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HIGH CLASS MOTOR DRIVEN TIMER, TYPE ATM1

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I. INTRODUCTION

Timers are very important components for sequence and program control and Fuji Electric started producing timers 8 years ago, only a few years after they first became well known. In the past, Fuji prepared series mainly of the ordinary type timers which account for the major part of the demand. These series were complete in respect to quality, performance and types and a manufacturing system was established so that users' demands in respect to quality and delivery periods could be met.

The high class ATM1 timer series with a long life (10 million times) and high accuracy (±0.5%) which can not be accepted or rejected only in respect to price has been developed to complete the high class timer series along with the former SM series. The ATM1 series has the following features:

1. Single Scale

Timers with both 50 and 60Hz scales which are characteristic of motor timers employ a single scale to avoid reading errors. Therefore, in consideration of easy operation of the frequency switch attached, all timer operations can be performed from the front surface. Even when using in regions where the frequency differs, the time taken for controller adjustments is saved since only operation of the frequency converter is needed.

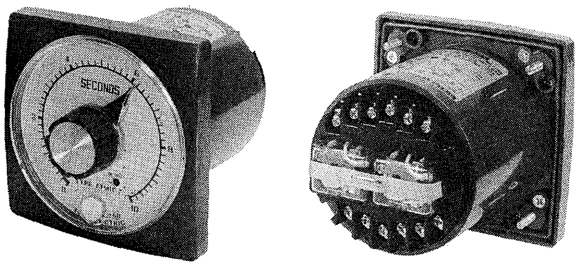
2. Convertable Output Relay

Since a relay which can be freely attached or removed is used in the output contact part, maintenance and inspection of the output contacts are very easy. Even though the unit has sufficient withstand in accordance with the load capacity, the entire timer must be replaced if the output contacts become bad but with this construction, only the output contact relay need be changed. This is highly economical since the timer can be used for the full life stated by the manufacturer.

3. Operation Display

Since the timer input/output conditions are displayed by means of a neon lamp, the operation conditions can be understood at a glance in dark areas or from afar.

The standard JIS C 4551 for motor timers was issued in 1973 and these timers conform to this standard. *Fig. 1* shows an exterior view and *Table 1*



(a) Front view (b) Rear view

Fig. 1 Exterior view of motor driven timer, type ATM1E

Table 1 Specifications

Items \ Model	ATM1EPJ (Self reset type)			ATM1ESA (Electrical reset type)	
Repetitive error	±0.5% (however, 5 sec. rating ±1%)				
Life	10 million times				
	Output HH62P conversion possible			—	
Contact specifications	Time limit 2C Instantaneous 1C, continuous conducted current 5A			Time limit 1C, continuous conducted current 3A	
Rated voltage	AC 100, 110, 200, 220V 50/60Hz				
Rated time limit	5, 10, 30, 60, 180 sec. 6, 12, 30, 60, 180 min. 6, 12, 24 hrs.				
Operation display lamp	Provided			Not provided	
Reset time	Less than 0.5 sec.				
Permissible voltage range	85~110% of rated voltage				
Permissible temperature range	−10°C~+60°C				
Power consumption (VA)	Clutch circuit	Motor circuit		Clutch circuit	Motor circuit
	3.6	1.3	AC 100V	2.4	1.0
	3.9	1.3	AC 110V	2.6	1.1
	3.8	2.0	AC 200V	2.4	2.0
	4.1	2.2	AC 220V	2.6	2.2
Withstand voltage	AC 2,000V 1 hour				

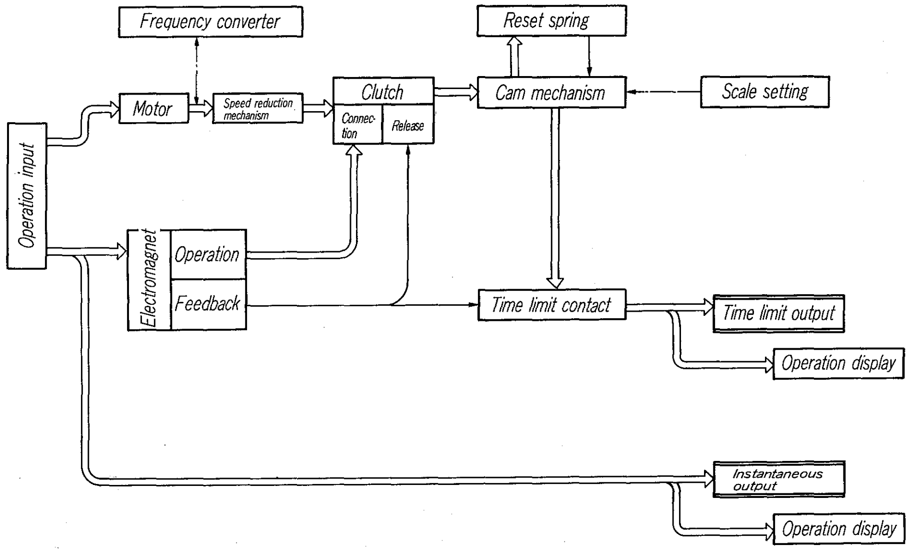


Fig. 2 Principle of the self-resetting motor driven timer (type ATM1E)

the specifications of the timers.

II. OPERATION OF THE ATM1 SERIES

Operation will be explained for the self-reset type.

This motor timer consists of a motor, speed reduction mechanism, cam mechanism, etc. for delay of the contact operation; the clutch mechanism, feedback spring, etc. for interruption of input after time mapping and for instantaneous feedback; and a relay for external output. *Fig. 2* shows the principle of construction of the motor timer which is explained in the following sections.

When operation input is applied to the timer:

1) Voltage is applied to the electromagnet, the armature is attracted and at the same time, the clutch is connected.
2) The motor rotational speed is reduced by means of a two shaft mechanism in accordance with the time rating.
3) Rotation is transferred to the cam via the clutch and the cam is rotated while the reset spring is coiled up.
4) On the other hand, the instantaneous relay operates when the power supply is connected in parallel and at the same time, the input display lamp lights.
5) The operation of the time limit contacts is stopped by the cam mechanism, the cam continues to rotate and operation is delayed until the contact mechanism falls into the cam groove. At the same time as it falls in the groove, the time limit contact operates and simultaneous with the operation of the time limit output relay, the time limit output is given out. At the same time, the output display lamp lights.

When the operation input is cut:

1) The electromagnet is reset, the clutch connection is broken and the contact mechanism is removed from the cam groove. Therefore, the cam is reset to an equivalent position on the setting scale by the force of the reset spring.
2) Simultaneously, the contact mechanism is reset and the time limit relay is reset.
3) The instantaneous relay when the power source is connected in parallel is also reset.

The electrical reset system is also applied at the same time as the self reset system as a type for different operation functions. The self reset timer is automatically reset simultaneously with input interruption and it has no memory functions. The electrical reset timer is not reset when there is no input and is constructed so that it can maintain current conditions. Therefore, the clutch mechanism is normally connected and resetting is performed by application of input to the clutch circuit. Thus, even when there is a power interruption prior to time mapping, operation can be performed. This timer can save more on power than the self-reset timer.

III. CONSTRUCTION AND FEATURES

The Fuji ATM1 series of motor timers incorporate the technology established for the ATM2 series and the series also features a high level of plastic technology, no unnecessary mechanisms and various new mechanisms. The construction features are described below.

1. Motor and Speed Reduction Mechanism

The motor used in the timer is a small synchronous motor which rotates at a constant speed synchronized with the power supply frequency. This motor has the following features:

1) Construction is greatly simplified and the motor is compact.
2) The rotational speed is constant. If the power supply frequency is constant, the rotational speed

is kept at a constant value even if the voltage and load vary within a certain range.

3) There is little variance in starting time and stopping is also rapid. The motor starting time (time from start of rotation until synchronization occurs) which can not be avoided as a cause of timer repetition errors is theoretically less than 2Hz and actually less than 40ms. The stopping time is within 0.5Hz and appropriate conditions for timers are arranged.
4) Durability and reliability are high. Since the construction is very simple, there is no static or dynamic unbalance in the rotor and there are many poles (24), the motor rotates at a low speed (50 Hz, 250 rpm) and a long life can be expected. Since the bearing is of the oilless type and is made of a polyamide resin impregnated with molybdenum disulfide, it can be used over a wide temperature range.

The speed reduction mechanism of former motor timers (at present, the models of other manufacturers are almost all of this type) was generally in the form of a single unit with the motor but even with the simple construction, because of considerations to prevent the leak of gearbox oil to the exterior, there are restrictions on timer attachment conditions during operation. Since the operation test must be performed for long periods with parts with long term ratings, there were cases where the test could not be performed sufficiently.

In order to eliminate these defects, all of the Fuji motor timers have the motor and the speed reduction mechanism separated. As can be seen in *Fig. 3,* the speed reduction mechanism is a two-axle, multistage with support on one side. The gears are made of polyacetyl resin which has excellent self-lubricating characteristics and it is easy to change the speed reduction ratio. Therefore, all the timers are assembled for short time ratings and after a test cycle consisting of several thousand operation tests, the timers are reassembled for the required time ratings so that high reliability can be maintained. Since the speed reduction gears require no oil dip, there are no limits concerning installation.

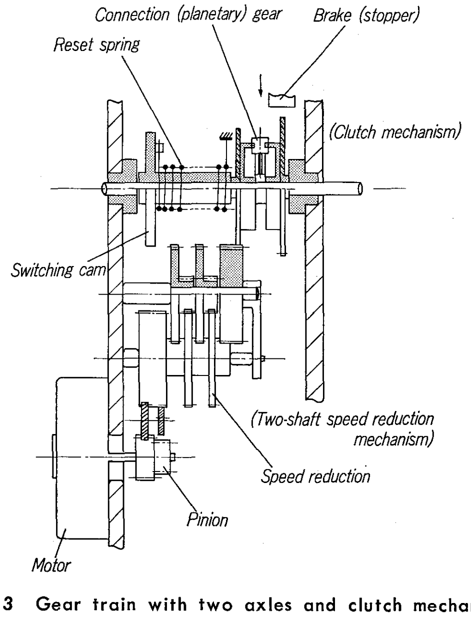


Fig. 3 Gear train with two axles and clutch mechanism

2. Clutch Mechanism

The motor timer clutch mechanism must conform to the following conditions:
(1) Speed response must be high.
(2) Transmission must be possible with no errors.
(3) Operation force must be low.
(4) Durability must be high.
(5) Quality must be easy to maintain.
(6) Low cost production must be possible.

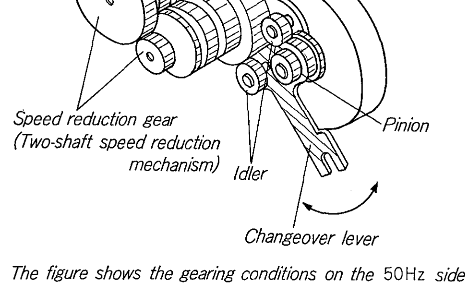
To satisfy the above requirements, tests were performed on various systems and as a result, the differential gear type clutch mechanism was adopted. This mechanism differs from the clutch mechanism used in the former ATM2 series in that the material of the gear part has been changed from resin to metal. The main reasons for this were that the expansion coefficient differed by about one figure, operation stability could be assured in the high temperature regions and repetitive errors were small. Since the moment of inertia was designed to be low, durability is high and speed response is also high.

Another feature of this type of clutch mechanism is that even when settings are changed during operation, no unnecessary force is applied to the internal mechanism.

3. Single Scale and Frequency Switching Mechanism

Most of the conventional timers made in Japan have been of the double scale type. This was because a motor with rotation synchronized with the power supply frequency was used and in the double scale timer, scale selection in accordance with the frequency used was a troublesome part of the setting work. There were also setting errors.

In the Fuji ATM1 series of motor timers, the single scale system is used through the use of an



The figure shows the gearing conditions on the 50Hz *side*

Fig. 4 Changing device for driving ratio of gear mechanism independent speed reduction ratio conversion mechanism.

As is shown in *Fig. 4*, the motor shaft pinion (speed reduction ratio is 5:6) is in two stages so that the gear meshing is in accordance with the frequency used for the idler. The full-scale time for 50 and 60 Hz is the same with a change in the conversion ratio of the speed reduction mechanism at the power supply frequencies of 50 and 60 Hz. Therefore, it is sufficient to select the frequency used by means of the knob on the frequency converter.

This type of converter is operated from the rear in some foreign made timers but in the ATM1 series, it can be operated from the front surface which completely eliminates the troublesome problem of operation from the rear.

This not only eliminates scale reading errors and setting mistakes but also improves the operational and test efficiency in areas where the frequency differs. For example, when a group of timers on a control panel used in a 60 Hz region is adjusted for a 50 Hz region, the frequency converter is set to 50 Hz in the 50 Hz region and after adjustment, when used in a 60 Hz region, it is not necessary to change the settings of the timers set in the 50 Hz region. Only the knob of the frequency converter need be set to the 60 Hz side and two adjustments are unnecessary.

4. Output Contact Conversion

The output contacts of conventional timers are normally constructed in a single unit with the timer mechanism and since the switching capacity is large in high class timers, the electromagnet load is increased, space is wasted and contact reliability is limited to confirmations of only the contact part. However, in the ATM1 series, a separate relay unit is used for the output contacts. The contacts which operate the relay are twin contacts and contact reliability is improved.

In accordance with this method, when the relay life which is shortened by the load switching capacity is shorter than the life of the timer itself, only the relay need be replaced and the timer can continue to be used. In this way, the utmost economy can be achieved.

5. Economic Design of the Electrical Reset System

With the electrical reset system, parts have been added to the self reset system and improvements have been made over former models. The electrical reset system therefore is higher in price. This is the same in the case of the ATM1 series but as a result of the construction, only one part has been added to the self reset type unit and the structural costs for the electrical reset type are the same as those for the self reset type.

A detailed explanation is omitted but with the structural design in which the clutch magnet can be attached in reverse as shown in *Fig. 5*, the electrical reset type can be achieved by adding only one part.

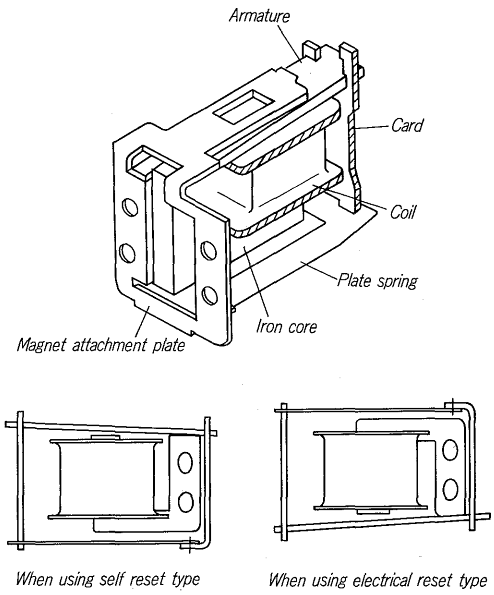


Fig. 5 **Clutch magnet**

IV. MAIN FUNCTIONS OF THE ATM1 SERIES

1. Variations in Operating Time

Variations in operating time are obtained by the following formula:

$$\pm\frac{1}{2}\times\frac{T_{max}-T_{min}}{T_{ms}}\times 100\ (\%)$$

where T_{max}: Max. operation time setting in the same set

T_{min}: Min. operation time setting in the same set

T_{ms} : Max. scale time

Variations in the operating time in JIS C 4551 are $\pm 0.05\%$ and in the maximum accuracy range, the variation in the ATM1 series is also $\pm 0.5\%$ which conforms to the JIS maximum class. The rotation of the synchronous motor which is the time standard for the motor timer is constant in accordance with the stability of the power supply frequency and is almost unaffected by voltage variations and ambient temperature changes. However, variations in operating time vary depending on the starting characteristics such as variations in motor starting time, clutch accuracy and the accuracy of the mechanisms such as gear train play. In the ATM1 series, the repetitive accuracy is $\pm 0.5\%$ and the special points to be considered in design and assembly are the clutch design and stabilization of the clutch processing precision. Setting errors (differences in average values of the setting scale values and the actual operation times) are $\pm 2\%$ or less. The setting errors are influenced by motor starting delays, scale eccentricities, gear train play, etc. but there is some difference according to the time ratings

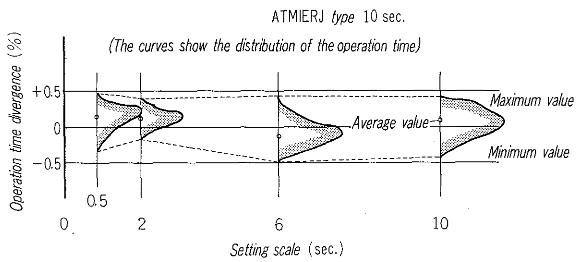


Fig. 6 **Setting and repeat accuracy of motor driven timer**

although it is small. However, in practice, the repetitive error is the most important and the setting error does not present much of a problem. An example of the operation time characteristics is shown in *Fig. 6*.

2. Voltage Range

The operating voltage in JIS C4551 is within the 85∼110% range of the rated values of the operating circuit voltage. This is also the standard range for the ATM1 series. Voltage variations within this range have almost no effect on the motor timer operating time and the upper limit of the voltage range is determined by the electromagnet in the timer and the temperature rises in the various motor coils. The lower limit is determined by the attraction characteristics of the electromagnet. However, one must not overlook the ambient temperature. Naturally continuous use at the maximum permissible voltage and temperature will lower the timer life and is not the desired method of use. Overvoltage for a short period are permissible but voltage of over 120% the rate values should be avoided because they will cause irregularities in motor starting and rotation.

3. Temperature Range

In the ATM1 series, the timers are designed for actual use in an ambient temperature range of −10° to 60°C. Naturally, there is almost no effect on the motor timer operating time within this temperature range. The point considered in design was the increase in operating voltage when the timers are used continuously at high temperatures. In DC electromagnets, it has been found in tests that the operating voltage is altered almost linearly by temperature rises and this will result in the same type of increase in the coil inner resistance. For withstand at the maximum permissible temperature and voltage, the electromagnet temperature rises were held down by limiting the electromagnet load to a minimum and the problem was also solved by using insulation materials with excellent thermal resistance characteristics.

4. Life

The main concepts to be considered in the life of the motor timers are mechanical life and electrical life. The former can be considered as related to mechanical friction, deterioration of mechanical parts due to environmental influences and the latter can be considered as deterioration in the contact resistance, insulation, etc. However, there are many cases where the mechanical and electrical lives do not agree, depending on the use conditions of the timer. In the ATM1 series, the nominal life is 10 million times. In consideration of the mechanical life, the DC electromagnet which has a longer life than AC electromagnets is used and the electromagnet armature stroke is as small as possible. The wear coefficients of sliding mechanical parts and the amount of sliding have also been minimized as much as possible. Considering electrical life, the relay used in the output contacts can be easily replaced and maintenance and inspection are easy when the contact life is shortened by differences in load capacities. Therefore, when the contacts deteriorate before there is any deterioration in the main timer unit, it is not necessary to replace the timer as a whole which is very economical for the user. The output relay used is the Fuji HH62P by-power relay.

5. Resetting Time

The resetting time of motor timers is equivalent to the time from switching on of the operating power supply until rotational resetting of the clutch and stopping at the scale setting position. (However, in the electrical reset system, it is from the moment 85% of the rated voltage is applied.) This changes according to the setting position and the resetting time at the maximum scale setting is about 0.4 sec. Therefore, the time from cutting off of the timer operation input until reclosing, i.e. the idling time, must be more than 0.5 sec. *Fig. 7* shows the idling time characteristics. In the electrical reset system, the time at which the reset input is applied is equivalent to the idling time as was described previously and therefore, care is necessary in circuit construction.

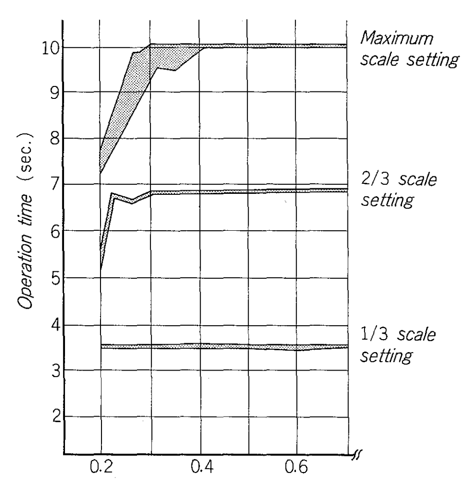
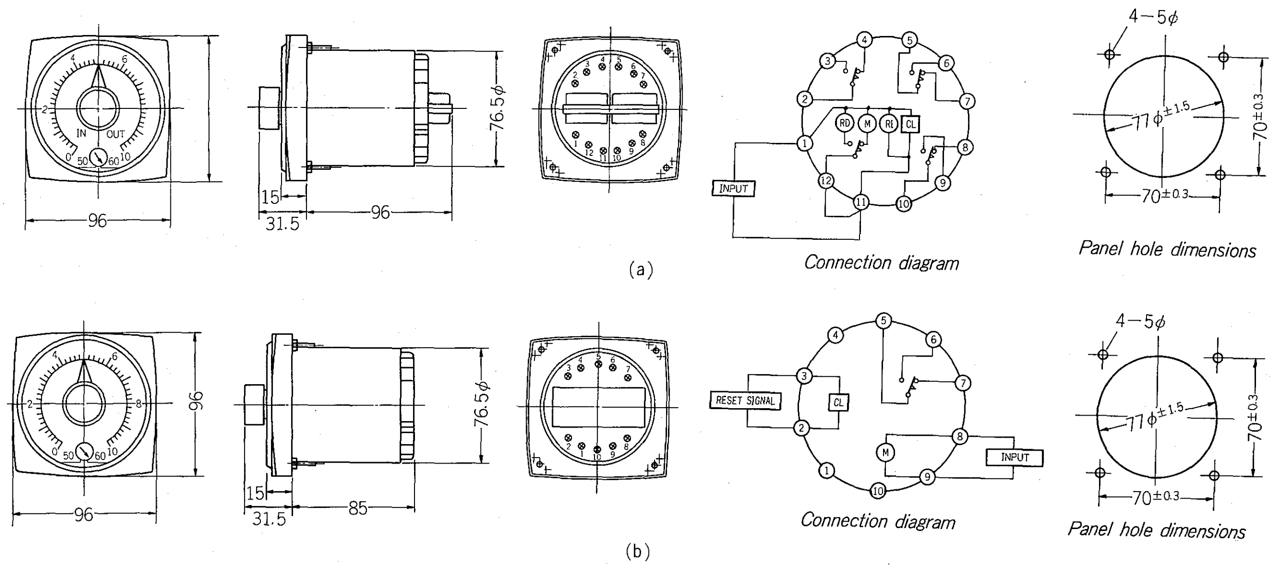


Fig. 7 **Characteristics of reset time in motor driven timer**



(a) Self reset (b) Electrical reset

Fig. 8 **Outline and connections**

6. Operating Environment

The ATM1 series was tested as follows concerning the operating environment and performance was confirmed. However, these tests do not show conditions of continuous use and should only be considered as performance criteria.

1) Thermal resistance

Heat resistance in storage

The timer was placed for 16 consecutive hours in a thermostatic oven at 70°C. It was then removed under standard test conditions and after standing for 1∼2 hours, operating and insulation characteristics were found to be good.

2) Moisture resistance

The timer was placed for 48 consecutive hours in an environment with an ambient temperature of 60°C and a relative humidity of 90∼95%. It was removed under standard test conditions and after standing for 1∼2 hours, operating and insulation characteristics were found to be good.

3) Vibration resistance

The timer was subjected to vibrations with frequencies of 16.7 Hz and amplitudes of 4 mm (maximum acceleration: about 2 g) in three axial directions, each for one hour. No mechanical or electrical abnormalities occurred during or after the test.

4) Shock resistance

Two impacts each with an acceleration of 100g were applied in the 3 axial and 6 directions and no mechanical or electrical abnormalities were found after the test.

V. DIMENSION AND CONNECTION DIAGRAMS

The outer dimensions and connections of the self and electrical reset models of the ATM1 series are shown in *Fig. 8*.

VI. CONCLUSION

In industry which is progressing at such a rapid rate, timers are coming to play an important role in various types of control equipment but users' demands are becoming more severe from the standpoints of performance, price and delivery periods. Greater efforts will be needed in the future to meet these demands.