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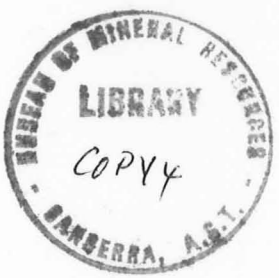
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1970 / 83

Supplementary Handbook for Willmore Seismographs



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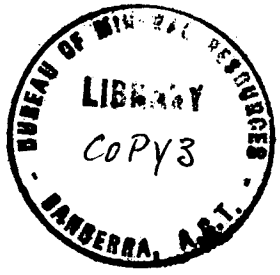

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SUPPLEMENTARY HANDBOOK FOR WILLMORE SEISMOGRAPHS

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Corrected drawings 27 Oct 69.

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ILLUSTRATIONS

SUMMARY

The standard Willmore seismograph system has been modified to meet observatory and field recording requirements at Mundaring Geophysical Observatory.

Both for station recording of weak, local events and for field recording of explosions, relatively high chart speeds are required, so the recorder speed has been increased four times to a maximum of 240 mm/minute. Larger lamps have been fitted to accommodate the higher chart speed and for longer life. Recorder power supplies have been removed or altered, and replaced by more reliable, external supplies of larger capacity.

An electromagnetic calibrator has been designed and fitted to Mark II seismometers, so that calibrations can be made regularly.

1. INTRODUCTION

Willmore seismographs are used for two purposes by the Mundaring Geophysical Observatory, operated by the Bureau of Mineral Resources, Geology & Geophysics (BMR). Firstly, as a short-period, vertical, station seismograph, supplementary to the World Wide Standard Seismograph (WWSS) for the study of local earthquakes; and secondly, for short-term field seismic recording.

Two recorders are normally operated at the Observatory Weir site, both recording for 12 hours (120 mm/min) and both connected to the same short-period vertical Benioff seismometer. The first recorder automatically switches off after about twelve hours and switches on the second recorder, thus giving 24 hours' recording at high chart speed.

The Willmore recorders normally have a maximum recording speed of 60 mm/min but for short-term seismic recording in the field, high recording speed (240 mm/min) is necessary.

The seismographs have been modified to make them suitable for these requirements, more reliable, and interchangeable with each other. Plate 1 is a circuit diagram of the modified Willmore seismographs. All modifications were carried out by Mr G. Woad at the Mundaring Geophysical Observatory.

This Record is intended to supplement the Willmore seismograph handbook (Hilger & Watts) and the Instruction Manual for the Willmore Seismometer Mark II (Hilger & Watts, 1965). It includes details of the modifications made to the seismographs, and procedures for using the seismographs in the field.

2. MODIFICATIONS

Recording speed and lamp source

The existing synchronous 1-rev/min motors were replaced by Philips 4-rev/min motors (AU5300) giving recording speeds of 240, 120, and 60 mm/min. The higher recording speeds made it necessary to replace the existing lamp source with a brighter lamp (Philips 6V, 1.45A, PX40S, Type 3871, C123) and hence a modified lamp holder was made (Plate 1).

The panel holding the lamp and covering the drive gears was divided into two so that the lamp and lamp-intensity photocell can be removed without disturbing the drive gears. The leads to the lamp and the photocell were connected through a Souriau five-pin plug so that the lamp section of the panel can be completely removed to facilitate maintenance on the recorder.

The original power supply was lightly constructed, inadequate for continuous operation, and too small for the requirements of the larger lamp. It was replaced by a 6.3-V filament transformer connected to an external 250-V mains or inverter supply.

The external mirrors on all galvanometers were replaced by mirrors measuring about 6mm by 6 mm made from thin glass microscope slides, which are easily cut. They make it relatively easy to adjust the light beam to fall on the galvanometer lens.

Time marks

The older type of recorder relied on a pulse to the galvanometer to impress time marks on the record. This was not satisfactory as it disturbed the recorder trace and often interfered with seismic phases. A deflecting time-mark mirror unit was installed in this recorder, making it standard with the newer recorders. This unit was constructed along similar lines to the WWSS recorder time-mark units (Plate 2C). Plugs (Belling Lee L1317) for the time-mark mirror, time channel, and galvanometer pulse were fitted into the top control panel of the recorder instead of the back, making them more accessible (Plate 2B).

To operate the time-mark mirrors, some recorders had internal batteries and some had full-wave rectifiers working from the power supply. In the latter system there was a 1000-micofarad capacitor across the time-mark solenoid, to smooth the rectifier. This capacitor would discharge through the solenoid and hold the time-mark mirror in the "on" position for several seconds after the release of the external time closure. To correct this fault, the position of the capacitor was altered so that it is not connected across the solenoid when the external time closure is open.

All recorders were modified so that the time-mark relays were operated by power supplied by the 6.3-V filament transformer, through a rectifier and a voltage doubler (Plate 2A) to ensure sufficient voltage for operation.

Recorder change-over switches

One recorder at Mundaring has been modified so that on completion of its record (12 hours) it switches on a second recorder and changes the seismometer input to the second galvanometer.

This is done by connecting the normally-open side of the limit microswitch to a three-pin power point fitted to the front of the recorder. The power lead of the second recorder is plugged into this power point so that when the first galvanometer reaches the end of its run and operates the limit microswitch,

power is connected to the second recorder. A 250-V a.c. relay also plugged into the power point operates and changes the seismometer input to the second galvanometer. Plate 3 shows the wiring diagram.

Caution should be taken as the limit switch is wired (original) in the neutral line of the 250-V circuit. To change this a considerable amount of rewiring would be necessary.

Seismograph plugs

The seismometer input plugs (Belling Lee L1349) of the new recorders were unsatisfactory as the spring of the plugs tended to loosen very quickly and so cause the seismometer-galvanometer circuit to open. Considerable trouble was also experienced with the galvanometer plugs (British mains type), through connexions breaking or working loose. It was also found that the wiring in the recorders differed in that the earth side was on the male pin in some recorders and the female in others. This meant that when a galvanometer was changed from one recorder to another the ground motion was reversed on the seismograms; in some cases with old galvanometers which were earthed on one side, the galvanometer was shorted.

To overcome the poor connexions and to standardize wiring, plugs from seismometer to recorder were replaced by waterproof Cannon connectors (details Plate 4) and the galvanometer plugs by five-pin Souriau connectors.

All Willmore Mark II seismometers were fitted with three-pin Cannon connectors, and connexions necessary to give the correct coil resistance were made at the terminals at the base of the seismometer, thus eliminating the need for an external junction box.

The magnets of galvanometers were reversed where necessary so that an upward movement on the seismogram corresponded to an upward ground movement (for vertical seismometers).

Calibrator unit

Electromagnetic calibrator units were constructed in the BMR workshop after the pattern of Stewart and Sutton (1967). These were modified to fit internally in the Mark II seismometers so that the waterproof properties were maintained (Plate 5). The connexions were made to a two-pin Cannon receptacle (MS 3102E-12S-3S) mounted in the hole that originally contained the desiccator.

The calibrating current will be supplied from 24-V control units used in conjunction with EMI digital clocks.

Other modifications

A nylon sleeve, in place of the metal one, was fitted over the dog clutch from the synchronous motor to the drive gears. This reduced a.c. effects on the galvanometers and also protected the recorder motor and gears from damage during transport over short distances. When transporting over long distances the clutch is best removed.

The metal rollers on all the old type galvanometers were replaced by nylon rollers, and a small perspex plate was placed between the knife guide and galvanometer frame. These isolated the galvanometer from the recorder frame, and so tended to eliminate mains a.c. interference with the galvanometer.

The graduated scale along the shutter aperture on the front of the cassettes was painted white with black graduations to make the galvanometer trace easier to see during adjustments and tests.

3. FIELD RECORDING

Willmore seismographs are at present used for all the short-term field seismic recording from the Mundaring Observatory. This section is written primarily to assist inexperienced operators.

Most field recordings made from the Observatory require the accurate absolute timing of seismic phases. The accuracy required is achieved by using the modified recorders with a paper speed of 240 mm/min (i.e. 4 mm/sec). One-second radio time pips are recorded via a 100-Hz filter directly onto the seismograms. Chronometer time marks are also recorded on the seismograms for quick reference. The time of seismic phases can be measured accurately to one twentieth of a second.

Typical field unit

Plate 6 is a schematic diagram of a typical field recording unit. Some components may be combined into one piece of equipment. For example a Labtronics time-signal receiver combines the radio receiver and filter; the BMR seismic timing unit STA 3 combines the filter and chronometer relay.

The setting up of a field unit requires certain procedures and checks to ensure that the seismograph is working correctly. Appendix 1 lists these procedures and checks, symptoms of malfunction, and the remedies. Appendix 2 lists some common faults which occur on seismograms, and their causes.

4. REFERENCES

HILGER and WATTS - Instructions for the operation and maintenance of the Willmore seismograph.

HILGER and WATTS 1965 - Willmore pattern seismograph.

STEWART, I. and SUTTON, D.J., 1967 - An electromagnetic calibration coil for a Willmore Mk II seismometer. J. Sci. Instrum. 44, 1035.

APPENDIX 1

PROCEDURE AND CHECK LIST FOR SETTING UP A WILLMORE FIELD SEISMOGRAPH

Seismometer (Vertical)

The seismometer is to be completely buried and tamped firmly in a vertical position, unless it is set on a solid rock outcrop, in which case it should be protected from wind. As the seismometer is being unclamped, watch the mass position indicator rise to its centre position.

Cable

A thirty-metre cable is generally sufficient between the seismometer and recorder. If the recorder is near an artificial noise or if it is being used with a high-gain amplifier, a 100-metre cable may be necessary to eliminate the effects of the noise and movements of the operator.

Recorder

The recorder is to be set on level ground if possible; if the ground slopes, the motor end is to be downhill.

Light spot

For rapid recording (240 mm/min) the lamp intensity is to be on maximum. The light beam is to be centred on the galvanometer lens in both elevation and azimuth by adjusting the galvanometer mirror. The beam will then focus as a line on the cassette. The elevation of the line is adjusted by tilting the galvanometer backwards or forwards until the line falls symmetrically across the cassette slit. Both ends of the cassette are to be tested, and a compromise made if necessary. The lateral position of the line on the cassette is adjusted by rotating the torsion head of the galvanometer until the line is just to the side of the external galvanometer mirror nearer the recorder motor.

Continuity of circuit

If the seismometer-galvanometer circuit is continuous, long-period ground movements should be seen by observing the recording trace at the cassette. Continuity of the circuit can be checked by turning the ATTENUATOR switch to TEST and pressing the PULSE

BUTTON. If the line oscillates freely at about 1 Hz the circuit connexions are complete. If the line moves but does not oscillate freely, the seismometer may not be completely free from its stops (refer to handbook). If the line does not oscillate when the button is pressed, but oscillates at the galvanometer free period if the recorder is jarred, then the seismometer-galvanometer circuit is open at some point and all connexions should be checked. Complete lack of line movement indicates that the galvanometer is shorted, and the leads and plugs should be checked.

Time marks

To be sure that the time marks are working, the light spot deflection should be noted. It should also be noted that the light remains nearly central on the galvanometer lens when the light beam is deflected; if not, the galvanometer mirror must be rotated slightly. If there are no minute marks from the chronometer relay, check its batteries. If the radio pips do not operate the time-mark relay, check the radio volume and the filter batteries. If the time-mark relay sticks on, either the radio volume is too high or the chronometer relay is stuck mechanically. VNG is used for radio time pips and good reception is obtained at most times on frequencies 12.000 MHz (day) or 7.500 MHz (night). The 59th second of each minute is missing and the transmission is identified by voice between the 00 and 01 minutes of each hour.

Cassette

When loading, make sure the record paper does not bulge out from the drum. Check by quickly rotating the cassette wheel when the lid is on. If the record paper is bulging it will be heard to catch on the lid as the drum rotates. Check that the cassette is correctly in position, that the cassette wheel is revolving, and that the drive gears are set at the correct speed. Non-rotation of the wheel means that the gears are out of mesh, that the cassette is incorrectly loaded or is not sitting correctly in position, or that the motor is not operating.

APPENDIX 2

RECORD FAULTS AND CAUSES

Record fogged

General fogging is caused by exposure to light during loading or unloading of the cassette. A black line across the record is caused by the cassette shutter jamming open.
A black line without any record is caused by the cassette wheel not rotating; check that the gears are meshed.

No record

The cassette shutter did not open; lengthen the plunger pin on the recorder lid by screwing outwards and run test records.

Jittery trace

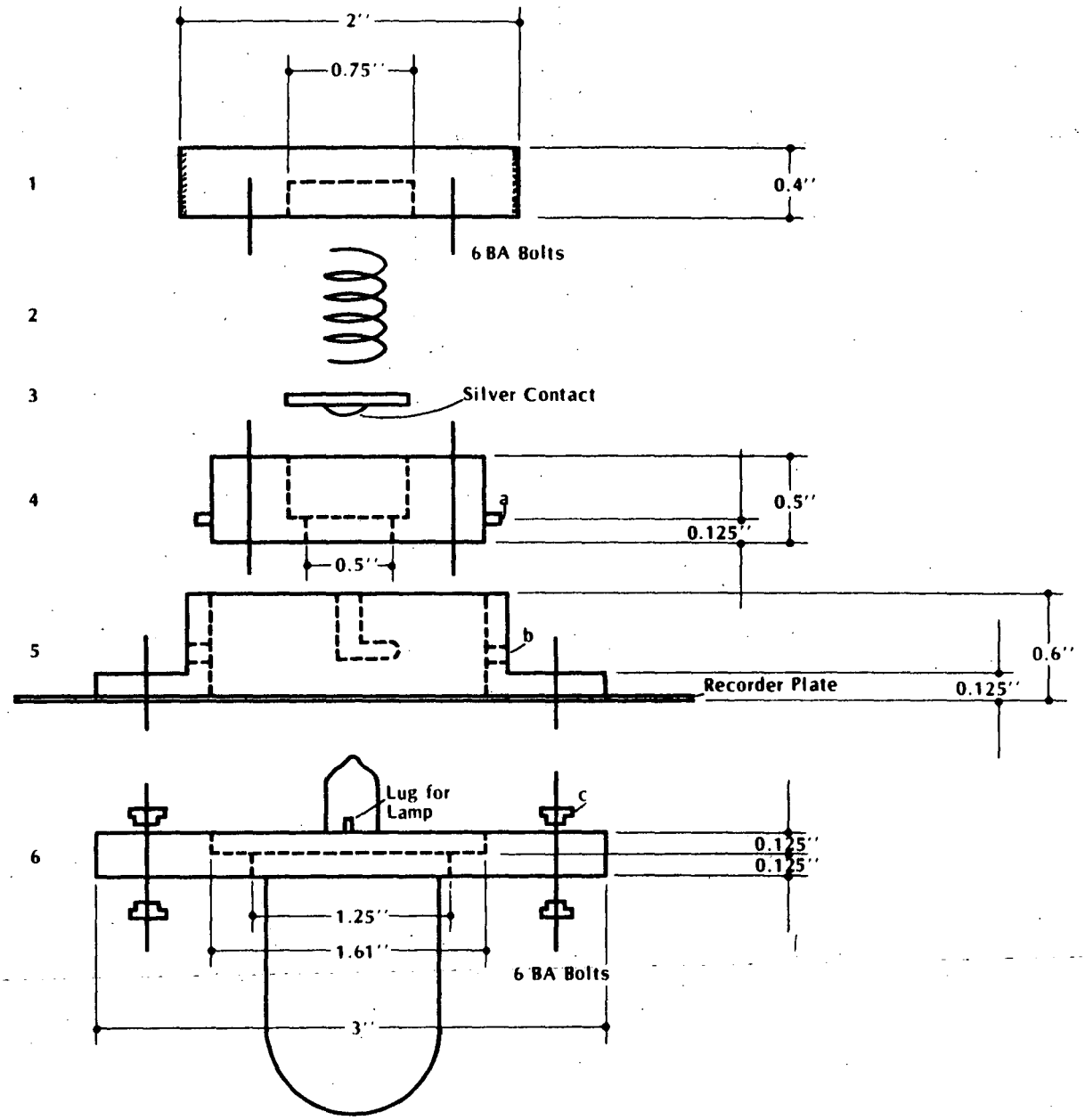
The recorder is not level. The galvanometer traverse should be level or slightly down in the direction the galvanometer is moving.

Time mark sticking

If the time-mark mirror sticks on for the last part of the record, the galvanometer magnet is operating the time-mark relay through the residual magnetism of the time-mark solenoid. Reverse the current to the solenoid by reversing the plug (P 4) shown in Plate 7.

Open circuit

Open circuit for the last part of the record is probably caused by a poor connexion at the galvanometer, resulting from movement of the galvanometer-recorder lead.

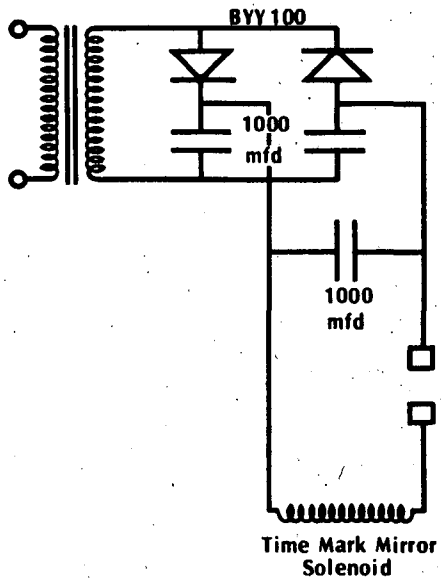


All sections are circular
1 and 4 screw together with three 6 BA Bolts
5 and 6 screw together separated by recorder plate and six insulating washers (c)
Lamp fits in 6 and held by Cap (1 and 4) locking by three lugs (a) in keyholes (b)
Lamp contacts (i) to 5 through one of bolts through 6
(ii) to a fourth bolt in 6

MODIFIED WILLMORE LAMP HOLDER

A

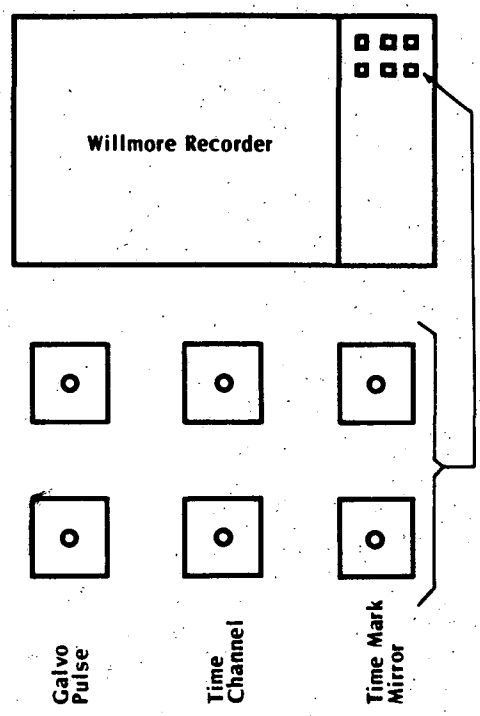
VOLTAGE DOUBLER



B

PLATE 2

TIME PLUGS



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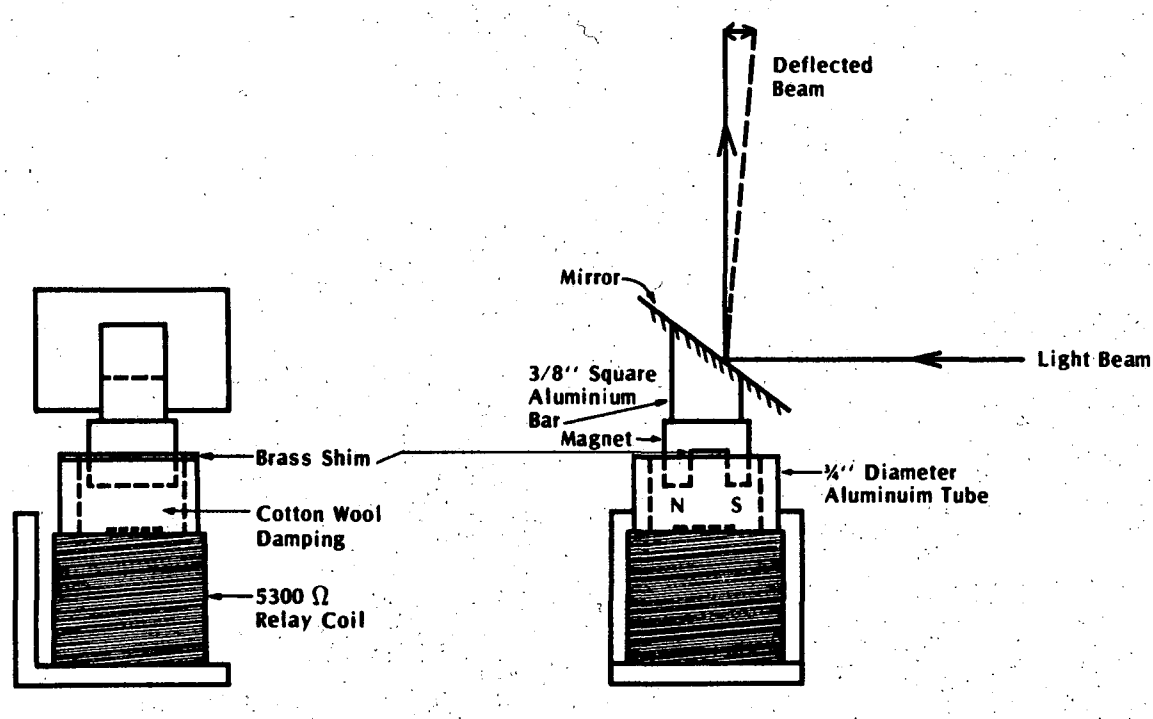
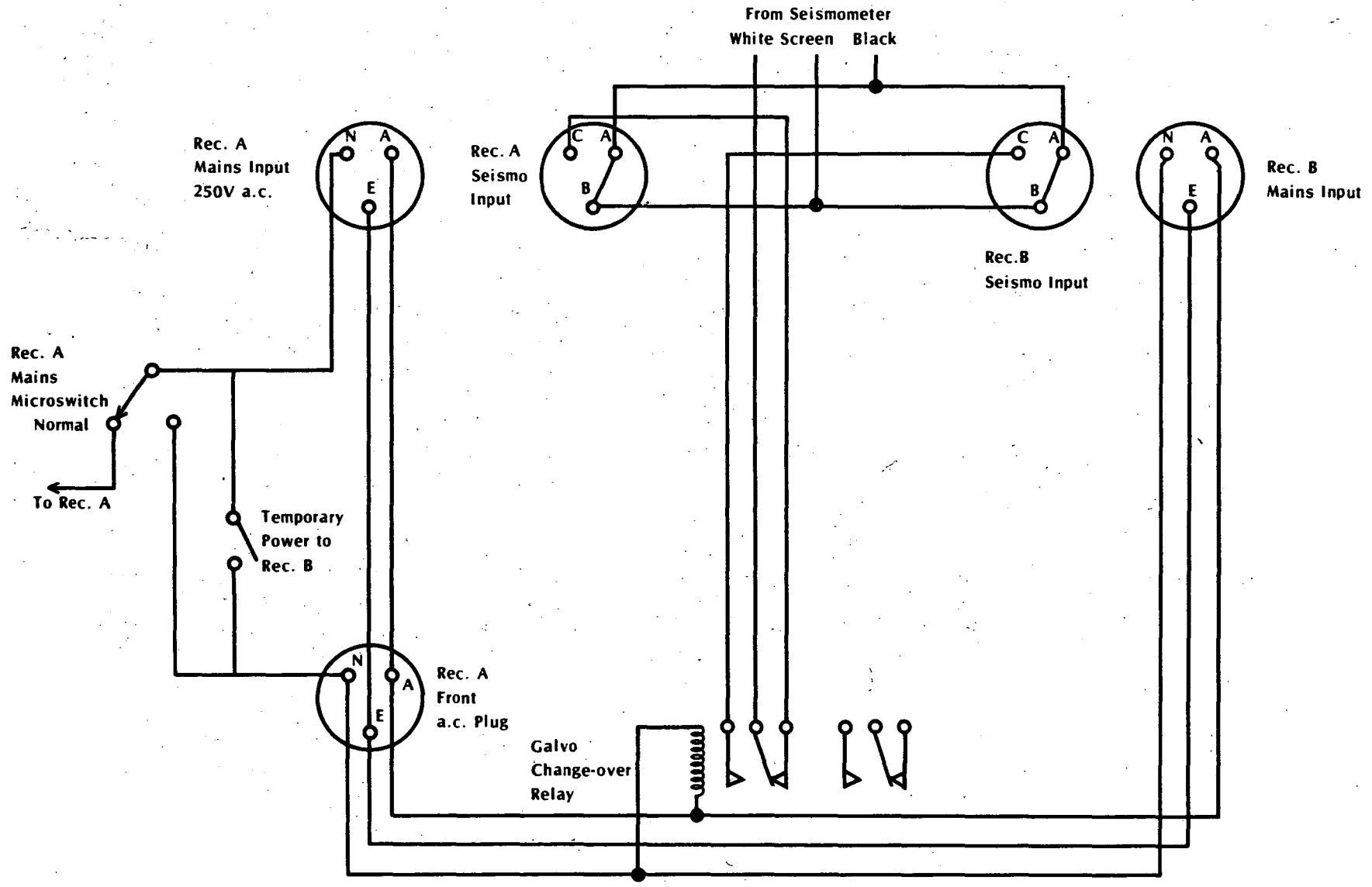


TIME MARK MIRROR UNIT

To accompany Record No. 1970 83

G82/3–136 A

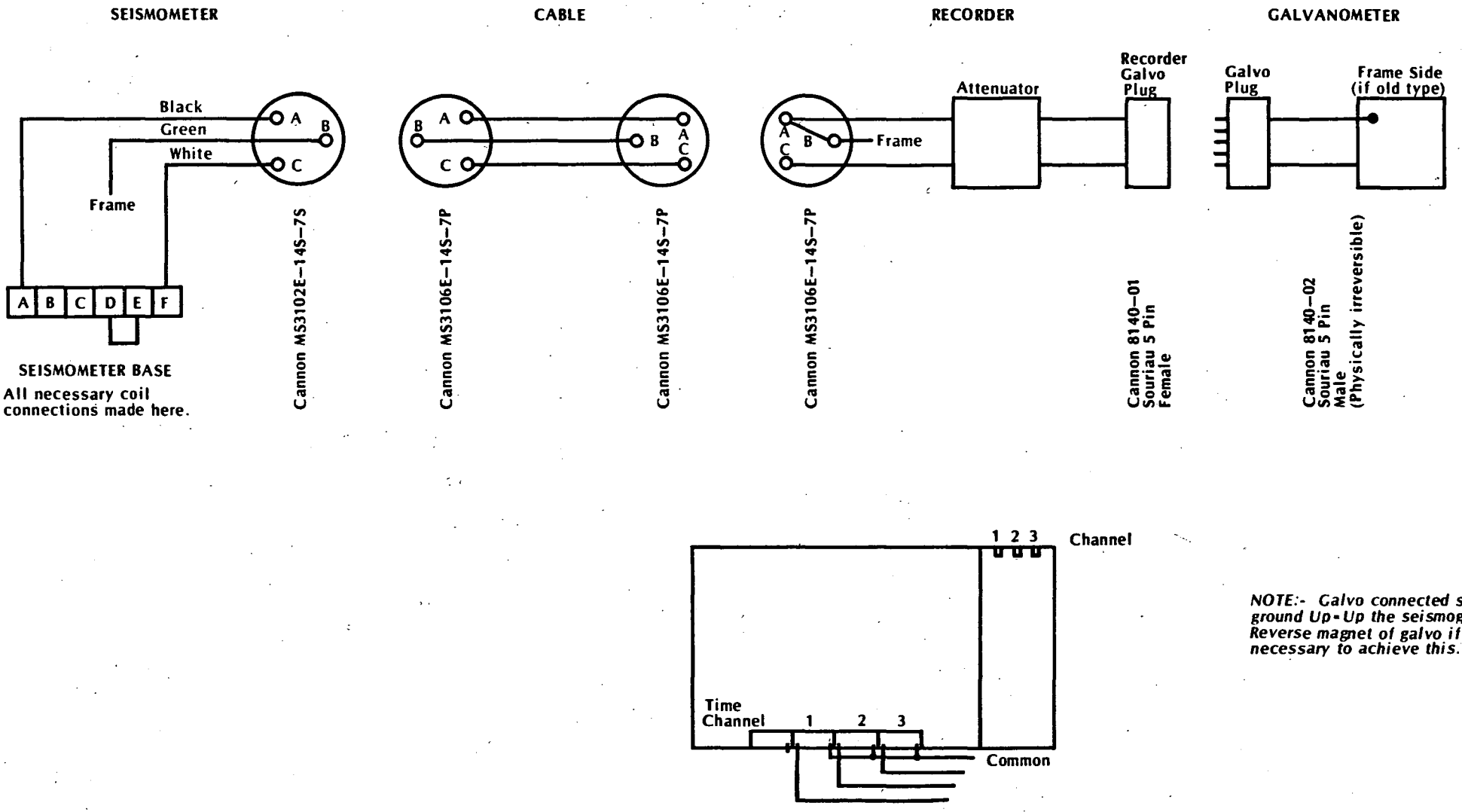


RECORDER CHANGE-OVER SWITCH

PLATE 3

To accompany Record No. 1970 83

G82/3-137A

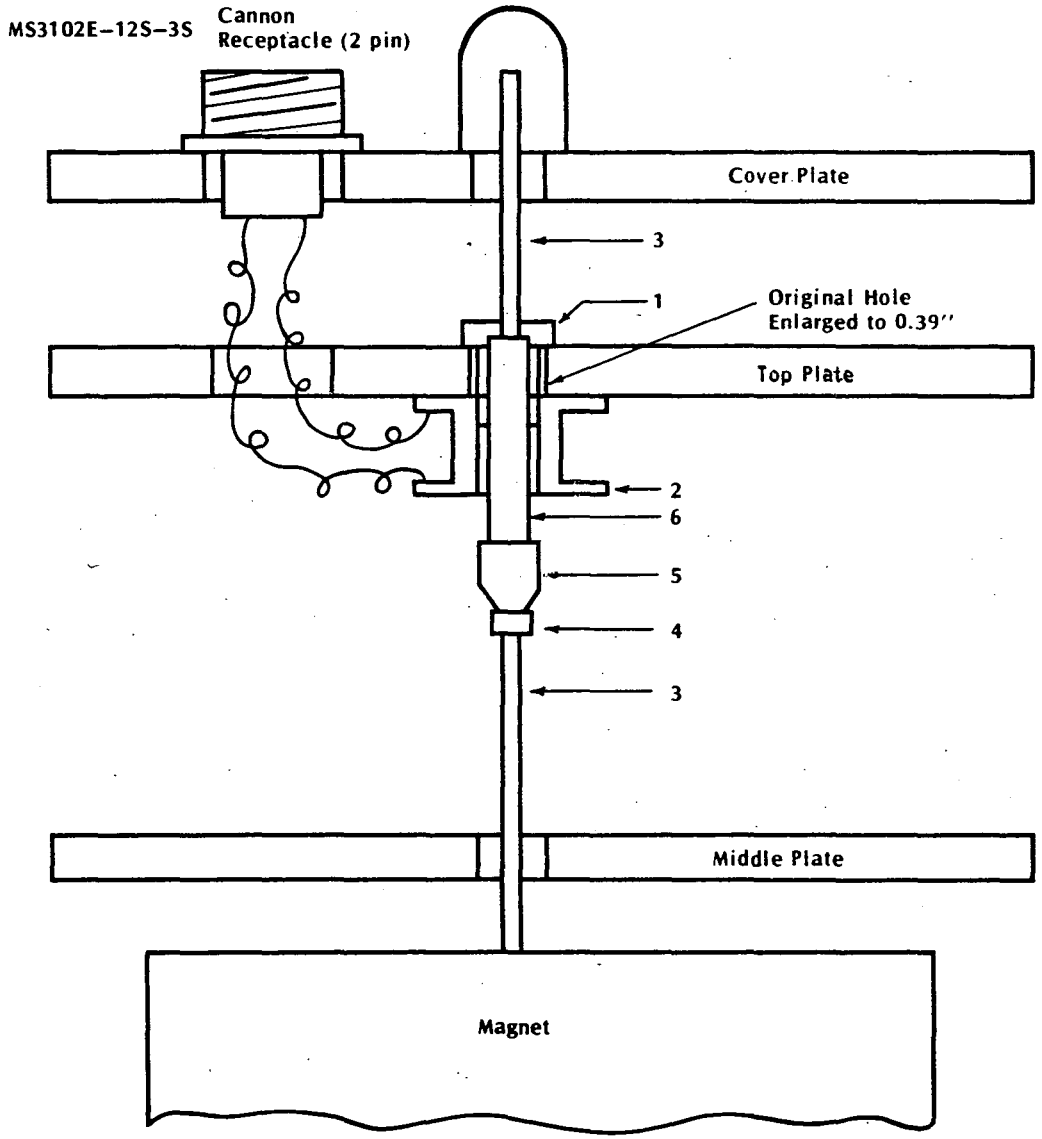


WILLMORE SEISMOGRAPH PLUGS

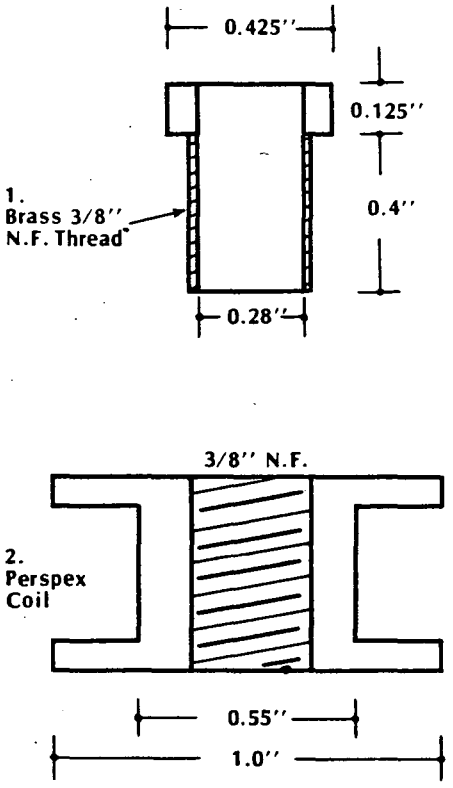
To accompany Record No. 1970/83

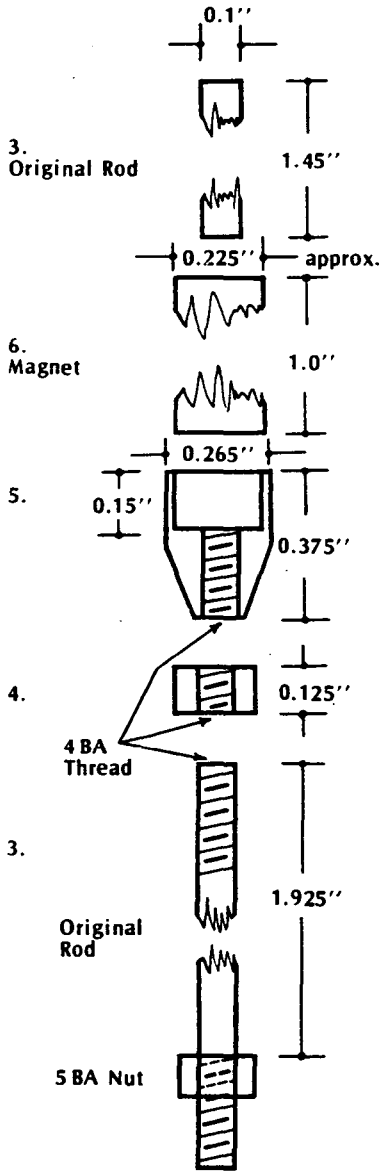
G82/3-138 A

PLATE 4



Section of Willmore Seismometer
with Calibrator





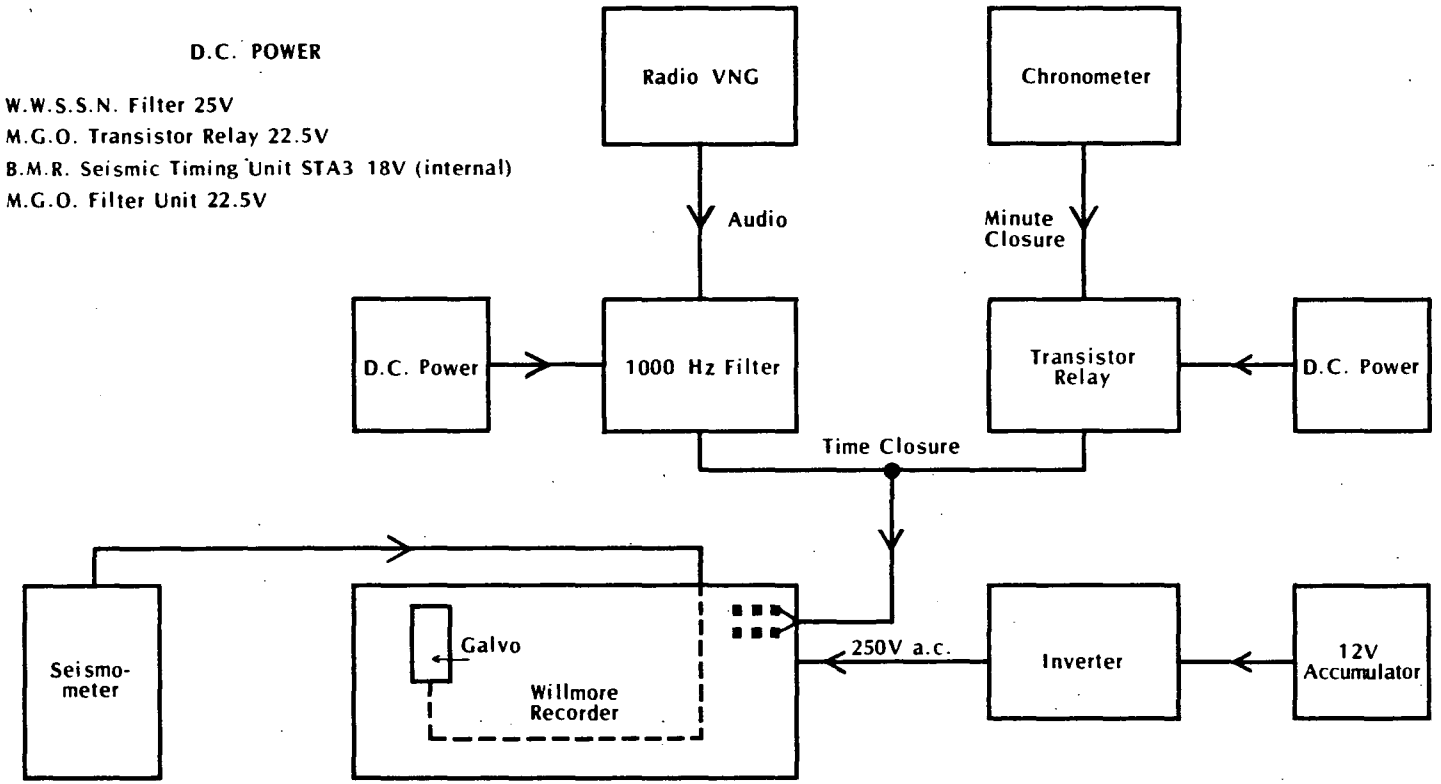
CALIBRATOR UNIT
(Sketch Only)

PLATE 5

To accompany Record No. 1970/83 G82/3–140A

D.C. POWER

W.W.S.S.N. Filter 25V
M.G.O. Transistor Relay 22.5V
B.M.R. Seismic Timing Unit STA3 18V (internal)
M.G.O. Filter Unit 22.5V



TYPICAL FIELD UNIT

PLATE 6

G82/3-139A

WILLMORE SEISMOGRAPH
RECORDER CIRCUIT DIAGRAM

COMPONENTS

RESISTORS

R1	22000 Ω	
R2	6500 Ω	
R3	2200 Ω	
R4	560 Ω	
R5	220 Ω	
R6	1000 Ω	
R7	68 Ω	
R8	150 Ω	
R9	360 Ω	
R10	390 Ω	
R11	750 Ω	
R12	5 Ω	
R13	100 Ω	
R14	250 Ω	
R15	5 megohms	

PLUGS

P1	Cannon 8140-1-2
P2	Bulgin P492
P3	Belling Lee L656
P4	Bulgin P28, P29
P5	Bulgin VH60 and P29
P6	Cannon 8140-1, 5 pin souriau
P7	Cannon 8140-1, 5 pin souriau
P8	Cannon 8140-1, 5 pin souriau
P9	Cannon 8140-1, 5 pin souriau
P10	Cannon MS 3102E-14S-S7
P11	Cannon MS 3102E-14S-S7
P12	Cannon MS 3102E-14S-S7
P13	Bulgin SA 1861

DIODES

D1	GEX 35
D2	BYY 100

CAPACITORS

C1	0.005 mfd
C2	0.1 mfd
C3	1000 mfd 25V

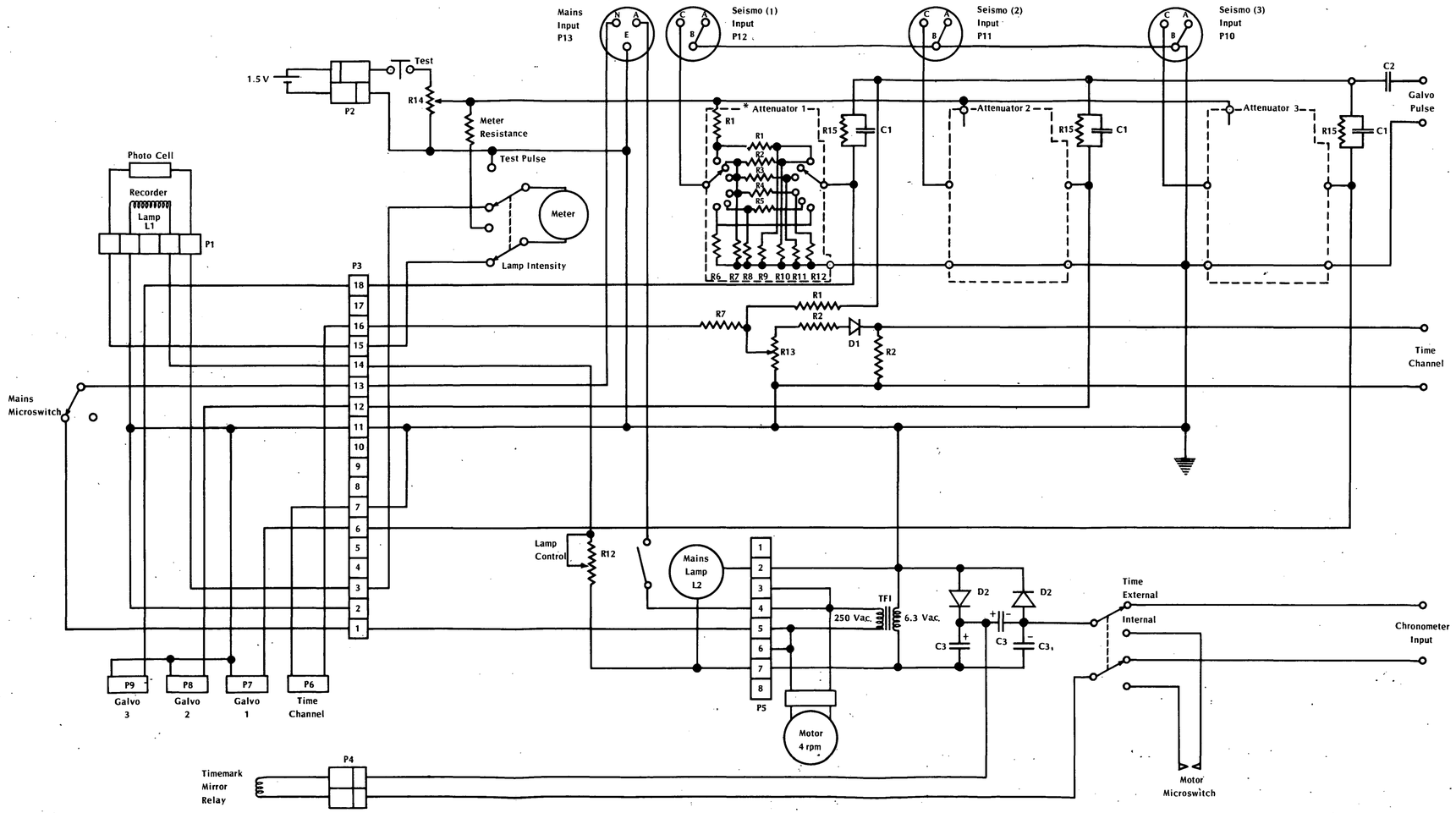
LAMPS

L1	Philips Type 3871
L2	MES, 6V, 40mA

TRANSFORMERS

TF1	Ferguson Type PF1728

* Attenuators 1, 2, 3 are identical



To accompany Record No. 1970/83

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