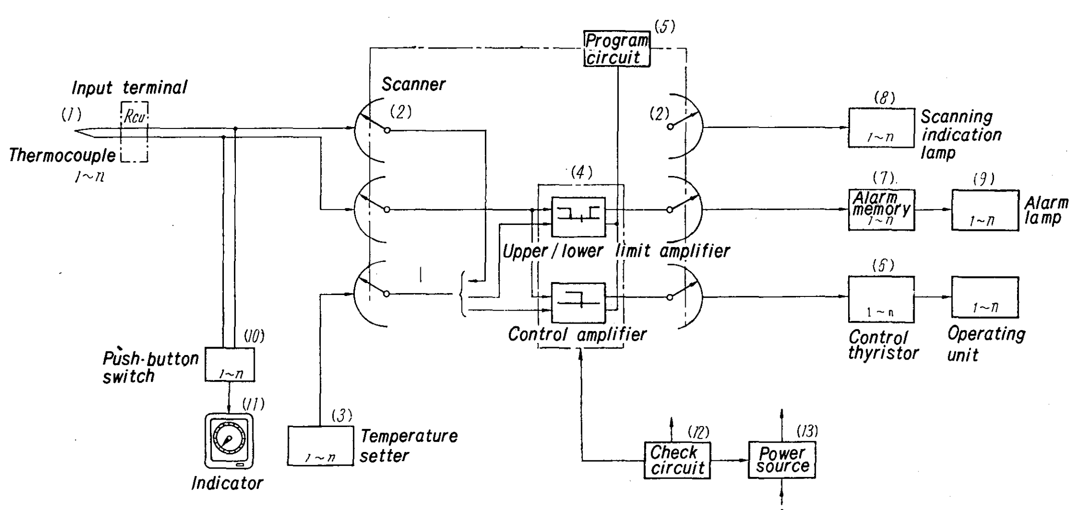


Fig. 7 Systematic diagram of scanner

scanning system. The detected temperature (1) is scanned by the selecting circuit (2) and connected to tne differential amplifier. The temperature setter (3) also is connected to the differential amlipfier (4). The measured and set temperatures are compared, and control and alarm output is generated in accordance with the magnitude and polarity of the deviation. There are separate differential amplifiers for control and alarm use, but the control amplifier has priority. If the control amplifier not functioning properly, the alarm amplifier is automatically switched to the control side and control continues as usual. In other words, the alarm amplifier also serves as a reverse control amplifier. The temperature setter generates a voltage (mv) which corresponds to the alarm temperature and control temperature for each point. By connecting the output and input of the differential amplifier, control and alarm output is sent to the exterior according to the following sequence : selection of scanner measured value→amplifier operation→amplifier output read-out. Control of this switching timing and of scanner switching are both carried out by program circuit (5). The control and alarm output from the amplifiers passes through scanning circuit (2) on the output side and is fed into the control relay (thyristor) and alarm memory (7), causing both of these circuits to commence operation. This operation continues during a scanning period and is further maintained or reset depending on the process state at the subsequent scanning. The control relay performs two position control of the heaters in accordance with the control output. The alarm memory indicates temperature abnormalities in accordance with the alarm output via alarm lamp (9). The scanning point is indicated via lamp (8). Indication of the measured temperature at the each points can be selected freely using push button switch (10) and a self-balancing type temperature indicator (11). There is one push button switch, one scanning point indication lamp and one alarm indication lamp for each point and all of these are arranged in an easy-to-see manner.

The operation of these devices is checked under normal condtions by a self check circuit. The power source unit is intended to supply stabilized power to all parts of the equipment, and an ac power source and a dc stabilizing power unit are included. All of the above equipment are accommodated in a single locker.

IV. HEATER POWER SUPPLY EQUIPMENT AND OPERATING UNITS

The heater power supply and the heater temperature operating units are the same in both the individual point control system and the scanning control system. A connection diagram for these two devices is shown in *Fig. 8*.

The heater power supply equipment is intended to supply power to the heaters, and the most suitable type of equipment must be selected in accordance with the heater characteristics and the magnitude of external disturbances. There are two types of power supply possible for the heaters : complete on/off control action and two-position control action which

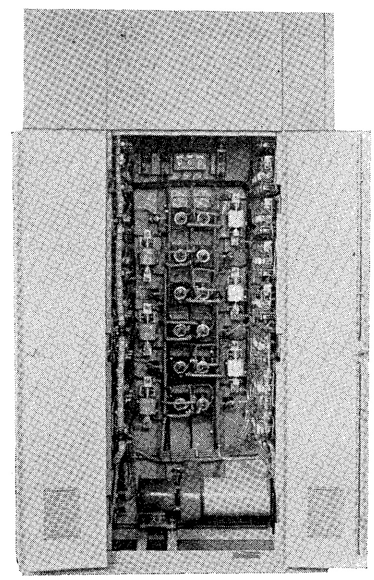


Fig. 8 Inside of thyristor cubicle

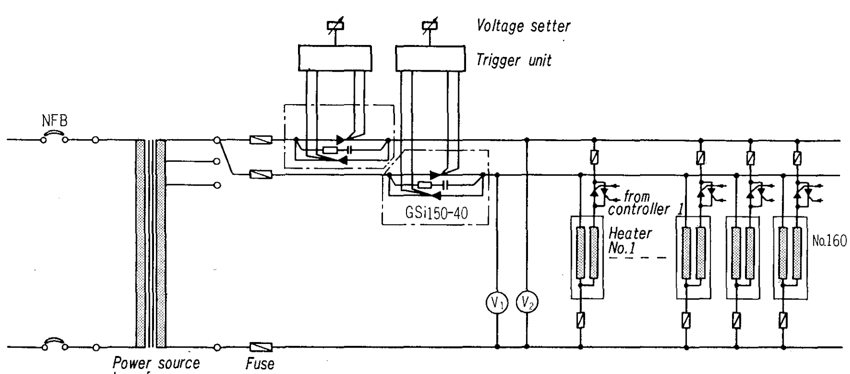


Fig. 9 Heater power supply and control diagram

allows for selection between high tension and low tension. Both of these types require fine selection of the voltage in the required range from the source transformer. For voltage selection, the most suitable method is one by which the set temperature can be obtained by operation midway between the two control points so that the heater temperature is not offset. In *Fig. 8*, the heater contains a base winding and a control winding. The base voltage is adjusted in accordance with the set temperature, denier, fiber speed, and the control voltage is adjusted in accordance with the magnitude of the disturbance. As to the voltage adjustment, the thyristor is inserted in the line and phase control in which the firing phase is altered by means of the voltage setter is carried out. The voltage setter is in the form of a trigger unit containing a UJT and a pulse transformer. Sometimes the voltage setter is arranged together with the operation of the temperature setter. The heater operating unit is operated by means of thyristors which are placed in the heater control winding. These thyristors are driven by the output from the temperature controller. The controller output is in the form of a 3 kHz trigger pulse. During on/off control, simple switching of the elements is carried out. During P control action, P control action effects phase angle control by means of the controller output trigger firing angle which varies in accordance with the temperature deviation. These thyristors are contained on a printed board as shown in *Fig. 6* when the equipment capacity is small. When the capacity is large, they are arranged separately. When scanning control is used, a flip-flop memory circuit is provided since thyristor conduction must be self held. The interior of a cubicle containing the voltage adjustment thyristors and heater drive thyristors is shown in *Fig. 9*.

V. CONCLUSION

In the last ten years, more than 200 sets of the equipment described in this article have been delivered. In this period, thyristors made their debut and this equipment is gradually switching to thyristors. The voltage regulators can perform continuous regulation of large power values using only a little power themselves. In this way, it has been possible to eliminate tap-changers, simplify transformers, cut down on panel space and decrease the amount of wiring required considerably. In the temperature controllers, the use of thyristors has made phase control by means of P control action possible. All of the contact relays used for heater control can be made contactless and the temperature control equipment can be completely changed to solid state. It is significant for this temperature controller to make all solid-state. This is especially desirable in temperature regulation where relay operation is very frequent and contactless relays therefore have a much longer service life.

On the alarm circuit in the temperature controller, two alarm checking operations—upper limit and lower limit—are carried out by switching an amplifier at 2 second intervals. This switching is also effected by means of thyristors.