AUTOMATIC DATA COMPUTING LOGGERS

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I. INTRODUCTION

Most of modern process plants have become so complicated that, to operate them with high efficiency, it is imperative to arrange in good order the numerous data available from respective elements. There has been a popular cry for the automation nowadays, which has come to call for speedy and pertinent treatment of the information obtained. Particularly if this information is secured from controlled stations which are in a wide distribution and close relation one another as in such cases as electric power systems or industrial facilities of a great scale, supervision and control must be made on the basis of correct information available from the controlled points.

In the case of such processes as mentioned, collective indication and recording by means of proper meters in the central control room ought to come in a regular routine. Those meters are necessarily to be operated electrically or pneumatically and one recorder is assigned to one kind of data, being mounted on a switchboard in a control chamber for a central supervision of respective conditions.

This arrangement, however, brings disadvantages of a great number of meters and bulky switchboards when required data are numerous. To read these data at a predetermined time and arrange them for judgment need quite tedious procedure accompanying a great effort in the maintenance and keeping the record charts in good order. To alleviate the troubles, sometimes recordings are made with one recording meter by sampling a variety of data one by one or miniature meters are employed to reduce the size of panels and minimize troubles.

Such systems as given based on an analogue method are serviceable for instantaneous direct operation, but the latest trend of has been attaching importance to information-transmitting arrangement, for instance making an operation log, for the direct connection between the plant and the superintendent and the foregoing systems are inconvenient for the automatization of preparing daily logs making necessary tables and their supervision.

For the above reasons, a digital system becomes necessary to make necessary recordings based on digital quantities available by automatic reading of the data, giving up the recording of unnecessary data changing momentarily and relieving the attendant from the troubles of reading, copying, computing, arranging and recording the charts. With this aim, the Company started the study in 1956 and completed automatic data computing loggers in 1956 and 1957 in succession.

II. FUNCTION AND CONSTRUCTION OF AUTOMATIC DATA COMPUTING LOGGERS

The automatic data computing loggers built by the Company have various functions which are roughly divided into the following items.

1. Measurement, analogue-digital conversion and scanning, synchronizing function
2. Computing and memorizing function
3. Printing function

From the view point of the construction the following varied mechanisms are involved in the apparatus.

1. A scanner which will change over measured quantities in succession and transfer their inputs in good order.

2. An analogue-digital converter for the purpose of converting analogue quantities into digital quantities by measuring inputs given by the scanner and applying these measured quantites to digits of codes.

3. A pin board to set up numeric values for the watch of measuring objects and to set a certain kind of programs and scale factors by means of figures.

4. A timer to instruct the starting of the apparatus at every fixed hour and give a sampling time.

5. A computing mechanism to make a computation of scale factors to have inputs of any scale coincide with required values to compute to see whether the measured values are in a normal zone and make such calculation as adding up, subtracting, finding mean values, the maximum values, the minimum values and efficiencies among varied data, and carry out data processing.

6. Auxiliary operating section and an auxiliary operation and memorizing mechanism to keep the memory of numerical values given for a certain determined period.

7. A program mechanism to give instruction according to predetermined program and manage the whole operation of the apparatus.

8. A typewriter to print measured values in red figures for alarm needed and in ordinary figures for other proccessed results of the data.

9. A lamp section to indicate the interior of the apparatus and present supervisory signals to a supervisor ; a manual check section capable of making a manual check when called for ; an alarm section to sound necessary alarm. Their constitution is as shown in a block diagram in Fig. 1.

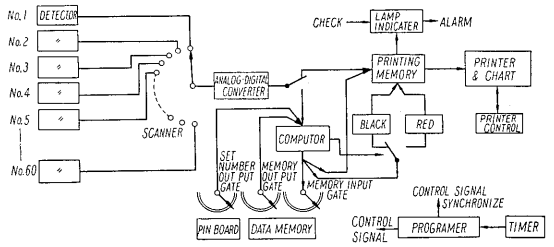

Fig. 1. Block diagram of data logger

III. DESCRIPTION OF EACH SECTION

1. Scanner

The scanner that will change over measured inputs in succession is desired to give no ill effect to the inputs, because it is in direct connection with the measured input. For instance care should be exercised with this apparatus not to cause poor contact to the connection between the selected circuit and measuring instruments, not to induce contact voltage and not to give noise to the circuit. There are various kinds of scanners : to be pneumatically operated, to be advanced with notches through pulses, to select the circuit mechanically with a driving motor and others.

2. Analogue to Digital Converter

1) Description about Analogue and Digital Quantities

Ordinarily those values measurable with a meter are analogue quantites. But what are the digital qualities mentioned here ? The following is a brief explanation of it.

Quantigation of measured amounts means to divide variable quantities to be indicated continuously into minute parts and apply numerical values to their instantaneous values. For instance in measuring the weight of substances a balance in most common use is of a spring balance type which makes the use of the displacement of a pointer in proportion to the weight. On the other hand a physical balance of precision is to measure the weight of substance by comparing it with the standard weight such as ; up to 10 g by the use of the weights of 1 g, 2 g, 2 g and 5 g and up to 100 g by the use of 10 g, 20 g, 20 g and 50 g, thus measuring the weight of substance in a discontinuous step.

The former may be called to represent the weight by analogy, while the latter by digit. For example a value represented by one continuous curve is an analogue quantity, and a value sampled at a certain instant and a numerical value applied to it is a digital quantity. In fact this is a common practice prevailing in a daily life. That means, in reading measured value with a meter, the quantigation is practiced unconsciously by us.

Within the accuracy of meters the reading of numerical values is made usually by us as mentioned above. But to read them decisively with higher accuarcy and free from personal errors, automatic reading operation is the only way to be relied on. This automatic reading apparatus is the A-D convertor to be stated below.

2) Advantage of Digital System

Advantages of the employment of the digital system over that of the analogue system are roughly the following two points. That is, (1) the preservation and arrangement of the record of data and (2) their transmission.

Ordinarily, in recording and keeping analogue quantities of such data as voltage and current, recording meters are employed. As it is known to everybody, the recording meter is constructed with a certain width for the chart on which only a point corresponding to an instantaneous value of measurement is to be marked at a cost of other broad space.

Accordingly the number of charts becomes quite voluminous for the system to record a momentarily changing quantity, leading to very complicated operation to read necessary data at a required moment. The operation of reading numerous measuring quantities is a quite troublesome work ; much more is the operation of the right judgement out of these data. In an ordinary measurement it is not very necessary to read data available from varying quantities with continuity. For instance, in reference to one continuous varying quantity as illustrated in Fig. 2, if measurements are made at point A first and then at points B, C and D, the mutual relations of these points may be represented later sufficiently.

Then in vacant moments other than needed, reading for another kind of varying quantity is possible

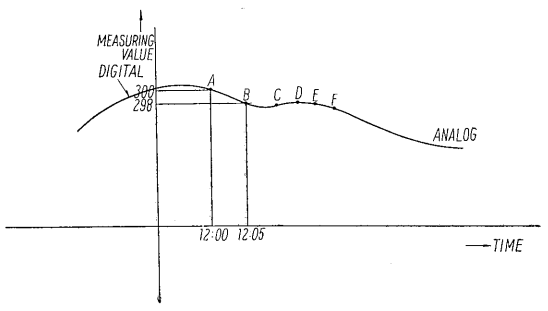

Fig. 2. Analogue and digital quantities

with the same measuring apparatus and also can be transmitted through the same transmission route.

These readings are by no means inconvenient in comparison with the continous reading, and with few apparatus can be made use of reading a number of varying quantities through a change over. Over the same carrier channel they may be sent by means of multiplex communication with great convenience. If the manual operation is replaced by the automatic operation, it will either reduce or eliminate the operator. Values once coverted to digital quantites will remain unchanged at high accuracy with no errors in spite of frequently repeated data processings. Further the values will be transmitted with less effect of lines and permit multiplex communications. These are another advantages.

3) Analogue-Digital Converters

Varying quantities represented by analogue are converted to digital quantities with the analogue-digital convertor. There are three kinds of converting methods.

(i) Counter System
(ii) Discontinuous Unbalance System
(iii) Commutator System

The counter system is further subdivided to: a system to count, by means of a time-gate corresponding to measured quantities, a standard frequency among it and another system to count, by means of a standard time-gate, a pulse corresponding to mesured quantities among it.

In this case when the higher the standard frequency is selected in the former system and the larger the standard time in the latter system, the higher the apparent accuracy results. In fact, the accuracy of the gate mechanism and other factors entail restriction to the accuracy.

In the discontinuous, balanced system, the states of "ON" and "OFF" are taken into account. When the object indicates positive, the circuit is so arranged as to work "MAKE" and when negative it work "BRAKE". By this operation measuring quantities are compared according to the analogue system with standard quantities discontinuously at each step. Through this measuring step digital quantities are made known. This operation is made automatically by receiving answer back from logical circuits to turn them to digits and each mesured quantity is made corresponding to digital figure.

The device of this system differs in the selection of the measuring step depending on the selection of a code to be turned to figures.

A binary code is able to indicate necessary figures with the least number of elements. But as the decimal system is in the ordinary use among us, the figures are to be transfered to this decimal system again, which makes the circuit complicated. Then a code applying the decimal system is now mostly employed, and in this system a decimal code with four elements, which is to divide the figure of 10 in one unit by the binary system, is extensively used. This is used for indicating from 0 to 9 by the decimal system, consisting of the minimum number of elements in the indication of this system.

Stating on codes, this decimal code with four elements is not so called "self checking". If any error occurs in the code, it turns to an entirely different code. To avoid this drawback, a code with one more element — five elements — is enployed. This is usually called "2 out of 5 code." It has 2 "ON" and 3 "OFF" in 5 elements without exception to check by itself. Such a system to discover errors by the code itself is termed "Self-Checking Code." Besides the above, there is a code to satisfy the decimal system by means of seven elements. This is named "Bi-Quinary Code" which operates just like the principle of the abacus. This is also a self-checking one. Further, there is a self-correcting code operating to correct errors by the code itself, but no mention will be made in this article. Fig. 3 illustrates examples of those mentioned above.

element number	4 element decimal 1 2 4 8	2 out of 5 0 1 2 4 7	Bi-Quinary 0₀ 5 0 1 2 3 4
0	○	○ ○	○ ○
1	○	○ ○	○ ○
2	○ ○	○ ○	○ ○
3	○ ○	○ ○	○ ○
4	○ ○	○ ○	○ ○
5	○ ○	○ ○	○ ○
6	○ ○ ○	○ ○	○ ○
7	○ ○	○ ○	○ ○
8	○ ○	○ ○	○ ○
9	○ ○	○ ○	○ ○

Fig. 3. Code example

The commutator system is the one, like a self balance type electric recorder, to convert inputs to mechanical positions corresponding to them and take them out by a contact between brushes and segments or a similar method. For instance in such a case as water level or gas tank level, the detector can be provided with a coder without modification, but ordinary measuring quantities need measuring instruments to convert these values to mechanical positions. One example is to use the electric recorder mentioned above and to the rotating part of its servomotor is attached an analogue digital converting mechanism to convert the measured values to digital quantities.

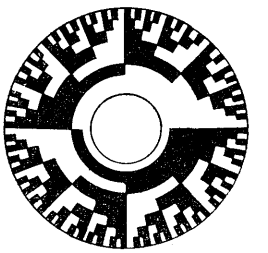

Fig. 4. Binary coding disc

In this system, too, according to the selection of the code, coding mechanisms of different types are employed. Fig. 4 illustrates one to arrange a full rotating angle of the servomotor to one turn and on a rotary axis of this one turn is fitted a piece of a coding disc so as to convert the measured value to a binary code. However, in such a method to obtain digital quantities by means of a piece of coding disc, it needs technique of high grade in manufacturing the disc and taking out the code. In a practical case, gears are used and, by making a proper connection to them, figures to be divided are first split to a decimal unit, and next the gears corresponding to these individual unit are used with discs divided into ten equal parts so as to make the figure of each unit known. This is the system in use.

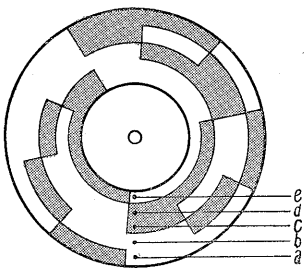

Fig. 5. Coding disc of "2 out of 5"

Fig. 5 illustrates a coding disc to turn one unit of decimal thus divided to a code. In Figs. 4 and 5, those painted black indicate conductive parts, i.e., "ON," and other parts "OFF." According to the position of the brushes coded figures consisting of the combination of "ON" and "OFF" are taken out.

If the brush position is fixed and the disc is directly connected to the rotating part, a coded figure corresponding to the measuring quantity is available. Besides the above, there is a divice which has transparent parts and opaque parts in place of the conductive and non-conductive plates of the foregoing unit. From one side of it light is projected and detect the measuring amounts by means of a photo cell, so that the coding can be accomplished without touching coded disc. There is still an another method to use reflecting parts and non-reflecting parts so as to read them by means of the photo cell and make digital quantities known.

This type, if an analogue section of high accuracy is available, is relatively an easy coding method, and is in a most popular use.

3. Pin-Board

Fig. 6 shows a pin-board made by the Company.

For the watch of measuring input there are several systems in the method of setting an established value. One of the systems is to make the setting

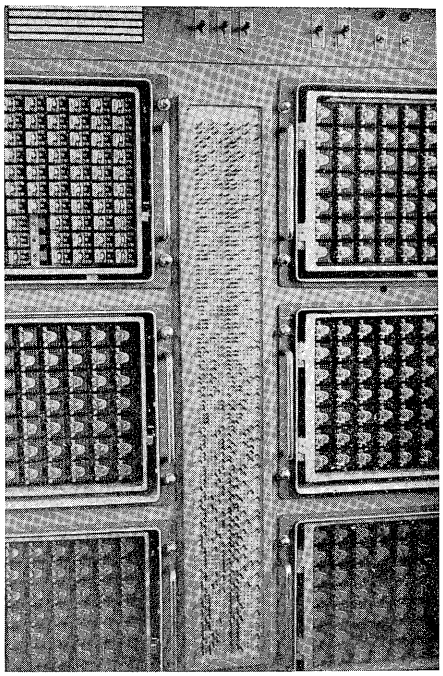

Fig. 6. Front view of pin-board

through the analogue method and make comparison on the value as the analogue itself. Another one is to set it through figures and make computation for comparison after obtaining digital quantities from measured values. But from the viewpoint of the setting method, computation method, circuit constitution, accuracy, and space, the latter digital system is much more advantageous.

To obtain figures as electric output, there is a method in which conductivity is made available at a part corresponding to figures. This can be accomplished, for instance, by such an operation as closing a switch. In the one shown in this photo., if a hole having a definite indication of figure is plugged in, a value is available there electrically, and from there electric output is to be obtained. This output is led to a program mechanism and a computation circuit.

4. Computation Circuit

There are several kinds in the code used in the computation circuit, but precise description is omitted herein. For instance, there are decimal coded computors, binary coded computors and etc., but in the logger coded with the highest dependability as stated above and the most economical in the constitution of the computation circuit—"Bi-Quinary Code"—is also used. This circuit has been in a practical use according to the technique of FACOM which was completed by the Fuji Tsushinki K.K. (an affiliated concern) and is being favorably commented upon. This assures the stability.

Though precise description is omitted on this circuit, it has advantages that the calculation of 2 times,

5 times, ½ and ⅕ are readily available by shifting on the circuit or subtraction is feasible with simplicity as addition.

IV. WORKING EXAMPLE OF AUTOMATIC DATA COMPUTING LOGGER

Figs. 7 and 8 illustrate respectively Locker type and desk type automatic data computing logger built by the Company. The one shown in Fig. 8 is a No. 1 machine specially completed by the Company. On the left side of the machine in the picture is an indicating panel on which integrated values of time, measurement channel, measuring values, necessary channels are shown by the lighting of lamps and also interior conditions are shown. The one on the right is a switching switch-board to give established values and deviation for the calculation of off normal (out of control) of measuring values. In the center of a desk is placed a printer to record the measured values. Inside of it an analogue-digital converter and a timer are set up on the left, front side, while control and programming relay circuits are set up on the right. On the back of the desk relay parts for memory integration and subtraction are installed. This device is provided with doors on both the front and back for the access to the interior.

Fig. 7 shows a device consisting of a main locker and an auxiliary locker. The main locker is to take the part of principal operation of this device ; the auxiliary locker is for the memory of numeric values and call of the memory. Both being 1,800 mm high, 1,300 mm wide and 600 mm deep, it is placed on the corner of the control room, and is serviceable with convenience if only a typewriter is set on a desk. The one shown on the right in the picture is the main locker upon which a timer, scanner, analogue-digital converter, control switches and control lamp board are set. A narrow, lengthy part in the center is a pin board mentioned above. In this pin board numeric value sets of more than 300 units and a number of program sets are operated in good order within a height of 1,000 mm and a width of 120 mm. This can be set in a space less than 1/10 of a switch-board for the establishment of numeric values as shown in a picture. Pins used here are made of a pin of 1.5 mm in diameter fitted on the end of a knob of 25 mm long and 3 mm in diameter. This pin is made of special metal with careful attention not to make miscontact. The one shown in the picture is an example of fully automatized electric power log made by electric power co. Though the contents are very versatile, one main locker is enough to answer the need as one used for the control of ordinary process.

The features of the apparatus are enumerated as follows.

(1) Many objects of measurements are rapidly measured, converted to figures, and printed in good order.

(2) With regard to a measuring object of one channel, measurement, conversion to figures, computing and processing of data needed, and printing can be accomplished in within 1 second.

(3) The number of units in one line required for 1 channel is taken as 5～6 digits and 60, 40 channels are made standard, which permits a great many data printed systematically in a space only less them 27 inches wide.

(4) In case this device is operated in common with a monitor, a much larger number of scanning and printing can be made in much shorter time.

(5) Processing of necessary data and computation of Off Normal are made with this device. For alarm condition the printing is made in red ink to draw an attention of a supervisor.

(6) A report which is to be made after reading the meters by a supervisor and based on the data in the old practice, is readily completed with this device. Necessary calculation is also accomplished simultaneously with the report. Several copies are made with no special handling, which eliminates human labour.

(7) Results of processing gained from data can be obtained as a case demands.

(8) Setting of the program and established value

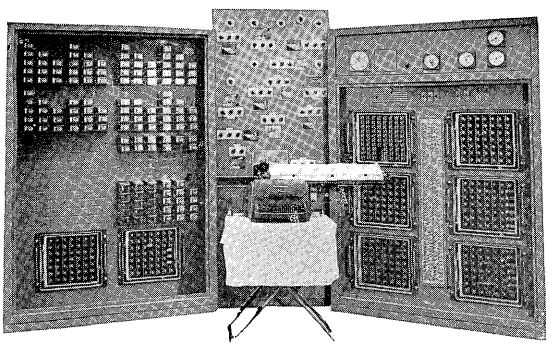

Fig. 7. Locker type logger

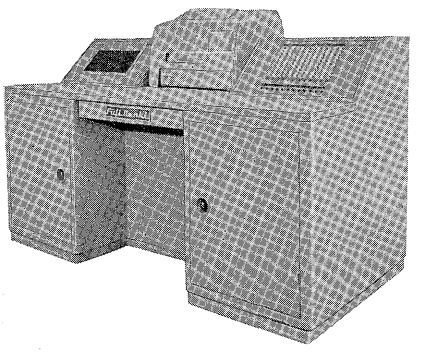

Fig. 8. Desk type logger

are to be made in an orderly way and many ways within a narrow space, which is very convenient.

(9) Reliability of the device is absolutely high. During the operation no human handling is needed after loading and unloading a chart. But in case there are special matters to be typewriter, it can be done by a manual operation.

One of operating examples will be given below. Fig. 9 illustrates a chart made when supply control is accomplished with full automatic operation in a supply control center of a certain gas business. For the most logical supply of gas it is natural enough to control the supply condition of gas at a certain place to be called a gas supply center. This is a management and control center where a gas supply condition of a certain moment is watched, supply quantities of gas in the past is integrated and recorded, gas supply log is made for the purpose of calculating the calories of most needed B gas and C gas in order to perform the most efficient supply operation. In this center printings are made on momentary flow volume of gas supplied to several objects of the consumer and supervision is made on supply operation with no excess or no deficient for momentary supply quantity, that is, neither waste nor illogical supply. The setting of these values are made beforehand by the use of the pin-board. If the flow volume goes outside of the preset value, it is quite natural that printing figures as Off Normal are to be altered to red ones. Gas supply volume is usually expected to undergo great fluctuation with a relatively short duration. Then, time for the scanning and sampling is to be speeded up naturally. In this case a method of printing Off Normal only to take care of such moment, without always printing all data, is mostly employed.

To make a gas supply log it is necessary to print the supply volume. Then it becomes necessary to make a record of supply volume in addition to the supervision and record stated above. This supply volume is given by an integrated value of the gas flow against the momentary flow volume in the above case. There are two methods in the integration : one is to make discontinous curve by constantly sampling momentary values and integrate this curve for a reqired period, and the other is to mount a integrating transmitter directly on a detector and print these values at every required time. The latter is a useful method because of ease in practical operation and few in errors.

Integrated amount of respective measuring objects is usually printed of its integrated value every hour, and at every 6th or 24th hour they are collected to give data for computing and processing. Then values for required period are printed.

Every required data chart is completed with this automatic data computing logger.

V. CONCLUSION

The writer feels sory to have been uuable to make a complete statement on the automatic data computing logger in spite of his intension. But he believes that this kind of data processing devices increasingly come in demand and will be an indispensable apparatus in future. He will be very happy if the time comes when this article proves to be of some value to those who make study on the device.

	COKES OVEN GAS															FURNACE GAS									
	GENERATED GAS	COKES OVEN	STEEL MANUFACTURE	STEEL MANUFACTURE	STEEL MANUFACTURE	BLOOMING MILL	BLOOMING MILL	LARGE SIZE	MIDDLE SIZE	SMALL SIZE	STEAM FACTORY	HEAT POWER	SHEET STEEL FACT			No. 1 FURNACE	No. 2 FURNACE	COKES FURNACE	BLOOMING MILL	BLOOMING MILL	SHEET STEEL	LARGE SIZE	SMALL SIZE		
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Fig. 9. Chart example for the gas center