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NEW PRINTING RECORDER

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I. FOREWORD

Printing recorders were developed around 1955 and first used to automatically record watt-hours (kwh) at unattended substations. Later, with the recognition of their extensive applicability, printing recorder were applied to monitor the power consumption of high demand consumers. This was followed by their use as multi-tariff watt-hour meters to measure the power supplied to special power consumers. This application requires higher recording time accuracy, smaller counting units and higher operational stability. In order to meet these requirements, Fuji Electric has developed a new Z-series printing recorder having performance which is higher than that of the presently used DZ-series. The high performance of the new Z-series recorder has been attained by the use of a high precision crystal clock, synchronous motor clock, high frequency pulse receiver designed to have an extended service life, and a stable printer.

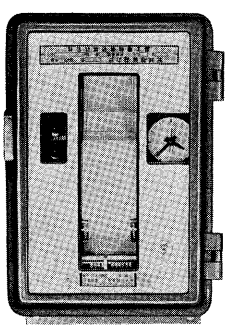


Fig. 1 External view of the new printing recorder

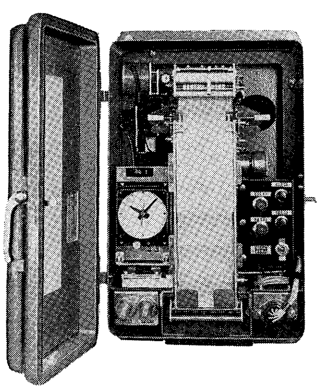


Fig. 2 External view of the new printing recorder with the cover open

II. TYPES OF PRINTING RECORDERS

The different types of Z-series printing recorders are listed in *Table 1*.

III. FEATURES

New printing recorders have the following features.

1) Both watt-hour integration and demand (kwh and kw) are recorded simultaneously

Total watt-hours (kwh) and inlegration per period are separately recorded, eliminating the necessity of manual calculation.

2) Measured values are in extremely small units

The measured power is in small units (1/100 of the minimum graduation of the electrical impulse meter [watt-hour meter equipped with a pulse transmitter]), total integration in *6* digits, and integration per period in *4* digits.

3) Recorded value over a long period of time can be easily read

Since the recorded values for more than 24 hours (integrated at 30 minute intervals) can be readily read from outside, confirmation of these values is convenient.

4) Present values are directly displayed (Refer to *Fig 3*.)

Table 1 **New Type Printing Recorders**

Type	Resistor	Type of Clock	DZ-Series Equivalent	Frame Type
ZS 1	Integration plus demand	Synchronous motor type (Power interruption free)	DZ-4	No mark: Surface-mounted meter (front connection)
ZS 2	Integration		DZ-1	
ZM 1	Integration plus demand	Master clock	DZ-5	Te : Flush-mounted meter (behind connection)
ZM 2	Integration		DZ-2	
ZC 1	Integration plus demand	Crystal clock	DZ-8	Ts : Surface-mounted meter (behind connection)
ZC 2	Integration			

Symbol Designations

Z: New printing recorders
S: Synchronous motor type (power interruption free)
M: Master clock type
C: Crystal clock type

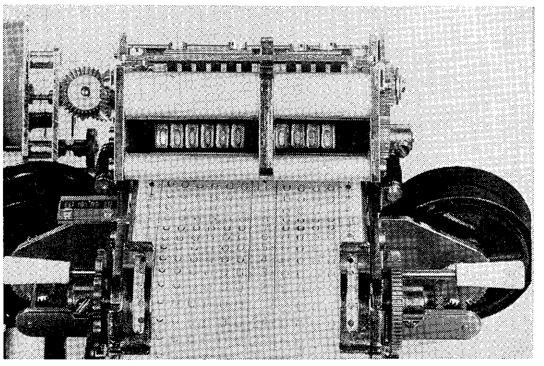


Fig. 3 Register

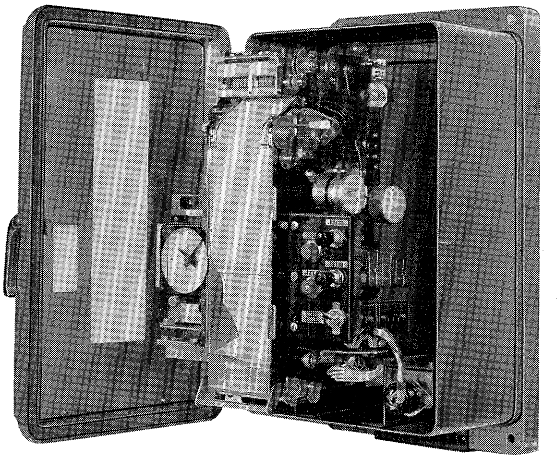


Fig. 4 Internal mechanism in case

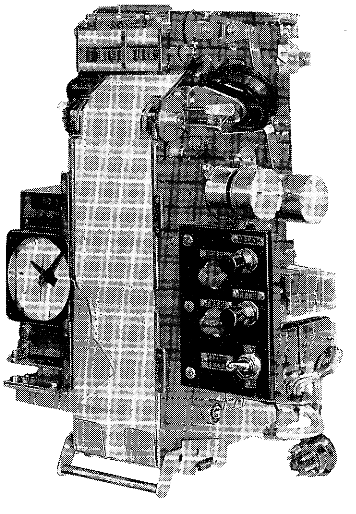


Fig. 5 External view of internal mechanism

Present values are displayed at the front of the instrument, facilitating comparison with figures measured at the electrical impulse meter. Dial lens makes reading convenient (utility model pending).

5) Ease of figure wheel adjustment

Individual figure wheels can be turned independently for quick resetting.

6) Motor-driven printing and resetting mechanisms

The printing and resetting mechanisms are driven by a high torque dc motor. This, along with simple construction, insures high reliability (utility model pending).

7) Impulse storage system for interruption during print and reset

Measuring impulses counted during printing and resetting are stored until completion of these operations and then fed at the beginning of the new integration period to prevent negative counts.

A maximum storage capacity of 8 pulses allows ample time for printing and resetting, thus assuring reliable operation.

8) Register circuitry has extended service life

The contactless circuit consisting of the stepping mechanism and thyristors makes the service life of the impulse receiver almost permanent and provides highly reliable high frequency pulse operation (utility model pending).

9) Highly accurate, long service life clocks

The highly reliable, long life crystal clock employs a 160 kc crystal whose output is frequency divided into the 1 pulse/sec signal used to drive the powerful stepping mechanism. The stability of this clock is ± 1 sec/day. The synchronous motor type printing recorder employs a high-torque low-speed hysteresis synchronous motor to insure stability and long service life except for small line fluctuations.

10) The internal unit can be readily exposed by means of rollers (Refer to *Figs. 4* and *5*).

All types are equipped with rollers to facilitate exposure of the internal components. All mechanisms are built as individual units for ease of maintenance and inspection.

11) Ink ribbon return

The direction of the ink ribbon feed can be easily switched by means of a lever.

12) More than 24 hours of power interruption assurance (In the case of a 1 hour integration period)

Operation for more than 24 hours on the built-in alkaline battery during power interruption.

IV. CONSTRUCTION

This printing recorder consists of a clock mechanism, timing pulse shaping circuit, control circuit, printing/feeding mechanism, resetting mechanism, register, and pulse memory (Refer to *Fig. 6*).

The timing pulses generated by the clock are converted into pulses (pulse width $1\sim2$ sec) by the timing pulse shaping circuit and then used to drive the printing/feeding and zero resetting mechanisms, which print the measurements on the recording paper and feed the recording ink ribbon, by means of a dc motor.

V. MECHANISM SCHEMATICS

1. Clock Mechanism

(1) Synchronous motor type (Type ZS)

A synchronous motor is used in the clock mechanism to deliver a timing pulse at predetermined

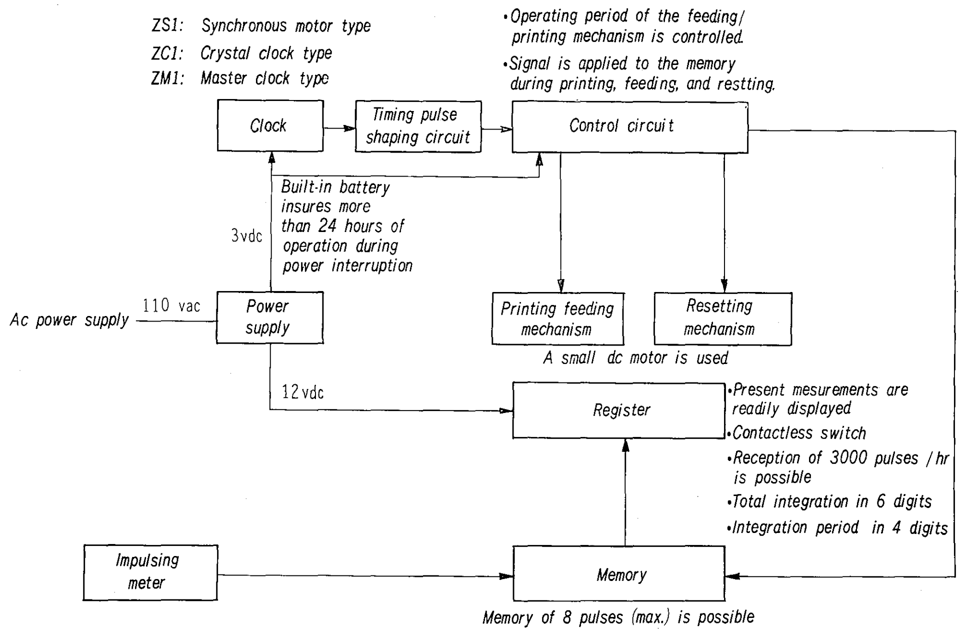


Fig. 6 Schematic diagram of new printing recorder

intervals (15, 30, and 60 min).

The synchronous motor (having a magnetic clutch) rotates in synchronism with the line frequency.

During power interruptions, the magnetic clutch is released and a balance wheel starts to operate. The balance wheel is driven by a dc motor whose energy is dampened by a buffer spring on its way to the balance wheel. A timing pulse cam, having a microswitch to deliver the timing pulse, is connected to the shaft which makes one complete revolution every hour. The timing pulse intervals can be changed by means of the pulse cam (4, 2, and 1 fin, respectively).

(2) Crystal clock type

Fig. 9 is an external view of the crystal clock and *Fig. 10* is its block diagram. The crystal clock

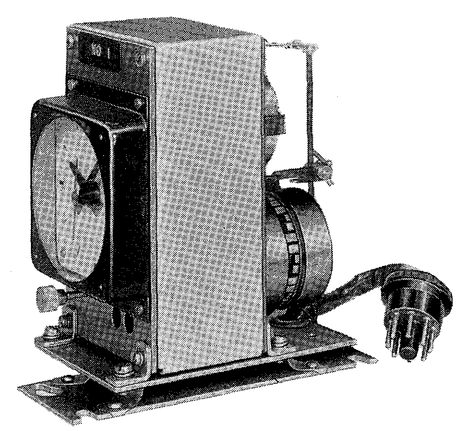


Fig. 7 External view of the synchronous motor clock

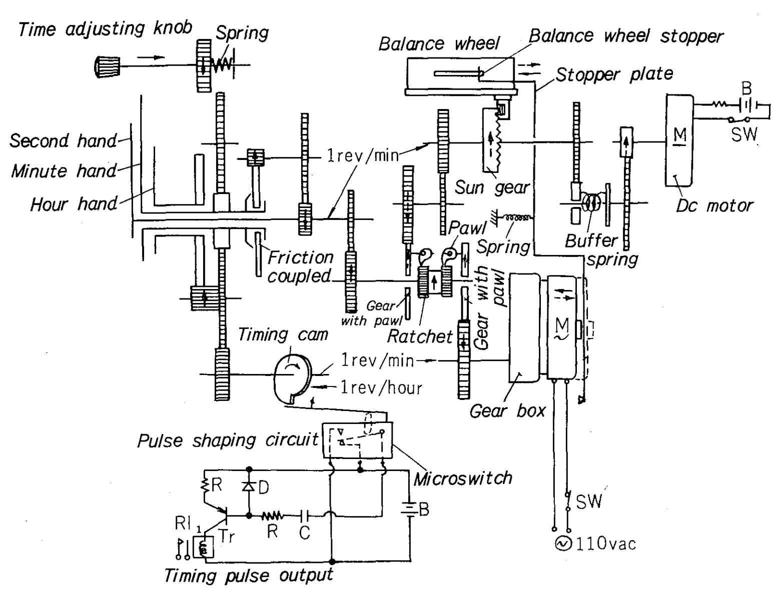


Fig. 8 Construction of the printing mechanism

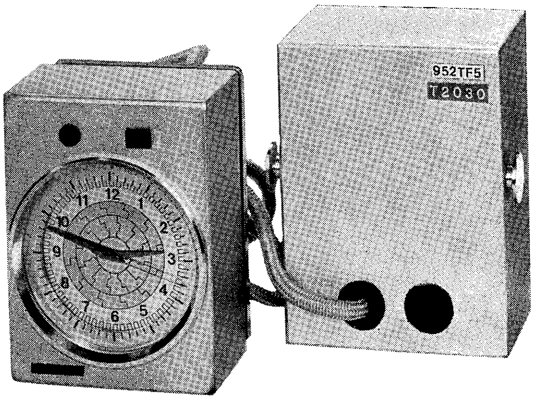
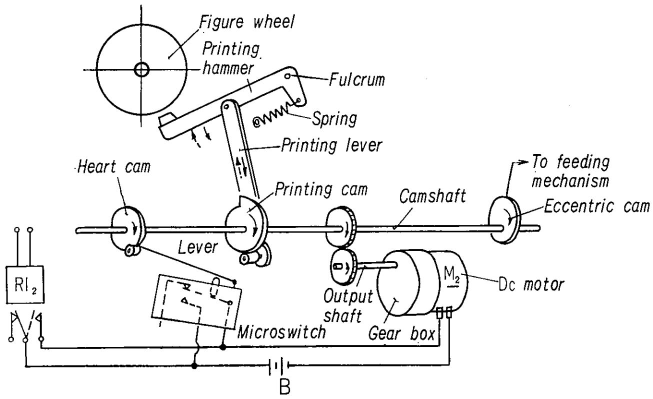


Fig. 9 External view of the crystal clock



Fg. 12 Construction of the printing mechanism

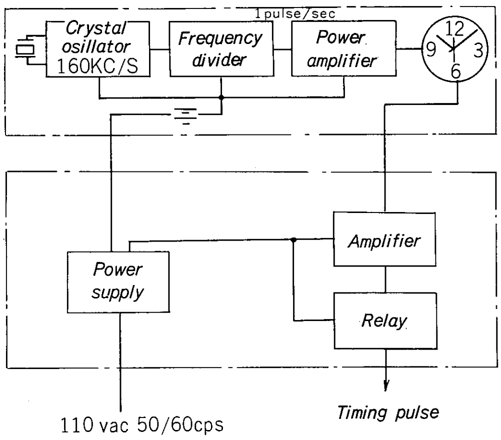


Fig. 10 Block diagram of the crystal clock

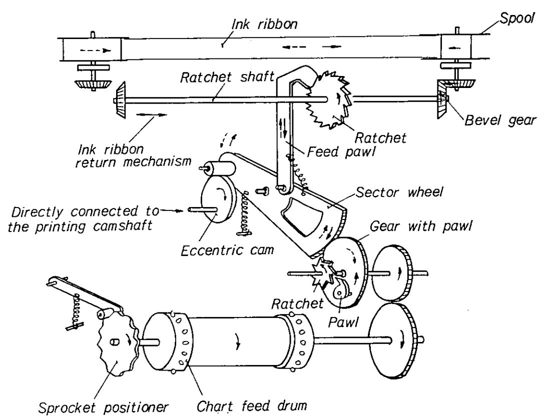


Fig. 13 Construction of the chart and ribbon feeding mechanism

mechanism includes a crystal oscillator, frequency divider, power amplifier, time display, power supply, and timing pulse generator. The 160 kc output of the crystal is frequency divided into a 1 pulse/sec signal by the transistor blocking oscillator and multivibrator and then amplified and used to drive the time display step mechanism (three pointers are driven to produce timing pulses at intervals of 15, 30, and 60 min). Timing pulse intervals (integration periods) can be changed by means of a switch.

The power supply converts the 110 vac line power into 4.5 and 15 vdc, by means of a transformer and rectifier, float charges the 4.2 and 14 v alkaline batteries, and supplies power to the crystal oscillator, frequency divider, and amplifier. The alkaline batteries insure continuous operation for more than 24 hours during power interruptions.

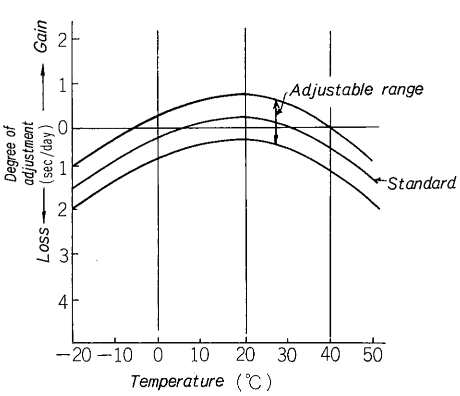


Fig. 11 Temperature characteristics and adjustment limits of the crystal clock

The temperature characteristics and adjustable range of the crystal clock appear in *Fig. 11*.

2. Timing Pulse Shaping Circuit

When the timing pulses are extracted from the timing pulse cam attached to the shaft which makes one complete revolution every hour, as in the case of the clock used in ZS recorders, the reduction of microswitch make time by improving the manufacturing accuracy of the cam is limited. Therefore, the pulse shaping circuit is used to reduce and regulate the pulse width to 1∼2 sec.

This circuit operates the relay Rl_1 and controls the collector current (output side) by means of the time constant of *R* and *C* in the transistor *Tr* base circuit.

3. Control Circuit

The control circuit is used to control the printing/feeding and resetting mechanisms by means of the timing pulses. It is also used to sequentially trigger the impulse memory. When a timing pulse is applied,

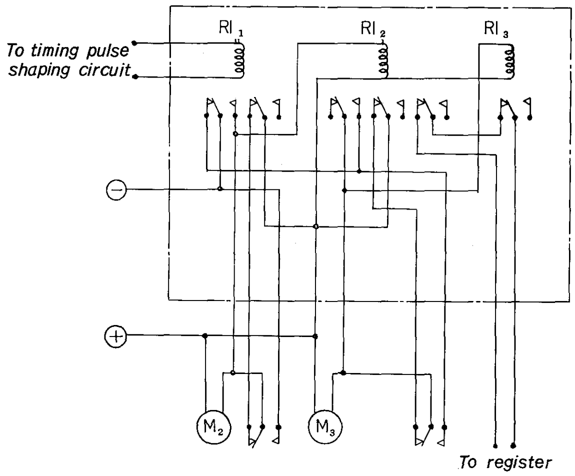


Fig. 14 **New printing recorder control circuit**

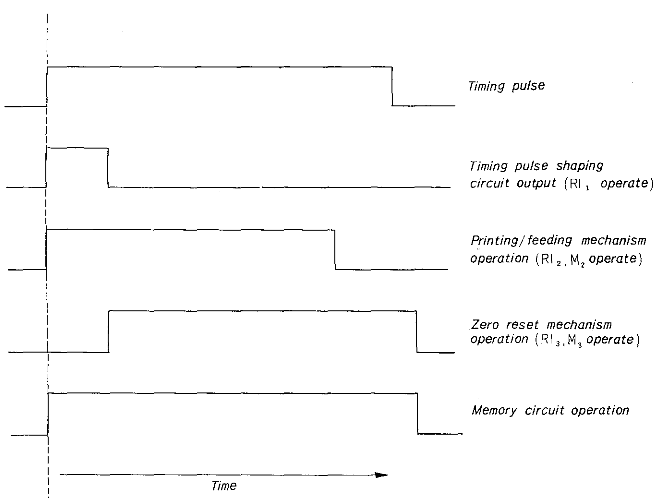


Fig. 15 **Timing relationships of new printing recorder mechanisms**

impulse Rl_1, M_2, and Rl_2 are actuated and when the timing pulse is removed M_3 and Rl_3 are actuated.

This circuit appears in *Fig. 14* and the timing chart in *Fig. 15.*

4. Printing/Feeding Mechanism

The printing mechanism is shown in *Fig. 12* and the feeding mechanism in *Fig. 13*. When a timing pulse is applied, relay Rl_2 is energized and starts the dc motor. The motor speed is reduced by means of the gear box and then transferred to the output shaft. A gear on the output shaft then transfers the rotation to the camshaft. The camshaft has a heart cam, printing cam, and eccentric cam. The heart cam transfers the motion to the microswitch, the printing cam transfers it to the printing lever, and the eccentric cam transfers it to the sector wheel gear. As the camshaft rotates, the heart cam shifts the lever and closes the microswitch contacts which are self-held to keep the motor circuit closed; the printing cam shifts the printing lever in the direction of the solid arrow when the cam makes the first half of its movement and, when the notch is reached, permits the spring to move the lever and hence the printing hammer in the direction of the broken line and print the measurement on the paper (printing action). The printing hammer is forked to apply a uniform pressure to each printing wheel, thus assuring clear print impressions. The eccentric cam shifts the sector wheel in the direction of the broken arrow during the first half of the motion and, by this action, turns the pawl in the direction of the dotted arrow. The pawl simply slides against the ratchet and does not turn the paper feed drum at this time. The feed pawl also slides against the ratchet and moves in the direction of the broken arrow and, therefore, does not transfer the rotation to the ink ribbon spool (delay action). During the second half of the motion, the sector wheel and pawl gear move in the direction of the solid arrows and the pawl and ratchet engage. This transfers the motion to the paper feed drum and turns it one step. In the meantime, the feed pawl moves in the direction of the solid arrow turning the ratchet which then feeds the ink ribbon an appropriate length (feeding action).

The direction of ribbon feeding can be switched by moving the ratchet shaft to either the right or left thus changing the bevel gears on the shaft which provide the different spool rotating directions when engaged with the spool gears.

5. Zero Reset Mechanism

Fig. 16 is a schematic diagram of the resetting mechanism. When a timing pulse is applied to relay Rl_3, the relay operates and closes the dc motor circuit thereby starting the motor. The motor speed is reduced by means of the gear box and appears

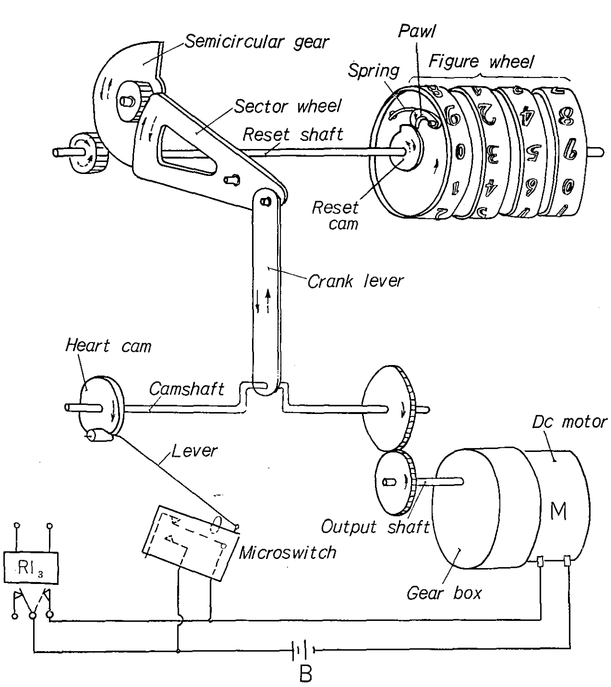


Fig. 16 **Construction of the zero reset mechanism**

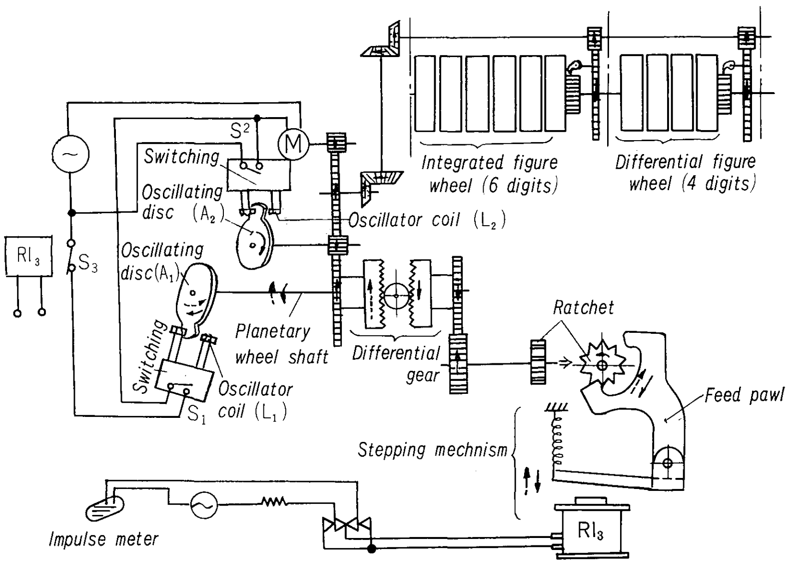


Fig. 17 Construction of the counting mechanism

at the output shaft. A gear on the output shaft then transfers the rotation to the camshaft. The cam shaft is equipped with a heart cam and a crank. A microswitch is attached to the heart cam and a crank lever to the crank. The heart cam moves the lever to close the microswitch contacts which are then self-held to keep the motor circuit closed. The crank moves the crank lever in the direction of the solid arrow during the first half of its motion. This operation moves the sector wheel and semicircular gear in the direction of the solid arrows. The semicircular gear turns the reset cam in the direction of the solid arrow. At this time, the reset cam slides against the pawl (the pawl is normally held against the reset cam by a spring) of the character wheel and is idle (delay action). During the second half of the motion, the crank lever, sector wheel, and semicircular gear all turn in the direction of the broken arrows. The reset cam is also turned in the direction of the broken arrows. The reset cam is also turned in the direction of the broken arrow by rotation of the semicircular gear. At this time, the reset cam engages the pawl of the figure wheel to reset the character wheel (resetting action).

6. Counting Mechanism

Fig. 17 shows the construction of the counting mechanism. A pulse transmitted from the impulse meter energizes stepping relay Rl_1 which then shifts the pawl in the direction of the solid arrow. The pawl then moves the ratchet forward one-half step in the direction of the solid arrow. The spring returns the pawl in the direction of the broken arrow when the relay is de-energized. This operation moves the ratchet forward another one-half step in the direction of the solid arrow. That is, the ratchet moves one step forward as the impulse meter turns a pulse on and off (stepping action).

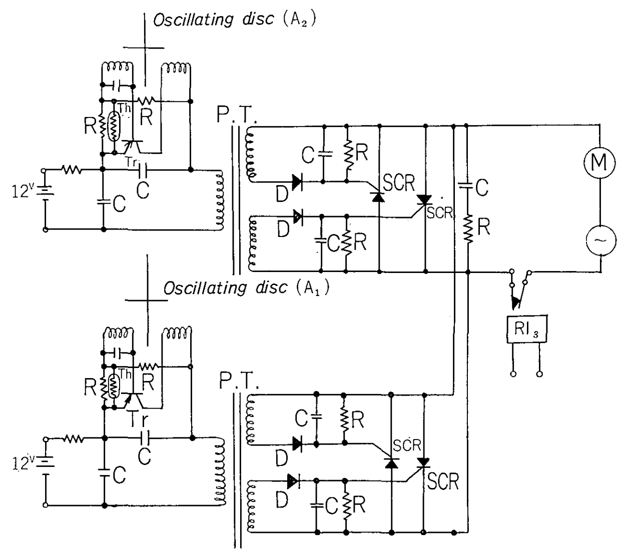


Fig. 18 Switching circuit diagram

This ratchet rotation turns the sun wheel (right hand side of the differential gear train) in the direction of the solid arrow and the planetary wheel a predetermined number of turns in the direction of the solid arrow. An oscillating disc (A_1) is connected to the planetary wheel shaft and revolves a predetermined angle to magnetically couple the oscillator coils (L_1). This closes the switching circuit (S_1) and starts the counting mechanism motor. The differential gear train also transmits rotation to oscillating disc A_2 which acts to couple oscillator coils L_2 thereby closing switching circuit S_2 and starting the motor. One rotation of the motor advances the counting mechanism figure wheel one character (counting action). This rotation also turns the sun wheel (on the left) in the direction of the broken arrow by means of a gear. The planetary wheel is also turned in the direction of the broken arrow at

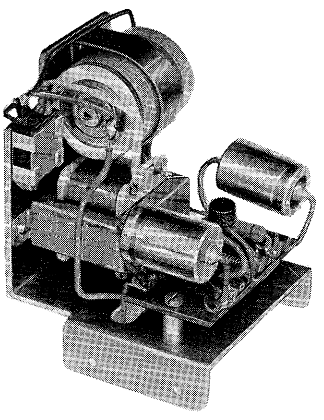


Fig. 19 External view of the power supply

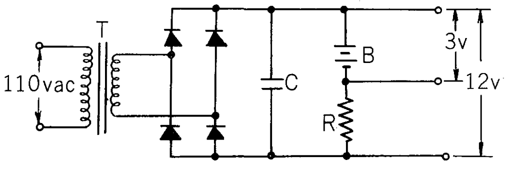


Fig. 20 Power supply circuit diagram

this time. This action returns oscillating disc A_1 to its original position and decouples oscillator coils L_1 to open switching circuit S_1 and stop the motor.

Switching circuits S_2 prevent pulses arriving during the counting operation from interfering with operation of the counting wheel. A timing pulse applied to relay Rl_3 energizes the relay and opens contacts S_3. Since contacts S_3 are open, the motor cannot start even when a pulse from the impulse meter actuates oscillating disc A_1 and switching circuit S_1. That is, the pulse from the impulse meter will actuate the oscil lating disc but the motor will not start (memorizing action). Contact S_3 is ganged with the reset mechanism so that it will close upon completion of the reset action and start the motor to count the memorized pulses on the counting wheel (memory reproduction action). Since contacts S_1 and S_2 operate every time a pulse is received, their operation is quite frequent. Mechanical contacts, such as microswitches, become faulty after a period of use. For this reason, an electronic switch consisting of transistors and thyristors is employed in this printing recorder. This assures long service life and stable operation. This switching circuit is illustrated in *Fig. 18*.

7. Power Supply

An external view of the power supply appears in *Fig. 19* and its circuit diagram in *Fig. 20*. The 110 vac line voltage is stepped down by the transformer and converted to 3 and 12 vdc to float charge the 3 v alkaline battery. It also supplies 3 v to the printing mechanism, reset mechanism d-c motor, and timing pulse receiving relay. The 12 vdc is supplied to the switching circuit of the counting mechanism. The 3 v alkaline battery is used to power the printing mechanism, reset mechanism, and timing pulse receiving relay during power interruptions.

No battery is provided for the 12 vdc since the 110 vac power is taken from the secondary of the instrument transformer (the same power used for the watt-hour meter equipped with an impulse meter). No pulses are produced during power interruptions because the power to the watt-hour meter is also interrupted.

VI. SUMMARY

Conventional printing recorders in commercial applications were not necessarily satisfactory with respect to the suitability of counting units and the service life. The newly developed Z-series offers a longre service life due to use of a contactless switch in the input section and counts pulses to the order of 3000 per hour. This series not only has counting units which are suitable for commercial applications but also completely satisfies JIS accuracy requirements for maximum demand meters. In addition to these excellent features, operation has been simplified. Fuji Electric intends to make further improvements on the basis of comments received from users.