There is a restoration constant which will stabilize the no load opening critically after the closure of the guide vanes. But from the viewpoint of stabilized time, speed rise and pressure rise, adjustment to overshoot the guide opening a little will give better results. The overshoot to this extent is not found giving any troubles.

The results of the load interruption tests show, as in Fig. 22, an appropriate value for each load, and aslo indicate a considerable improvement compared with the conventional mechanical governor.

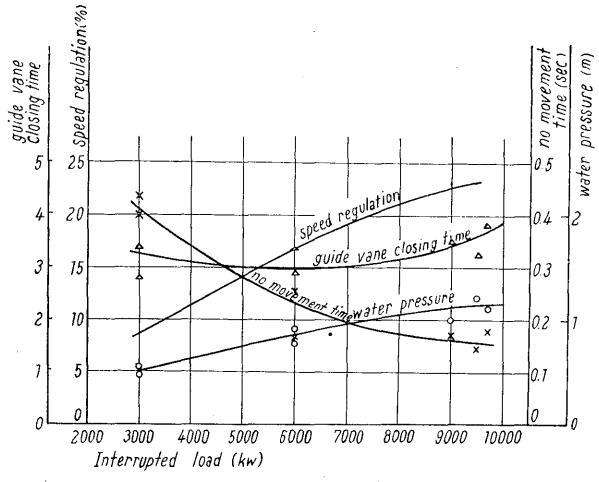

Fig. 22. Test record of electric speed governor

There are difference in the head when the tests were conducted on the electrical governor and mechanical one.

9.6 m at the test electrical governor.

10.4 m at the test mechanical governor.

Furthermore in the case of the electric governor test, the auxiliary servo was throttled, the main pressure distribution valve sping and its lap were given some reconstruction, and it is too hasty to make a comparison. It is judged from the result of the full load interruption, the guide vane no-movement time is reduced by 50%, the stable time by 40%, the speed rise rate by 30% and the pressure rise rate 20%.

Since the tests were conducted by making use of on off-hour of commercial operation with one generator, it was impossible to have tests on the electrical and mechanical device under the same condition, the numerical values given above were only mentioned for reference.

4. Investigation on frequency deviation and guide vane response

The tests were conducted by putting power of about 2,500 MVA in Kansai and Hokuriku power systems and by taking the adjustment rate of 3%. The response is very reliable.

It is also learnt that the response is made to frequency variation of below 0.02 %.

VIII CONCLUSION

The principle of elec. speed governor and its construction is roughly explained. As to the performance of the speed governor, the test data described below many be of some reference.

No. 1 machine is equipped on the Kaplan turbine of JINTSU RIVER No. 3 power station of the HOKURIKU ELEC. CO. (11,000 kVA) and the performance test was made at the station. This is now running satisfactorily. The elec. speed governors for TOCHIO power station of the HOKURIKU ELEC. Co. (17,000kVA Pelton wheel), for MOTOSU station of the NIPPON LIGHT METAL CO. (12,800 kVA Pelton wheel) are under manufacture.

VARIOUS PROBLEMS ON AUTOMATION

By

Tsuneo Oura

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I INTRODUCTION

Hitherto equipment in various industries has been operated by the judgement and hands of men. Without any instruments to guide them in operation, the entire equipment was watched over and operated by only the feel and experience of these men. Consequently, there have been many factories where if skilled operators were lost, would at once fall into difficulty. In order to eliminate this situation, indicating meters were at first used to indicate the necessary quantities and act as a guide in the manual operation. The next step was in the direction of using a recorder which would record the operating condition of equipment to be used as reference data in investigations at some later date. Finally, not stopping at merely indicating and recording of various quantities with instruments, these measured values were utilized to maintain certain quantities at a constant value or to change them with time accord-

ing to some fixed program, or to maintain a constant ratio of two quantities, in other words, the utilization of automatic control system.

In this way, a certain quantity is detected and an action to maintain automatically this quantity or its relative quantity or relation between a number of quantities in a planned condition is called the feed-back control and comprises a closed loop formed by detection, regulation and operation for the system to be controlled. There is also a separately installed portion with auxiliary power applied from outside the loop. Besides this method, there is one in which the detection of any quantity is not made but by closing a control switch, time relays and limit switches is made to operate causing a series of actions to take place in a fixed order. This method is called a sequence control. Automation is considered as the two methods of automatic control mentioned above combined into one system.

In short, automation gives machines and equipment a power to make judgement and based upon this judgement the operation is carried out automatically and continuously. In the feed-back control system, the detector corresponds to the eyes, the regulator to the brain, the operating portion to the hands and feet of man and the wires and pipes which connect these devices may be considered as the nerve system. As long as the operation is dependent on man, there will be mishaps, mingling of feelings and also accompanied by fatigue, a phenomenon which cannot be avoided. Since there is a limit to a man's capacity for work, the amount of operation which can be accomplished in a factory is limited by this factor. This inconvenience is eliminated by adopting automation and will raise the quality of the product and lower the production costs.

In this paper, several problems mainly concerning feed-back control systems were chosen and explained followed by a short explanation on sequence control and finally on care which must be taken when inquiry or order is to be placed. The paper is concluded with the hope that further development in automation will take place.

Although the topics chosen are of ordinary nature and contain no new ideas ; however to keep abreast with the development in automation, it is hoped that this article may be of some assistance and guide to those who are planning to install automation systems.

II PLACE OF APPLICATION OF AUTOMATION

It is desirous that automation be planned from the beginning of plant construction and the recent tendency is in this direction ; but at present there are still quite a number of cases where automation is being adopted at the time repairs or improvements are made on existing installations.

It is a problem to determine which part of the manufacturing equipment should the automation be initially carried out. This may be solved by the following 2 points. The first is the automation of the part which occupies the most important stage in the production and will result in improving the quality of the product and at the same time capable of administering quality control. The second is the carrying out of automation on part which does not directly affect the quality of the product, but where the control is complicated on continuous regulation is required or locations where conditions are unsuitable for the workers to operate. By this application, raw materials and personnel expenses may be economized resulting in a large reduction in production costs and also effect cooperation with the phases of heat and labor management. In either case, if automation is adopted, it is a fact that economy will result. However, no matter how excellent one part of the installation is, it does not always mean that the entire installation is operating at a high efficiency. Therefore, if automation is carried out in one part of the installation, it becomes necessary to make improvements on the remainder of the installation to obtain balance. It is not wise to adopt the other countries' technique unmodified but must be thoroughly digested and convert it in such a way to suit our condition in all phases of capital, material, labor, etc. By the use of experience obtained in manual operation and information in practical examples received from other companies and after thorough study, automation of important part in the production should be planned and competing with other countries for something new by imitation should be refrained.

III SELECTION OF SYSTEM OF REGULATION

When the part for which the automation is to be applied has been decided, the question of what system to adopt arises. In the feed-back control, the three systems namely, oil pressure system, pneumatic system and electric system are widely used. However,

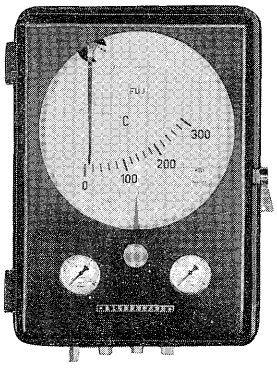

Fig. 1.
Pneumatic temperature regulator type PTAR

the oil pressure system is relatively expensive and also there is a problem of fire hazard and oil leakage and at present is utilized only in special cases. There seems to be only a few manufacturers of this system. The following is a simple description of principal methods of regulation.

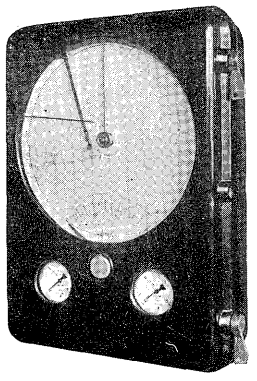

Fig. 2.
Pneumatic pressure regulator
type PDSR

1. Pneumatic system

Pneumatic system was developed in the United States and is becoming widely used in various industries in our country. This method is capable of effecting continuous control and since there is no electrical contact as in the electrical system to be explained later, fireproofness is not necessary. This point is in favor of this method ; however in some cases where remote control or temperature control is required, this method is inferior to that of electrical system. Control by pneumatic system is ordinarily accomplished by operating a diaphragm valve and if a strong operating power is required, a power cylinder is utilized. Although air is free, to minimize the cost of installation an air compressor and also to economize electric power, the consumption rate of air should be small. There are two types to this system namely, the bleed type in which the pilot valve is operated by a continuous supply of air and the non-bleed type in which the air is supplied only during operation. The latter type is advantageous because the air consumption is $\frac{1}{5}$ to $\frac{1}{6}$ of the former type ; however, the complicated structure of the valve is the shortcoming of this type. Fig. 1 illustrates a pneumatic indicating regulator and Fig. 2 a pneumatic recording regulator.

2. Electrical system

In the electrical system, oil supply system, air compressor, etc. are not necessary, only the electrical wiring being required from the power source. Moreover, remote control is easily accomplished. Since the detected quantity can be easily converted to electrical quantities such as electro-motive force, resistance, capacitance, etc., it is a simple matter to amplify this quantity and operate the regulator. A typical example of electrical type as illustrated in Fig. 3 is an on-off type regulator consisting of graduated scales as in a ordinary indicator and with the lower and upper fixed values as the boundaries, the contacts are opened or closed to make necessary controlling actions.

Operation in this method is intermittent and control is accomplished without regard to the amount of deviations, but the bridge type automatic regulator which has control plates moving up and down at

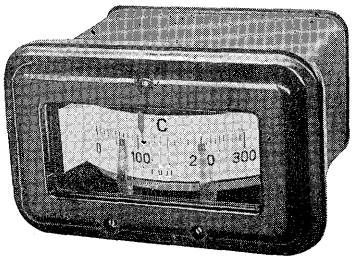

Fig. 3. NZ regulator

certain time intervals, changes the duration of control by changing, according to the amount of deviations, the time that needle is pressed by the control plates.

3. Electro-pneumatic system

Electro-pneumatic system consists of combined features of the electrical instrument and pneumatic regulator and utilizes the bridge zero potential method to obtain high degree of measuring sensitivity. It is a pneumatic PID operated continuous control capable of giving excellent performance and can be used for various purposes. This type is illustrated in Fig. 4. Moreover, if an indicator or recorder is required for this method, a pneumatic type automatic balance indicating regulator or recording regulator is recommended. In this method, detected quantity is led into an automatic balancing instrument through a vacuum tube amplifier and control is accomplished in exactly the same manner as in the peneumatic type. The outside appearance of this regulator is same as those shown in Fig. 1 and 2.

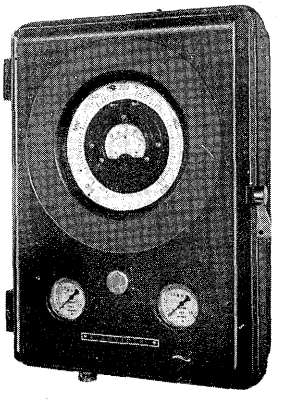

Fig. 4.
Electro-pneumatic regulator
type EPGR

4. Magnetic amplifier type

Next, there is the magnetic amplifier type which is beginning to be used and is becoming very popular. As an automatic voltage regulator and automatic speed regulator, this type is already in use and is gradually being applied in industries as an ordinary automatic regulating device. As compared with the type having moving parts, rotating parts or with those using electron tubes, the construction is very rugged and is a perfect static type. Besides the life of this instrument being permanent and not requiring any particular maintenance, various kinds of input can be freely mixed and can easily attain high precision automation. Fig. 5 shows one example of this type.

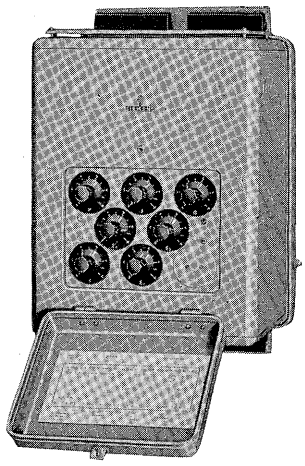

Fig. 5. Magnetic regulator

As explained above, since there are merits and demerits in every type, the selection of the type of instrument to employ should be made after making clear the purpose of automation and studying the adaptability of each type. Moreover, it is necessary to take into consideration the nature of the factory, experience of the person in charge, and the maker's recommendations. For instance, in the petroleum and its related industries, it is customary to select the pneumatic type, and usually the electric type for temperature control of electric furnace. In any case, the type to be used should be decided according to the purpose intended for in each case and it is impossible state positively what type is the best.

IV SOME EXAMPLES OF AUTOMATION (Problems of detecting parts)

In automation, quantities to be controlled are temperature, pressure, flow, level, weight, size, speed, density, viscosity, pH, thermal conductivity, transparency, relative humidity, voltage, current, electrical resistance, operating time, number of repeated actions, etc. and may be classified as those that measure energy, those that indicate quantity or composition of matters, and those that show electrical quantities. Any one of the principles used in measuring instruments can be applied to the detecting device of these quantities. In the ordinary use of measuring instruments, it is necessary to have the instruments indicate or record the detected quantity by the movement of the needle, but in automation, the wide range indication is not required and often only the variation in the quantity to be detected is necessary. In this way, there is only a small difference in the use for automation and very often a converter is attached to the indicator or recorder and then connected to the regulator. The detected quantity is usually converted into electro-motive force or impedance, and the recent trend is to convert it into air pressure. The special requirement demanded for the detector is that transmission time lag be made as small as possible as well as for accuracy. Next, a few examples of automation will be given together with problems concerning installation of detector.

1. Temperature control

For the electric furnace, the method used is the electric type " on-off " control by which the power source of heat element is opened or closed according to the temperature required or changes its connection to Y–△ and if the temperature is still too high to cut-off the source. In heating with gas, crude oil or steam, either the flow of these heating materials or that of the cooling water is controlled to maintain the temperature constant at a desired value. Instead of detecting the temperature and regulating the flow of the gas for heating, there is a method in which the flow is controlled to maintain the flow of the gas constant and in case the temperature changes due to gas pressure variation or other outside variations resulting in change in temperature, the fixed value of the amount of flow is made to change. This method is called the cascade control and has a high stability since it is capable of maintaining the temperature at a fixed value without waiting for the temperature to change.

In iron, chemical, chemical fiber, petroleum, cement and glass industries, temperature control is widely applied using measuring resistance element or thermocouple as temperature detecting device. The former is utilized for ranges of –200°C to 500°C and the latter from 400°C to 1400°C. They are placed inside protective tubes and inserted. The material, size and the method of setting of the protective tube must be determined according to the condition of the place where the tube is to be set. Temperature detector using a measuring resistance element has a certain length, thus at least a length equal to this must be inserted into the place where

the measurement is to be made. In case with a thermocouple, although the detecting part is a point, the protecting tube if made of non-metallic material, is inserted to the depth more than 10 times its diameter and more than 15 times if it is made of metallic material. This is done to minimize the error introduced in thermal conduction. To decrease the time lag, the thickness of the protection tube must be made as thin as the pressure and the structural strength will permit. When the length of insertion is quite deep, only the wall of the tube tip is sometimes made thin.

The insertion of the device exactly to the point, where detection of temperature is actually desired, is most important because if the point of insertion is not appropriate, valuable automation has no effect. There have been cases where resistance element was broken or protection tube damaged by vibration due to the installation of the measuring element inside a pipe in which there is a rapid flow or in a place adjacent to a compressor. Therefore special care must be taken when placing an order according to a plan for automation.

A radiation pyrometer is utilized in the remote detection of ceiling temperature of open hearth furnace or inside of a salking pit. The purpose of this type is to detect very high temperatures but lately is being applied for the detection of low temperatures of surfaces. The application to control surface temperature of rollers of paper manufacturing machines in paper plants has been a success.

2. Control of flow

Next to the temperature control, there is the flow control which is also widely used. Flow control is used not only for the object of maintaining a constant flow but also for control in relation with the above-mentioned temperature control or liquid level control and ratio control to be explain later. The method used here is to detect the amount of flow and open or close a regulating valve of either the inlet or the outlet. In detecting the amount of flow, differential pressure, areal and volumetric types are used. However, the differential pressure type is the most widely used. This method is capable of measuring various kinds of fluid flowing through pipes of any diameter having a head producer and does not require the fluid to pass directly through the instrument. Moreover this method is capable of indicating, recording, integrating or regulating but error will become larger when there is any pulsating flow. The selection of type and material for the head producer is made by taking into consideration the kind of fluid, pipe diameter, permissible range of pressure loss, etc. and when installing the system, a considerable length of straight position of the pipe should be left in front and back of the head producer to obtain accuracy and at the same time the distance to the differential pressure gauge be made as close as possible so as to minimize the time lag in detection. It is a good practice to install the system in a location where inspection and repairs can be made easily and at the same time will not hinder operation. In the measurement of pressure difference, types of meter used are U-tube, ring balance, bell, diaphragm, float type, etc., and the selection of suitable type is made by the amount of pressure difference that can be obtained.

For utilization of the above in automation, there is a system in which the difference in pressure is directly changed to electricity for transmission, and another, an indirect system, in which the difference is first converted to mechanical quantity and then to electricity for transmission. Together with the recent development in pneumatic type automatic regulator, a differential pressure converter in which the difference in pressure is changed into pneumatic transmission pressure and transmitted to a distance, has begun to be utilized. Pneumatic pressure is led into a pneumatic type automatic regulator and to instruments on meter panel board.

An areal type is one in which the fluid passes directly through the detecting element and is suitable for use in measuring the flow of high viscosity fluid in small diameter pipes. The straight portion of the pipe may be short but this type is not capable of measuring the flow in the vertical portion of the pipe. A volumetric type also measures the flow by passing the fluid directly through the detecting part and is hardly affected by the variations in viscosity, temperature, flow speed, and fluid pressure. This type of flow meter manufactured hitherto has been only for integrating but lately meters which are capable of indicating, recording, and transmitting have been manufactured and are being applied in automation fields.

Moreover, among the types under research, there is the magnetic flow meter. This meter amplifies the electro-motive force induced in the fluid by the magnetic field applied perpendicular to the direction of flow. This method owes its existence to the progress made in the amplifying technique. The fact that detection can be made without coming into direct contact with fluid having corrosive properties is the merit of this type ; however, it is necessary that the fluid be the kind having electrical conductivity.

3. Pressure control

Control of pressure is obtained by changing the revolution of fans and pumps or opening and closing of regulating valves. The former has small pressure loss and is usually equipped in large capacity installations. However, it requires a restoring device to obtain stability and is incapable of following

instantaneous changes in pressure. The regulating valve on the other hand, is superior in stability and response as compared with the former but control becomes difficult when power loss and change in load are large. Therefore, although the method of opening and closing the regulating valve is better in performance, the ideal condition is to use this method together with the change of revolution method because power loss and range of control must be taken into consideration. In pressure detection, suitable type of detector is selected according to the amount of pressure to be controlled which is the same as for selection used in flow measurement. Although the pressure to be measured in a furnace or chamber can be obtained by the use of a pressure tube with one end connected to a pressure gauge and the other end projected to the atmosphere, however in case of detecting pressure inside the furnace where difference in pressure is very small and moreover temperature near the door of the furnace is very high, there is a difference between the atmosphere near the detecting point and the atmospheric pressure surrounding the gauge. Therefore, two pressure tubes are used, one for the detecting point and the other for the atmospheric pressure. Also in order to reduce the time lag in detection, it is necessary to use pipes of approximately $1\frac{1}{2}''$ or $2''$ in diameter.

4. Liquid level control

Rate of change in level of liquid is slow and in many cases a large deviation may be allowed. Therefore a float type which uses its own energy is often used. In case a float cannot be used, detection is made using the pressure difference between the surface and the bottom of the tank as the height of liquid. In either case, it is only necessary to open or close the inlet or outlet valve depending on the height of the liquid and the size of valve must be determined from the amount of flow and capacity so that there will be no overflow or emptying of the tank.

For high pressure sealed tank or for liquid having corrosive properties, recent use of isotopes is significant. The above-mentioned regulating valve is opened or closed in the following manner. Radio active rays are passed through the liquid. The difference in the amount of rays absorbed by the liquid surface level is utilized in measuring and amplifying the amount of rays which have passed through the tank and led into an electrical type regulating device to operate the regulating valves. By the use of isotopes, it has become possible to control certain types of surface level which up to now have been impossible.

Also, there is a special 3 element type water level regulation system by which the ratio of amount of water supplied to a boiler to the amount of flow of steam produced is maintained constant at a predetermined value and if any change occurs in the water level, this predetermined ratio is made to change.

5. Ratio control

In various industries, to maintain a constant mixing ratio of gas C and B, or gas and air or crude oil and air, etc.; or in the manufacture of ammonium requiring a mixture of H_2 and N_2 in the ratio of 3 : 1, the amount of flow of both is detected and flow of one is controlled. In this cose, the flow of the gas which is to be used as the basis must be controlled to a predetermined value by some other means.

6. Control of components

The control of density, pH, etc. is sometime accomplished by detecting these quantities and directly controlling the inflow of liquid. However, for example, in ammonium saturation bath or the like, ratio of the amount of inflow of NH_3 and H_2SO_4 is controlled at a fixed value and pH of the product is detected and then correction is made to the predetermined ratio. This indirect method is used in many cases. In the detection of the above quantities, care must be taken in selecting the point for detection and the anticorrosive property of the part used in the detector.

V OPERATING MECHANISM

Ragulating valve and magnetic contactor used in electrical type are called the operating mechanism and no matter how excellent the regulator is, unless this operating mechanism which is the final stage in automation acts satisfactorily, the purpose of automation cannot be fulfilled. Thus the operating mechanism plays a very important part in automation. For regulating valves, the pneumatic type uses diaphragm valves whereas the electrical type uses electromagnetic or motor valves. The diaphragm valve is used in pipes up to $3''$ in diameter and having less than 10 atmospheric pressure. In places where large operating power is required a power cylinder is used. The use of electro-magnetic valve is limited since the valve can take only two positions, fully opened or fully closed, and can only be installed in pipes 1 inch in diameter and having approximately 5 atmospheric pressure. To move butterfly valves, a damper controller is used in electrical type and a diaphragm motor or power cylinder for pneumatic type. These are illustrated in Figs. 6 & 7. In general, near the fully closed position of the valve, a little movement will greatly affect the degree of opening; however near the fully opened position the effect is very small. Thus the valves must be

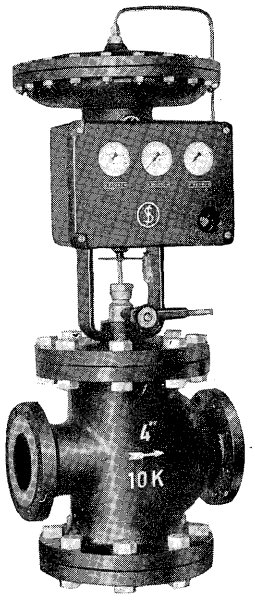

Fig. 6. Diaphragm valve with positioner

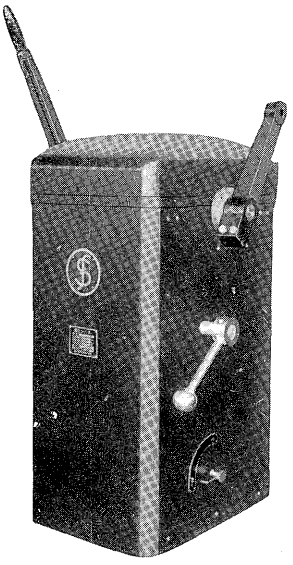

Fig. 7. Power cylinder

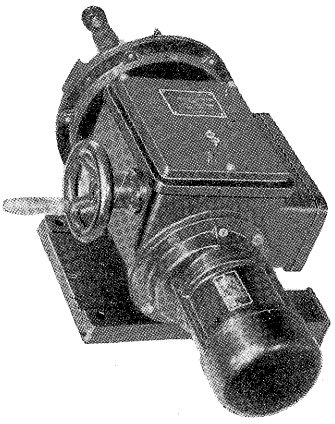

Fig. 8. Damper controller

specially designed so that amount of movement will be proportional to the degree of opening. Also there is a tendency to design the area or the diameter of the valve large to be safe, and if they are made too large, the result will not be desirable since the valve will open or close at the position where the valve opening is very small. It becomes necessary to either use a pipe of small diameter or throttle the portion of the pipe where the valve is located. However, before this is done, characteristics of the plant should be closely investigated and consideration given to recommendations of experienced persons because it has been tried out in several places without satisfactory result. Also in the selection of valves, its type and construction and its material must be considered with the corrosive properties of the fluid in mind. In case of power failure or other troubles, the valve should open or close to take such position to protect the equipment. It is also necessary to have equipment capable of being changed over to manual operation in case of trouble.

Our Company has been depending on sub-contractors for the manufacture of operating mechanisms but there have been cases where satisfactory operations were not attained and as the result our Company has gradually changed over to our own product and at present all types of operating mechanisms are manufactured in our factory.

The history of electro-magnetic contactor is old and lately very small and excellent type have been manufactured. If a suitable size is selected, it can be used without any fear of trouble. Fig. 8 shows a damper controller.

VI SEQUENCE CONTROL

Up to now, various problems on feed-back control have been discussed and in order to carry out perfect automation, sequence control must be introduced. For instance, in the ceiling temperature control of open hearth furnace, although there is a control for changing the supply of fuel from one side to the other side of the furnace, a sequence control system is also utilized which actuates the valves for fuel supply, air and flues in a fixed order. Also in the salking pit a sequence control is carried out so that when the cover of the pit is to be opened to charge or take out ingots, automatic control circuit is at first cut-off, then the supply of gas and air is stopped followed by closing of damper in the flue and finally the cover is opened. For closing the cover, the above sequence is reversed.

In the automation of gas producer, various types of valves are closed or opened in a fixed sequence at fixed intervals so that air, gas and steam are sent in or exhausted periodically to produce the desired gas. In order to accomplish the above sequence control, time relays and auxiliary relays are used and after confirming the opening or closing of the valves, and to start the next action, limit switch is used. Besides the above devices, automatic coal supplying device may be used to obtain periodic stoking, or warning devices may be installed so that the attendant has merely to watch the valve pilot lamps, and chronograph which indicates the operating condition of time relays. In this way gas producer can be operated without any trouble.

In manufacturing plants, if perfect automation is realized, manufacture of end product from material to packaging may be accomplished by one smooth assembly line system without practically any attendant. In the manufacture of cigarettes, automation had been carried out from long ago to some extent and lately automation is strongly recommended for application in manufacture of soap, caramels, etc.

An electronic calculator is also a type of automation, capable of completing a calculation within a short time where as it would take a man several years to go through. It is also used widely in lens designing, consolidation of data in weather forecasts, etc.

VII SUPERVISION OF AUTOMATION

When the automation is carried out, satisfactory operation of the factory as a whole cannot be expected if each part works individually. Initially a

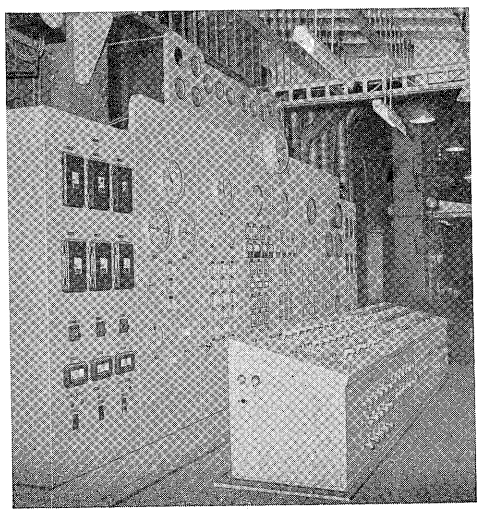

Fig. 9. Meter panel and control board for electric control system

supervisory panel was installed in each factory and operation supervised by meters, regulators, indicating lamps, etc., but lately method of supervising the operating condition of the entire installation from one location such as a central supervisory room has been adopted. Figs. 9 and 10 illustrate these meters and control panels. There are cases where temperature, pressure, flow, etc. of various points are recorded by installing recording meter panel to watch and record

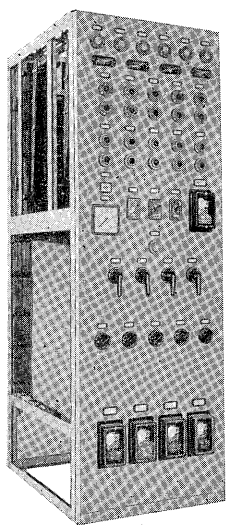

Fig. 10. Sequence control panel

the condition of operation of automatic control system.

Furthermore, graphic panels as shown in Figs. 11 and 12 were installed and meters which indicate temperature, pressure. etc., are located in the diagram on the panel. This method has become very popular within this one year and as a result, manufacture of smaller instruments has become necessary. In this way, condition of all stages of production in the factory is placed under control from one point and by supervisory operation of entire installation, automation will prove its effectiveness.

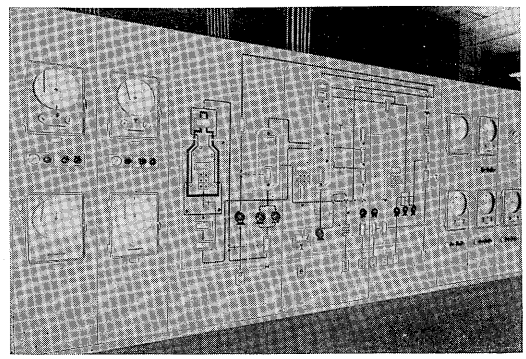

Fig. 11. Graphic panel for pneumatic control of petroleum industry

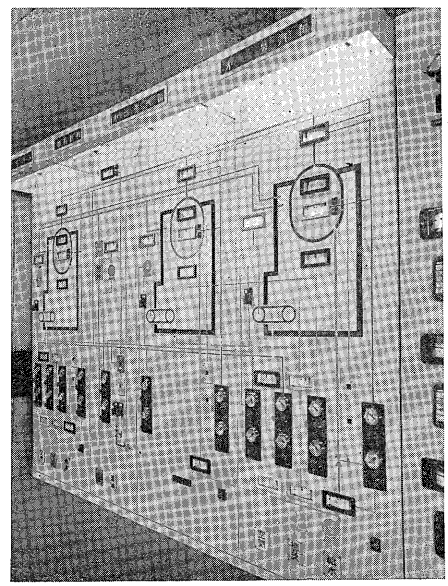

Fig. 12. Graphic panel for pneumatic A.C.C.

In places where a large number of instruments are used, various records must be consolidated and maintained or when records taken at certain hours must be compared and studied, it is necessary to convert the recordings on the charts into numerical figures. Also the charts to be maintained will become enormous in volume. As a result various types of calculators including analog-digital converter were developed, and data from more than 100 points

are consolidated and automatically type written in numerical values. In the United States the above method is already in use and when the detected value is of a desired value, the value is typed in black and if the value does not meet the requirement in red. A buzzer or a lamp will notify the workers whenever the value is typed in red. In future, it is expected that we will also show progress in this field.

VIII INQUIRY AND ORDER

When the plan for carrying out automation has materialized, the next step is to make inquiries to the maker for an estimate on the cost and then place an order. At this stage, it is necessary to give the maker an explanation of the entire equipment in the plant. An experienced user will make a detailed plan and issue appropriate specifications so that there will be hardly any mistake ; however, sometimes in order to keep the most important part of the equipment secret, only a simple specification is given to the maker. After the equipment is completed, new factors are revealed resulting in the manufactured equipment being a failure.

As for example, a certain chemical manufacturing company had a plan for installing a pH control system and since the detecting unit was the company's own design and make and to keep it secret, the specification given to the maker specified only the mV for manufacturing an on-off type automatic regulator. When the equipment was completed, it was found that it did not meet the requirement. The result was that later a new order had to be issued after a thorough study with the aid of the maker and finally obtained satisfactory equipment. Also there has been a case where it was believed that simply an order for a temperature control system would be a sufficient information for the maker. However, when the system was installed, the result of trial operation revealed that unless a program type temperature control system is used, a satisfactory performance could not be expected. Thus, it shows that a detailed planning based upon the characterics of equipment, its condition, when operated manually together with the information on practical examples in other companies is necessary before an order is issued.

There are two methods which may be considered when placing an order, namely, one in which a maker is selected to manufacture the entire system and the other in which the order is divided among several makers. Although this differs according to the contents of the plan and the scale of the system, it is best to select one trustworthy maker, because it is very convenient for coordination after the order has been placed, for adjustments to be made after delivery, after-service, etc. However for special parts, it may be better to have those parts made by a manufacturer who specializes in making those parts. If possible, plan should be prepared together with the maker and with mutual cooperation begin manufacture. This may increase the cost but would be profitable if satisfactory result can be obtained much quicker. Just because the cost estimate submitted by the maker is above the anticipated cost, it is not wise to split the order among cheaper makers. If the order is divided, it will result in various troubles occurring due to lack of liaison, non-uniformity in various makers' diagrams and explanations, and might produce an unexpected omission causing further trouble and delay.

IX CONCLUSIONS

To attain success in automation, it requires a detailed and careful planning on the side of the user combined with conscientious manufacture on the side of the maker and by a continued cooperation even after completion of the equipment. Do not give up the use of automation if any difficulty or trouble should happen to occur, but utmost effort should be made with the aid of the maker to accomplish perfect performance of the automation system.

Several problems on the subject of automation have been explained in this paper and since the explanations covered widely here and there on the subject, many points were not sufficiently covered.

The writer would be very happy if this article would be of any use to the readers in the development of automation.