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# AUTOMATIC TEST EQUIPMENT (RC METHOD) FOR SINGLE-PHASE WATT-HOUR METERS

*By* Atsushi Nakaoku

Japan Electric Meters Inspection Corp.

Masakuni Yoshimoto

Hideo Tatsuzawa

Fuji Electric Co., Ltd.

## I. FOREWORD

Various types of watt-hour meters are used in electric power transactions. In order to insure fair practice in these transactions, all meters must be inspected and approved by the Japan Electric Meters Inspection Corporation prior to their actual use. This, as well as the new regulations concerning the methods of measurement which have become effective recently, means that there is a tremendous amount of meters which must be tested and approved. The majority of these meters are single-phase, ac, two-wire watt-hour meters. The Japan Electric Meters Inspection Corporation has, therefore, developed an automatic system of testing these meters.

The introduction of the type SA-1 Automatic Test Equipment, a new concept in test equipment, was based on recent achievements in this field, Fuji Electric and Fujitsu have jointly produced this equipment under the directions of the Japan Electric Meter Inspection Corporation. Units No. 1, 2, and 3 have already been delivered to the Shibahashi, Tokyo, and Nagoya facilities, respectively. This report introduces this new test equipment and describes the power supply and test board manufactured under the direction of Fuji Electric Co.

## II. EQUIPMENT OUTLINE

This equipment automatically tests (by the RC method) the meter error of 10 single-phase, ac, two-wire watt-hour meters, out of the 60 that can be mounted on the test board, and prints the results on paper. While 10 of the meters are being tested for error, another 10 are tested for creeping, 10 other meters are tested for starting current, and the remaining 30 meters are tested for self-heating.

### 1. Type of Meters Tested

Single-phase, ac, two-wire watt-hour meter 100 v, 50/60 cps

| | |
|---|---|
| Wide range Type III | 15 amp, 30 amp |
| Wide range Type II | 10 (5) amp, 20 (10) amp, 30 (15) amp |
| Standard Type I | 10 amp, 20 amp, 30 amp |

(The above classifications are based on former regulations.)

### 2. Tested Items

The principal tests conducted by this equipment are :

(1) Visual inspection
(2) Insulation test
(3) Creeping test
(4) Starting current test
(5) Register test
(6) Error calculation test

### 3. Component Units

This equipment consists of the following units.

(1) Power supply (including a precision rotary standard) 1
(1) Test board for 60 meters 1
(3) Control section (including printer and operating panel) 1

## III. OUTLINE AND FUNCTION OF EACH UNIT

### 1. Power Supply

*Fig. 1* is an external view of the power supply

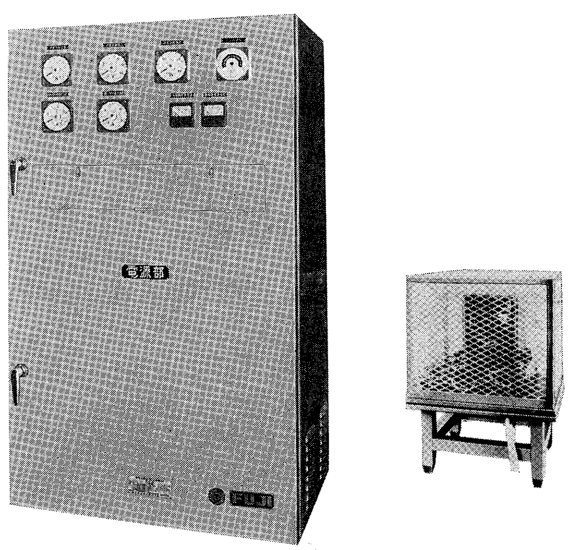


*Fig. 1* External view of power supply

unit. This unit is connected to the test board and control section and supplies the required testing power to the test board in response to a command from the control section. This power supply has the following ratings:

Input:

| | |
|---|---|
| Voltage | 200/220 v |
| Current | 30 amp |
| Frequency | 50/60 cps |

Output:

Power supply for error calculation test

| | | |
|---|---|---|
| Voltage | 100 v | 220 va |
| Current | 30 amp | 300 va |

Power supply for self-heating

| | | |
|---|---|---|
| Voltage | 100 v | 400 va |
| Current | 30 amp | 1600 va |

Power supply for starting current

| | | |
|---|---|---|
| Voltage | 100 v | 100 va |

Capacity of auxiliary power supplies

Power supply for test mark matching
Power supply for relays
Power supply for electromagnetic contactors
Power supply for precision rotary standard
Power supply for projectors
Power supply for photoelectric sensor and amplifier driving device
Power supply for outlets
} 3300 va

A motor-generator (MG) or commercial power line can be used as the input power source. However, the power supply for each testing section must be highly accurate and adjustable. This is achieved by taking the voltage difference between a set value and the actual value and amplifying it by means of a transistorized chopper amplifier and using the amplified difference voltage to automatically adjust the error calculating test voltage, current, and phase and the self-heating current to preset values by driving a servomotor coupled to the shaft of a slidac. This automatic adjustment provides accuracies of ±0.3% for the error calculating test voltage and current, ±1.0% for its phase, and ±1.0% for the self-heating current. Automatic voltage regulators are used to maintain the power supplies for the creeping test voltage, starting current test voltage, and self-heating voltage to within accuracies of ±0.2%, ±0.2%, and ±1.0%, respectively.

A precision rotary standard and its enclosure are used to perform RC method error measurements. The enclosure has special air-circulation and vibration resistant characteristics.

## 2. Test Board

*Fig. 2* shows the external construction of the test board. As shown in the figure, the test board consists of light projector/sensors which can be moved left and right, backward and forward and 6 test blocks (K1~K6) consisting of 10 mounting positions (5 in each upper and lower row) for the meter to be tested.

The conventional type of automatic test equipment uses a system in which the test board rotates while the light projector/sensors remain fixed. This makes it possible to provide sufficient self-heating with a minimum amount of floor space required for the test board. On the other hand, however, the creeping test and starting current test cannot be conducted (additional equipment is, therefore, required for these tests).

The conventional type of test board also requires a comparatively large mechanism to move it and therefore increases costs. This new equipment, however, employs a movable light projector/sensor to overcome this disadvantage.

The major problem encountered in the development of this new system was the method of stopping

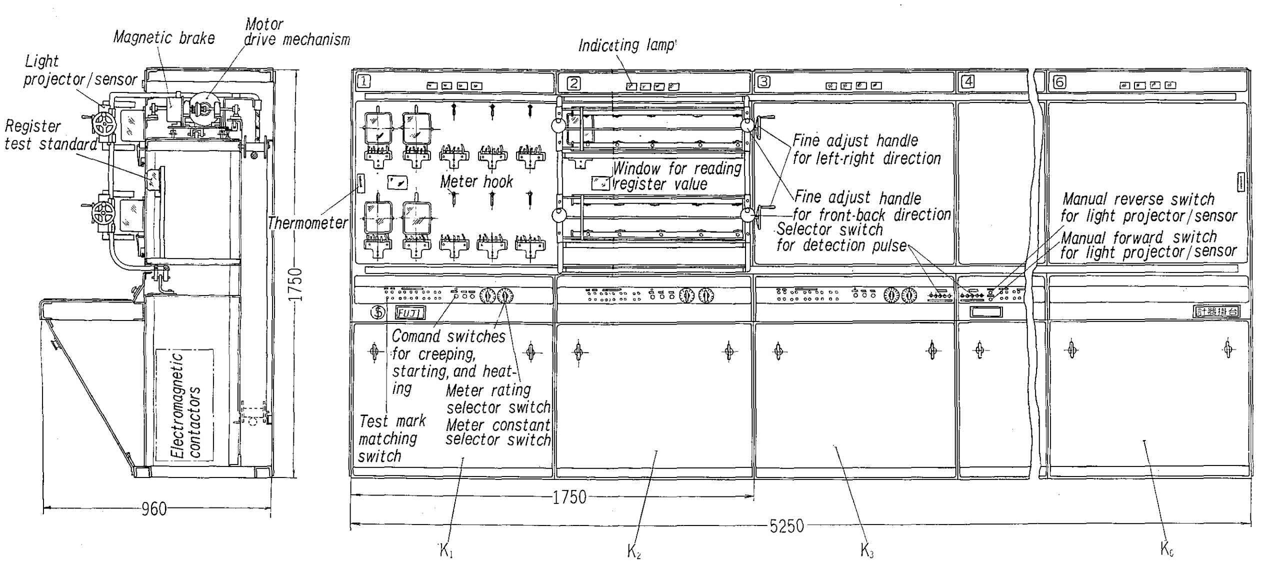



*Fig. 2* Watt-hour meter test board

the light projector/sensor at the predetermined position of each test block. Since a constant distance must be maintained between the meter and the light projector/sensor in order to accurately detect the speed of the meter being tested, the light projector/sensor must always stop at the same position and the test board itself must have precise mechanical dimensions. These requirements have been taken into consideration and the light projector/sensor installed on a truck driven by a motor. The speed of the truck is controlled by microswitches, electromagnetic contactors, relays, and a magnetic brake. Final positioning of the truck is performed by a mechanical stopper.

The conductors for the moving light projector/sensor and motor are bound together as a single line and positioned on a pulley to prevent them from interfering with the movement of the truck. A protection device is employed to immediately stop the projector/sensor the instant it comes in contact with an object during the moving operation.

Conventional equipment has one light projector/sensor for each meter to be tested and, therefore, each light projector/sensor can be individually adjusted. However, in the Type SA–1 equipment, five light projector/sensors are installed as a unit corresponding to the five meters (on the upper and lower rows) to be tested. Adjustment of the light projector/sensor is possible in conventional equipment when pulses of a certain meter disc are not detected and, since the units are separated, there is no interaction between them. The disadvantages of this system were found to be in the individual operation of the units, the necessity of making all adjustments accurately and separately, and the necessity of using individual cases.

The type which uses five light projectors/sensors as one unit, on the other hand, can be manufactured easily and economically to provide a constant relationship between the corresponding positions of the five sets. However, this construction requires that, since the five sets operate together, they be adjusted as a single unit. It has been found from actual use that this problem can be easily solved by the accurate production of the light projectors/sensors and test board.

The required register testing standard is installed inside each test block of the test board. Reading of the register can be done at the front of the test board while the registers themselves can be easily replaced from the rear of the board. Since each test block has a different test function, each block must be able to perform its function as soon as the light projector/sensor arrives. This is accomplished by means of various types of switching devices and operating switches.

### 3. Control Section

This section consist of an electronic computer for the calculation of errors from the number of rotation pulses of the watt-hour meter being tested and the standard pulses from the rotary standard, its peripheral equipment, a printer to print out the error values, and an operating panel. *Fig. 4* is an external view of this equipment.

This equipment can automatically perform the error calculation test with an accuracy of $\pm 0.1\%$. A FACOM 270–10 electronic computer, having improved performance and smaller size than the previous model, is used.

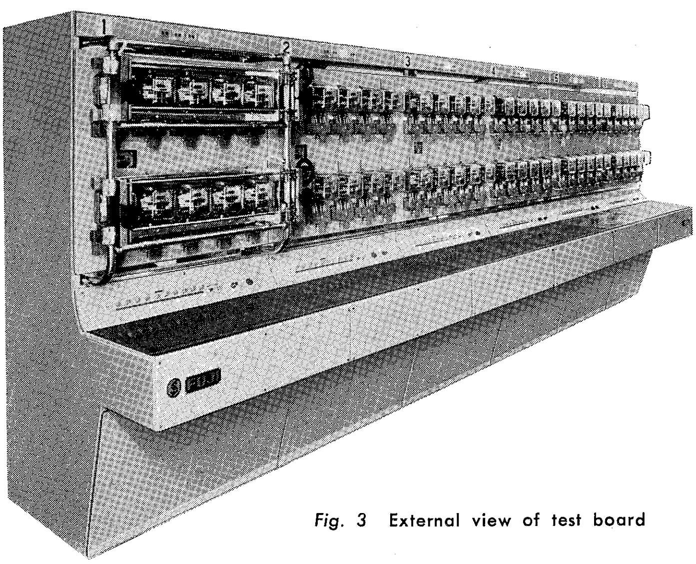


*Fig. 3* External view of test board

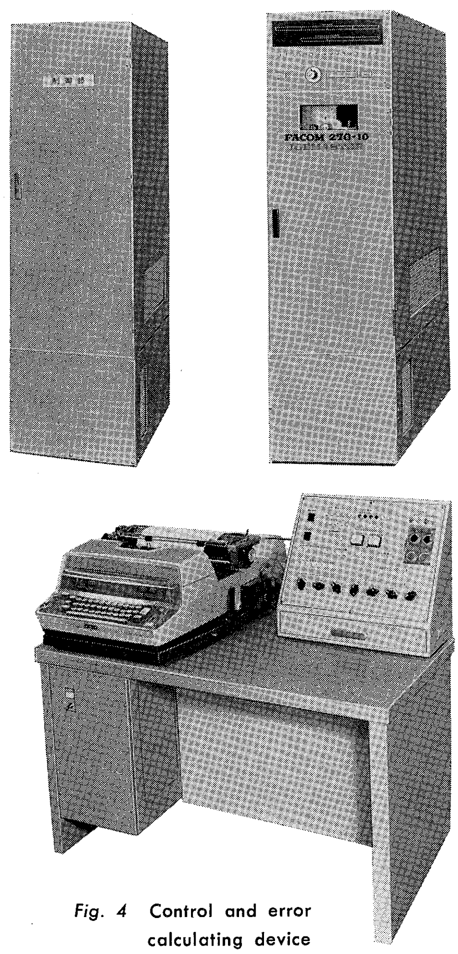



*Fig. 4* Control and error calculating device

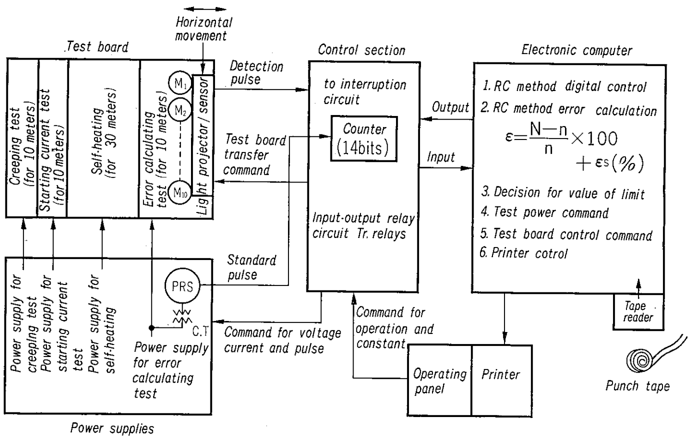



Fig. 5 Block diagram

Various indicating devices and operating switches are mounted on the operating panel to indicate the test point and test block where, for example, the error calculating test is being conducted and whether the rotation pulses of the meter being tested are being properly detected or not. The movement of the light projector/sensor and the switching of the test point can be performed both manually and automatically. The movement of the light projector/sensor can be performed automatically as soon as the error calculating test is completed or held until a specified time has elapsed (by means of a timer) even if the error calculating test has already been completed. Faulty equipment detection and operating condition of the complete control system can also be indicated. *Fig. 5* is a block diagram of the control section.

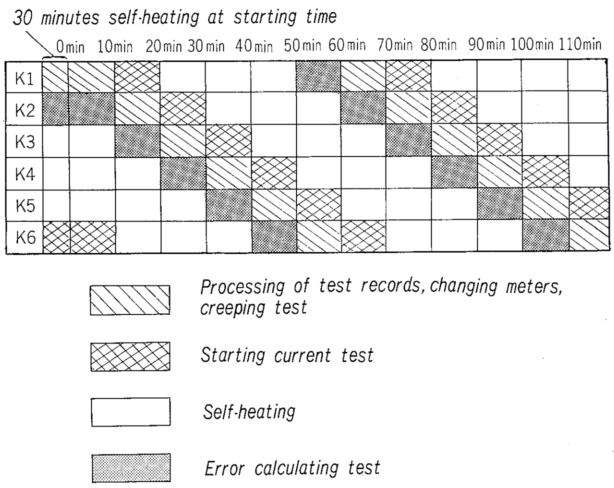



Fig. 6 Test program sequence

## IV. TEST PROCEDURES

### 1. Test Sequence

The items tested and the test sequence for each test block are illustrated in *Fig. 6*.

Self-heating is performed for the first thirty minutes after the power is turned on. After this, the error calculating test is conducted at position K2 (if the light projector/sensor was stopped at K2), self-heating at K3, K4, and K5, starting current test conducted at K6, and the creeping test conducted at K1. All these operations are carried out simultaneously, as shown in the diagram. Upon completion of the error calculating test (which lasts approximately 10 minutes), the light projector/sensor automatically moves to the next block (K3) and starts conducting the error calculating test there. At this time, self-heating is being performed at K4, K5, and K6, the starting current test at K1, and the creeping test at K2. As described above, tests are conducted in a creeping test→starting current test→self-heating→self-heating→self-heating→and error calculating test sequence with a cycle time of approximately 10 minutes. Therefore, it takes about 60 minutes to conduct this series of tests on the 60 meters mounted on the test board (10 minutes for ten meters).

### 2. Individual Testing Procedure

1) Creeping test

Since the meters which have already been tested for errors (final test) are on the test block where the creeping test is about to be conducted (first test), a test record is made and the meters then changed. The operating switches are then used to select the meter ratings and constant. These signals are then fed to the power supplies and the control section where the power supply for the meters for each test is obtained. After completion of the insulation test (by a megger), the creeping command pushbutton is depressed to apply a creeping voltage to the meters. The torque in both directions for each meter disc is checked by depressing the pushbutton for test mark matching.

2) Starting current test

By operating the starting command pushbutton, starting voltage and starting current which correspond to ratings of the meter are applied by means of the automatic switching device. Thus, testing is carried out by confirming continuous rotation of the meter disc.

3) Register test

The initial reading of the register is recorded for reference purposes when the meters are changed. The final register reading, after all the tests have been completed, is then compared to the reading of the register test standard and the performance of the register determined.

Since two types of self-heating current is supplied by the power supply, two different types of meters having different ratings can be placed on the test board for testing.

4) Error calculating test

The error calculating test is highly suited for automation and the RC method employed because of its high measuring accuracy. Error is calculated by counting the number of standard pulses from the precision rotary standard corresponding to the speed of the meter being tested. Error $\varepsilon$ at this time can be given by

$$\varepsilon=\frac{N-n}{n}\times 100+\varepsilon_s\ (\%)$$

where $n$: Counted number of standard pulses for each meter being tested.

$N$: Calculated pulse number (counted number when error of CT and errors of meter and precision rotary standard are zero.)

$\varepsilon_s$: Sum of CT error and error of precision rotary standard.

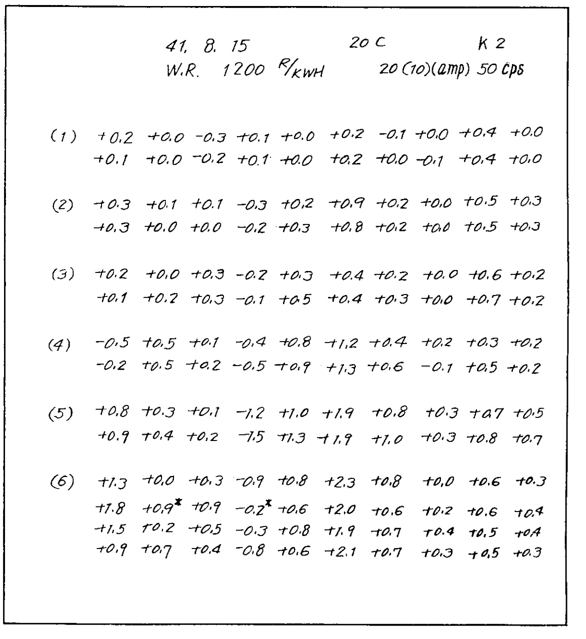
The meter rating and meter constant signals are fed to the control section as soon as the light projector/sensor stops at the predetermined position. The power supplies corresponding to the testing point shown in *Table 1* are then automatically supplied to the meters (starting from test point 1) in accordance with these signals. The speed of the meter is then converted into an electrical signal by the light projector/sensor and the error automatically calculated, in accordance with the above equation, by counting the standard pulses from the precision rotary standard while detecting the predetermined rotation number of the meter and then printed out on paper. The variation of the meter itself is considered and two tests are conducted at each test point. If either the first or second measured error values exceed a predetermined value or the difference between the two error values exceeds the comparison value limit, two additional tests are conducted before moving to the next test point.

*Table 1* **Test Load**

| Test Point | Test Load (Rated load %) | Power Factor |
|---|---|---|
| 1 | 100 | 1 |
| 2 | 100 | 0.5 |
| 3 | 50 | 1 |
| 4 | 20 | 0.5 |
| 5 | 10 | 1 |
| 6 | 5 | 1 |

The printed form of the measured error values is shown in *Fig. 7*. The error value exceeding the limit value is printed in red ink and all errors exceeding ±4.9% are printed as +4.9 or −4.9. A faulty comparison mark (*) is printed immediately after the second measured value whenever the measured values of the first and second test exceed the comparison value limit.

The computer does not operate when the rotation pulse from any of the ten meters being tested is missing. The position of the missing pulse is indicated at the operating panel of the control section. Adjustment for the reading of all pulses can be easily performed, at this time, by manually operating the adjustment handles located at the light projector/sensor.



41. 8. 15 20 C K 2
W.R. 1200 R/KWH 20 (10)(amp) 50 cps

(1) +0.2 +0.0 −0.3 +0.1 +0.0 +0.2 −0.1 +0.0 +0.4 +0.0
+0.1 +0.0 −0.2 +0.1 +0.0 +0.2 +0.0 −0.1 +0.4 +0.0

(2) +0.3 +0.1 +0.1 −0.3 +0.2 +0.9 +0.2 +0.0 +0.5 +0.3
+0.3 +0.0 +0.0 −0.2 +0.3 +0.8 +0.2 +0.0 +0.5 +0.3

(3) +0.2 +0.0 +0.3 −0.2 +0.3 +0.4 +0.2 +0.0 +0.6 +0.2
+0.1 +0.2 +0.3 −0.1 +0.5 +0.4 +0.3 +0.0 +0.7 +0.2

(4) −0.5 +0.5 +0.1 −0.4 +0.8 +1.2 +0.4 +0.2 +0.3 +0.2
−0.2 +0.5 +0.2 −0.5 +0.9 +1.3 +0.6 −0.1 +0.5 +0.2

(5) +0.8 +0.3 +0.1 −1.2 +1.0 +1.9 +0.8 +0.3 +0.7 +0.5
+0.9 +0.4 +0.2 −1.5 +1.3 +1.9 +1.0 +0.3 +0.8 +0.7

(6) +1.3 +0.0 +0.3 −0.9 +0.8 +2.3 +0.8 +0.0 +0.6 +0.3
+1.8 +0.9* +0.9 −0.2* +0.6 +2.0 +0.6 +0.2 +0.6 +0.4
+1.5 +0.2 +0.5 −0.3 +0.8 +1.9 +0.7 +0.4 +0.5 +0.4
+0.9 +0.7 +0.4 −0.8 +0.6 +2.1 +0.7 +0.3 +0.5 +0.3

*Fig. 7* **Printing form**

## V. CONCLUSION

A general description of the SA-1 Automatic Test Equipment (RC Method) has been given above. This equipment is now being used at the Shibahashi, Tokyo, and Nagoya test facilities and is the most useful test equipment for single-phase, ac, two-wire watthour meters. Automation of test equipment will increase as the number of meter tests increases. This test equipment will be installed in the near future at all the facilities of the Japan Electric Meters Inspection Corporation located throughout Japan. Units No. 4 and 5 are presently being manufactured for installation at the Osaka and Fukuoka test facilities.

We wish to express our appreciation to the staff of Fujitsu for their cooperation in the joint manufacture of this equipment.