C. THEOD. WAGNER A. G. WIESBADEN
(Established 1852)

MASTER CLOCK 'E.C'

with Impulse Storage and Electro-magnetic Regulation

HANDBOOK

No. V9/HB209

Incorporating Handbook for Dial Slave Clocks

Distributed by

E. S. Rubin & Co. Pty. Ltd.

73 WHITING STREET, ARTARMON, N.S.W.

Telegrams: "ESRUB," SYDNEY. Phone :43-4141

INDEX

1. INTRODUCTION.

Master Clock EC is a mechanical device with a 1/1 Second Pendulum Ambient temperature compensated driven by weight through an endless chain. The weight is raised every minute by electrical winding mechanism. The clock is equipped with an automatic impulse storage system, which restores correct time to slaves and re-winds weight to top position after power failure.

Stripped of all electrical functions, Type EC is a mechanical clock of the "grandfather" type, and as such will operate indefinitely provided its weight is regularly wound up to store drive energy.

The pendulum of one metre length weighing 10 kgs (22 lb.) allows (at the end of each one second swing) to "escape" one tooth of escapement wheel. This motion is taken up by clock's gears and transferred in appropriate ratio to second, minute and hour hands.

The pendulum receives its maintenance (energy) through the escapement, i.e., power from a train of wheelwork which drives it.

Mechanical energy is used for cueing of small auxiliary synchronous motor which at predetermined times drives ancilliary equipment of master clock functions.

1.1 Pendulum Theory.

The whole pendulum assembly must be considered as a mass turning upon its point of suspension.

The period of swing depends on:

1. the turning effect of the weight about the point of suspension increase of which causes acceleration.
2. the opposition to change of motion (moment of inertia) an increase of which slows the swing.

The increase in turning effect is directly proportional to the depth of the added weight below the point of suspension; but the increase of moment of inertia about the point of suspension is proportional to the square of this depth.

The acceleration effect is much greater than the retarding effect.

To determine mass of an accelerating weight to be applied half-way on the rod between point of suspension and bob for one second per 24 hours following formula applies:

$$\frac{\text{weight of bob (in grammes)}}{10865} = \text{accelerating weight (gms).}$$

READ ALL INSTRUCTIONS CAREFULLY BEFORE INSTALLATION.

2. GENERAL MECHANICAL DESCRIPTION.

2.1 The complete unit consists of a rectangular metal housing fitted with glass insert. The housing's back plate fixed to the wall carries all equipment. Glass fronted "cover" lifts off completely leaving free access to all components. The cover is equipped with two locating pins which fit into top edge of back plate and lock at bottom edge.

2.2 **Dimensions:**

Height	1350 mm	=	53.150"
Width	390 mm	=	15.354"
Depth	190 mm	=	7.480"

2.3 **Mounting Details:**
Details shown on Drawing No. 4160 and described in Section 4.2. Jig for wall drilling is available.

2.4 **Cable Entry:**
Four bushed cable entries are provided at top of back plate (ref. Fig. 2 and Drawing 4160). Each bush is plugged with a push-out rubber stopper.

2.5 **Terminals:**
Three separate terminal blocks are provided in the vicinity of cable entries approximately labelled TSA, TSB, TSC.

Terminal block No. 902 (TSA) consists of 13 terminals to which clock functions are wired (refer circuit diagram). Terminal No. 901A (TSC) is provided with plastic cover for 240v AC termination.

Terminal No. 901B (TSB) is for 50v DC and earth.

2.6 Oiler, regulating weights, oil, spare springs are mounted in holder near bottom edge of back plate.

2.7 Remote Electromagnetic Regulation Control is contained in separate housing as per Fig. 9. Its dimensions are —

Height	120 mm	=	4.724"
Width (overall)	132 mm	=	5.197"
Depth (without lever key)	102 mm	=	4.016"

Mounting holes are 4 mm diameter and their centres are —
120 mm horizontally
60 mm vertically.

3. GENERAL ELECTRICAL DESCRIPTION.

Time control provided by the Master Clock is a combination of mechanical and electrical functions. The hour, minute and seconds time division is given by a robust mechanical gear system deriving its driving torque from gravity force acting on weight (P/No. 52).

The rate of release is controlled by the escapement mechanism (refer Fig. 1).

The pendulum turning upon its point of suspension allows escapement pallets to release one tooth of escapement wheel (at one second intervals) and receives at the same time some energy imparted by lever P/No. 24.

3.1 **Movement (mechanical) driven functions:**

3.1.1 Cam MCC/1 (P/No. 220) turns on minute shaft operating contact MCC 1 at 60th second. It cues AC motor in series with contact ISCA 1.

3.1.2 Contact assemblies SA and SB operated by topmost part of pendulum assembly every second and control relays A/1 and B/1.

3.1.3 Special Hour Time Contact HC1 is operated by cam HC/1 fitted to hour hand shaft closing from 59' 55" to 0' 30" (refer section 8.1).

3.1.4 One side of differential gear box (Fig. 3) turning cams ISCA/1 and ISCB/1, ISCC/1 anti-clockwise.

3.2 **Operating Sequence.**

3.2.1 Contact ISCA1 (P/No. 161) is closed by cam ISCA/1 (P/No. 160) at approximately 40th second preparing motor power circuit (50v AC).

On the 60th second contact MCC1 (P/No. 60) is closed by cam MCC/1 (P/No. 220) and completes motor M (P/No. 10) circuit.

The motor's drive shaft is fitted with two cams MCA/1 and MCB/2 and a mechanical link via a gear train to differential gear box and weight rewind assembly.

3.2.2 Turning of motor shaft operates cams MCA/1 and MCB/2 actuating alternatively contacts MCB1 and MCB2, which provide polarised pulses to slave clocks. Relay C/2 is energised at the same time providing non-polarised pulses (to terminals 5 and 6).

3.2.3 The gear train lifts clock's weight by distance descended during preceding minute.

3.2.4 The differential gear box returns ISCA/1, ISCB/1, ISCC/1 cams to zero position, thus opening contact ISCA 1. This must take place before cam MCA/1 opens contact MCA 1.

3.2.5 Contact MCA 1 maintains power to motor after contact ISCA/1 has opened and allows motor to rotate cam MCA/1 a full 180° in 2.5 seconds. This motion being completed, MCA 1 opens and removes power to motor **unless** impulse storage has taken place (see paragraph 3.3).

This process is repeated every minute.

3.3 **Impulse Storage.**

Should AC or DC power fail, Slave Clocks will stop and clock's weight will gradually descend. Master clock will mechanically operate for approximately 26 hours. When power is restored, "missing" minute pulses are fed out at 2.5 second intervals until time displayed by slaves is equal to Master Clock.

3.3.1 Storage system commences to operate approximately 90 seconds after the last operation of motor, when ISCB 1 contact (P/No. 172) is closed by cam ISCB/1 (P/No. 170) (one turn per hour) and ISCC/1 (P/No. 171) (one turn per 12 hours) by the clock's mechanical weight driven gear train. Cam ISCA/1 (which is coupled with ISCB/1) also rotates and closes contact ISCA 1.

3.3.2 Special note is required of the construction of the double cam ISCB/1 and ISCC/1. The vertical drop in the leading edge of the notches on each of these cams are displaced approximately 1/16". Contact assembly ISCA 1 will open before contact assembly ISCB 1, when the cams rotate clockwise (driven by weight) during a power failure. Normal operation under weight drive results in the cams rotating from the contacts open until contact ISCA 1 strikes the leading ramp on the notch cut in advance of the rear notch. Continued rotation causes contact ISCA 1 to close whilst contact ISCB 1 is commencing operation by the lift imparted by the ramp of the rear lagging cam. The front contact ISCA 1 operates 40 seconds after the last minute impulse; rear contact ISCB 1, 90 seconds after last minute pulse.

To ensure that contact ISCA 1 operates before ISCB 1, ISCA 1 is fitted into a slot cut into the mounting plate, which allows it to be slid up and down into correct position of the cam notch.

3.3.3 Continued powed failure results in the cam ISCA/1 and ISCB/1 rotating once per hour. Cam ISCC/1 rotates 1/12 revolution per hour and ensures that contact ISCB 1 remains closed when cams ISCA/1 and ISCB/1 pass (every hour) through zero position and momentarily open contact ASCA 1.

3.3.4 If power fails for **exactly** 12 hours, all cams will be in zero position, but all 12-hour time indicating systems will be showing correct time. 24-hour systems will be 12 hours slow. Under this particular set of circumstances no impulses are stored and motor will not operate. The clock's weight will remain about half-way down and with now normal operation of clock will be maintained in this position. This does not impair accuracy of the clock, but reduces mechanical running reserve. The weight should be raised to normal by hand.

3.3.5 If power failure lasts for more than 12 hours, but less than 24 hours, impulses will again be stored as described above for time elapsed minus 12. Drive weight will be raised automatically to the "12-hour" position and remain there, being re-wound every minute. To secure full mechanical power reserve the weight should be raised to the top position as soon as possible. (The relative position of weight/clock does not affect accuracy of clock in any way.)

3.3.6 When power is restored, contacts ISCA 1 and ISCB 1 will be closed and motor will operate instantly. Sequences 3.2.2, 3.2.3, 3.2.4 will take place until cams have been returned to zero position.

4. INSTALLATION INSTRUCTIONS.

4.1 Satisfactory operation of the whole Master/Slave Clock System depends entirely upon selection of proper site and on meticulous observance of hanging instructions.

NEAR ENOUGH IS NOT GOOD ENOUGH.

Room: The room selected for hanging of Master Clock should have an even temperature and be free from large and sudden temperature fluctuations.

Wall: Should be as solid as possible (brick) reasonably perpendicular, free from vibration and possibility of shock waves being transmitted through it.

4.2 **Drilling of (Wall) Mounting Holes:**

Refer to Drawing 4160. Note distances between fixing points (295mm = 11.6142" horizontally and 1250 mm = 49.213"), and total area requirements. The two set bolts provided in packing case are for the top of housing; wooden blocks for bottom holes. Make sure with spirit level that all fixing points are truly level (horizontally and vertically).

Use drilling jig with plumb bob for marking off holes.

Check with spirit level machined surfaces of movement support 80 for horizontal alignment.

Set bolts and blocks must be cemented into the wall and back plate of Master Clock can be mounted only AFTER fixing points have thoroughly dried and are firm.

4.3 **Remove Master Clock Housing from shipping case:**

Place into upright position.
Lift off front cover.
Remove dial face (refer Section 9.1).

Caution: The most critical part of assembly follows.
TAKE ALL POSSIBLE CARE.

Withdraw wiring plug 903.
Remove rubber transport ties.
Remove knurled screws 984.
Lift movement with CARE.

Note: It is advisable to have movement held upright by another person. DO NOT LAY movement on its side, back or front. If it is stood on a table, make sure that escapement lever (P/No. 24) is not damaged and that weight chain does not twist. Movement is to remain always vertical.
Do not touch any contacts.
Fasten back plate assembly to prepared points on wall.
Adjust levels.

4.4 **Installation of Pendulum.**

With movement removed, unpack pendulum assembly. Inspect for transport damage. Pendulum bob to line up with mark on rod back (line on edge) (refer Section 9.4). Top of weight tray to be placed on mark on rod. When hanging avoid damage to seconds contacts and make sure that pendulum lever spring is not twisted. Opening of pendulum hanging hooks to face forward.

If the rear plate has been properly mounted the pendulum will point exactly to "O" on scale (Fig. 2). Should it not be so, mounting of back plate **must** be adjusted until this is achieved.

Mechanical operation of seconds contacts is now to be checked. Take pendulum bob into **both** hands and swing left until right contact is just starting to move.

Note deflection on scale. Now swing to right and observe left contact. Deflection on scale should be the same. Should this not be the case and operation is uneven, adjust fork striking plates by adjustment of screws at top of P/No. 85.

Remove transport tie from escapement lever of movement. Place movement (hold vertically) into position on support. Escapement lever is to take position as shown on drawing 4163.
Tighten (finger tight) screws P/No. 484.

Inspect correct position and registration of chain within clock. Hang weight on pulley. The weight should now be AT LEAST **one foot below** mechanism.

Deflect pendulum to 35 on scale and release. Escapement will now commence operation and "ticking" will be heard as pendulum swings. It is vital that "ticking" is regular, i.e., that escapement is releasing equally on both sides. Visual check is to be made from both sides of movement to ensure that escapement is lifting equal distance on each side of escapement wheel.

Adjustment if necessary must be made by turning knurled nut (drawing 4163) to set position of escapement lever for correct escapement operation.

Unless this function is correctly balanced and regular release by escapement assured, clock will stop within a period from few minutes to several hours, depending on degree of misalignment. Place dial into position.

Plug in electrical connections.

5. COMMISSIONING.

The Master Clock requires source of 50v DC as well as 220-250v AC (50 cps).

The secondary winding of built-in transformer is 50v. AC power is supervised by relay D/2, which is energised by DC (refer circuit).

5.1 Place seconds isolating switch (Z2) into OFF position.

5.2 Place AC switch (Z70) into OFF position.

5.3 Connect 240v AC power to terminals (901 A).

5.4 Connect temporary one slave clock to appropriate (minute impulse) terminals 1 and 2 and (seconds) to 3 and 4.

5.5 Deflect pendulum to No. 40 on scale and release. The pendulum swing of a clock in new condition will settle between 34 and 38 divisions on each side of scale.

Minimum deflection which should just clear escapement is 26-27.

5.6 Switch AC power "ON."

5.7 Connect DC supply (901 B).

Note: The impulse storage system will immediately operate as prior to packing the power was switched off for some time before clock was stopped. Weight will be re-wound automatically to top position approximately level with lower edge of dial.

5.8 Observe if re-winding of weight functions correctly every minute.

5.9 Place second isolating switch (Z2) into "ON" position. Temporary connected slave clock will now be stepping according to clock's pulses. The time shown by slave is irrelevant at this stage. Observe the exact **second** at which the slave receives its **minute** pulse. This second we shall call for installation purposes the 60th second (no matter where the hand is pointing). It will be noted that AC motor starts operating at 59th second.

5.10 Stop pendulum at next 58th second, noting which way pendulum was travelling. Be sure that no further pulse is sent by the master. Place dial in position (refer Section 9.1).

5.11 Insert seconds hand firmly on its bos (push-in) so that it points to 58th second of Master Clock dial (two lines before full minute). Refer 9.2.

5.12 Push pendulum gently in the same direction in which it was travelling when stopped as per 5.10 above (i.e., it should now continue its path).

The 59th pulse will now be sent and AC motor will start operating. At the 60th seconds pulse a minute pulse will also be sent.

The Master Clock is now **internally** synchronised.

SECONDS HAND MUST NOT BE ROTATED MANUALLY FROM THIS POINT ONWARDS.

If not successful at first attempt, remove seconds hand and repeat procedure from 5.10.

5.13 Stop Pendulum. Insert hour hand. Minute hand to be inserted on square bos of minute shaft. Hand and shaft bear inscribed mark (or centre punch) for correct assembly. Both marks must be aligned for correct operation of special hour contact (Drawing 4116/25a) (refer Section 9.3).

5.14 Rotate **clockwise** hands to correct time (this does not affect impulse storage in any way nor send pulses).

5.15 Disconnect Slave Clock and switch off seconds pulses.

5.16 Synchronise clock with exact time signals with which it will be regulated.

It is important to synchronise SECONDS first as seconds hand must not be rotated manually.

If PMG (GPO talking clock) is used, stop pendulum at 58th second and set in motion at second "pip" of next minute signal. The third "pip" should fall on 60th second.

Alternatively, as "pips" are given every 10 seconds this procedure may be started at 8th, 18th, etc., second on the dial.

Having checked several time signals, rotate minute hand clockwise to correct time.

5.17 Replace cover. DO NOT DISTURB PENDULUM.

You may now commence regulation of Master Clock.

6. REGULATION OF MASTER CLOCK.

General.

Reliable source of time signals is necessary for proper regulation such as PMG time service, etc.

6.1 **Rough Regulation.**

The Master Clock has been tested and regulated at the factory and again after arrival in Australia. Each Master is accompanied by a "Regulating" log showing adjustments and readings during tests and final setting. As the clock had to be dismantled and re-packed, it is suggested that setting stated in log be adopted as starting point. These adjustments apply to elevation of 200 feet above sea level, and barometric pressure as per recorded readings.

1. Switch off seconds pulses (Z2).
2. Stop pendulum carefully.
3. Hold bob in left hand and release counter nut (P/No. 823).
   DO NOT TWIST PENDULUM. You may destroy pendulum spring.
4. Adjust calibrated nut (P/No. 822) as required.
5. Hand tighten counter nut (P/No. 823).
6. Deflect pendulum to starting point (38-40 on scale).
7. Switch seconds pulses "ON" if required.
8. Enter variation of adjustment in log.

NOTE: To prevent twisting of pendulum you may insert provided metal pin through hole in bottom of rod to counter leverage exerted by tightening of regulating nuts.

Regulating Data.

Pendulum is of nickel silver alloy (INVAR) and is ambient temperature compensated (refer chapter "Pendulum"). Regulating nut (P/No. 822) has 20 divisions of which every second one is numbered. Each division covers time range of 1.38 seconds per 24 hours. One complete revolution of nut causes a change of 27.5 seconds per 24 hours. Turning nut to the right lifts bob and ADVANCES the clock. Turning nut to the left lowers bob and RETARDS the clock.

Note: Rough regulation is to be carried to a point when the clock is still somewhat SLOW (approximately two seconds per 24 hours).

6.2 **Fine Regulation.**

Each Master Clock is supplied with a number of small weights, which are to be placed on pendulum dish (see drawing 4163).

Addition of weights ADVANCES clock.

They are:

3 silver weights for advancing 1 second/24 hours.
3 aluminimum strips for advancing 0.5 second/24 hours.
5 aluminimum strips for advancing 0.1 second/24 hours.

Note: Use tweezers for placing and removing of weights. It is not necessary to stop pendulum for fine regulation; indeed, avoid disturbing it.

6.3 **Electro Magnetic Regulation (EMR).**

Clocks equipped with this device may be regulated to very fine limits by this means. EMR should not be attempted during or immediately after initial "rough" and "fine" regulation, but several weeks later after the clock's behaviour has been carefully studied and only if exact comparison time signals are available.

EMR permits regulation remotely; i.e., eliminates necessity of opening clock's housing, which may cause interference with the all-important pendulum swing.

Theory.

Theoretical data for EMR are contained in the Thesis of Dr. Treusein of Hamburg (Hydrographic Institute). Variations of pendulum beat rate are achieved by the application of current to coil into which pendulum dips a strong magnet. The effect is the same as changes of gravity would be. (Increase of gravity accelerates.)

Regulation.

By changing variable resistance provided in remote control box (refer Fig. 9) and selecting ADVANCE (+) or RETARD (—) by lock-out key switch, Master Clock may be influenced in the range of —

1/60th to 8 seconds/24 hours.

Barometric Pressure.

Rise and fall of pressure will cause variations in the period of pendulum swing (barometric error). One inch fall of mercury will cause acceleration of approximately 1/3 second per day and vice versa. The rate chart should be coincident with an inverted barograph record.

Barometric error must be taken into consideration when (fine) reguating Master Clock by EMR.

7. CONNECTION OF SLAVE CLOCKS.

7.1 **Minute Pulses.**

1. Check all slave loop wiring with meter for possible short circuit.
2. Set all slaves to indicate same time at two or more minutes **behind** time shown on Master.
3. Connect minute pulse wires of slaves to terminals 1 and 2.
4. Await one minute pulse from Master; if any slave did not step, reverse its leads (polarity). All slaves should now be synchronised as to correct polarity.
5. Operate hand pulsing lever (No. 61) up and down at approximately one second intervals to pulse all slaves to correct (master clock) time. PLUS ONE PULSE. If polarity of all slaves is correct, next pulse from Master Clock is not going to move slaves and at following minute the system will be correctly in operation.

7.2 **Seconds Pulses.**

Proceed similarly to minute pulses. Synchronise all seconds hands; reverse polarity where necessary. When all slaves are synchronised, switch pulses OFF. Observe seconds hand of Master until it catches up to time shown on (seconds) slaves. Throw switch into "ON" position at the appropriate time when pendulum passes over "O" on scale.

8. AUXILIARY EQUIPMENT.

8.1 **Special Hour Contact HC1.**

Master Clocks EC for Department of Civil Aviation are provided with this special contact facility consisting of CAM (viz., Dwg 4116/24a) HC/1 fixed to minute shaft and contact assembly Z60.

NOTE: Never turn minute hand anti-clockwise, especially not between 55th to 5th minute, as you will damage this contact.

The contact is designed to close between 2-5 seconds before the full minute and hour until 30 seconds after the hour. Small variations can be effected by careful and slight anti-clockwise movement of minute hand, but NEVER between 55th and 5th minute. The time during which contact HC1 remains closed is governed by eccentric lever Z61. Stamped letters "L" indicates longer; "K" for shorter (Fig. 7).

The contact set is suitable for max. 0.4 amp at 240v AC. It is connected to terminals 7 and 8. Contact pressure is 5g for swing spring and 3g each half (6g total) of the opposing spring measured at contact pip.

8.2 **Seconds Contact and Impulse Relays A/1 and B/1.**

The Master Clock pendulum operates non-polarised seconds contact, which energises alternatively relays A/1 and B/1 every second. Relay contacts A1 and B1 provide polarised seconds pulses of approximately 400 m/sec. duration.

NOTE: Nothing will happen if both seconds contacts are closed at the same time nor if both relays are operated by hand. Short circuit will not be caused. Contact A1 and B1 are connected to earth and battery, and a short **may be** caused if pressure is applied to them.

Before touching or cleaning, switch seconds pulses "OFF."

Spark quench circuit operating on these contacts is shown in diagram, Fig. 10.

Relay contacts A1 and B1 will carry maximum 0.5 amps at 50v DC.

Contact pressure of spring 1, 10g; spring 2, 25g, on spring 3.

8.3 **Special Non-polarised Minute Contact.**

For special purposes, Relay C/2 is provided (type No. AZ218-305-1). Relay is energised by minute pulse and closes contacts C1 and C2 every 60th second for approximately two seconds. Contact rating, 0:5 amp at 50v DC.

8.4 **Supervisory Relay D/2.**

Relay type AZ218-305-1 has been incorporated to cut off AC power supply should external source of DC fail. This provision is necessary to make impulse storage operative. Contact D1 serves this purpose.

8.5 **Alarm Contact.**

Contact D2 is wired to terminals Nos. 9 and 10 and will close if DC power fails. The contact is rated 0.5 amp at 50v DC.

No alarm device is incorporated within the clock, and should be provided externally.

9. USEFUL HINTS AND FAULTS.

9.1 **Dial Face Removal.**

Dial is held in position by two strong tension springs (P/No. 703) (Figs. 1 and 7).
Remove all clock hands first.
Remove one spring after the other from guides in rear of dial.
Press dial **lightly** against black plate. Dial may now be easily lifted out from its three locating holes in front plate.
Mounting Dial: Proceed in reverse as detailed above.

9.2 **Seconds Hand** (P/No. 75).

Seconds hand is located on seconds shaft connected to escapement wheel. Any application of force may cause damage to escapement machanism.
The hand should be pressed firmly on to the shaft when placed into position. When pendulum is at rest pointing to "O," seconds hand will rest half-way between seconds bars painted on dial.

9.3 **Minute Hand** (P/No. 74).

Refer section 5.13.
The minute (and hour) hands are held in position by knurled hand nut P/No. 741 and domed washer (P/No. 742). The dome of the washer must be placed outward and nut tightened by finger pressure only. Before tightening, make sure that minute and hour hands are in correct relative position to each other.

9.4 **Pendulum.**

C. T. Wagner Invar pendulum is ambient temperature compensated. Influence of heat will change length of pendulum rod. However, compensating device will lift or lower bob by exactly the same distance. Timing of swing remains constant.
The rear of pendulum rod has been marked in the factory during initial run for pendulum bob "starting" position.

The Master Clock has been further regulated in Australia prior to delivery, and bob may be in different position; most likely sitting higher, i.e., the engraved line on rod will be hidden from view. When starting initial regulation at site, it is suggested that the figure shown on accompanying log be used as initial setting of knurled regulating nut (P/No. 822) (Fig. 6).

9.5 **Pendulum Swing.**

Scale below pendulum is graduated in approximately $\pm$ 65 divisions. 1/1 second pendulum of a new clock ex factory should settle down to 34-38 divisions on each side. If started at smaller amplitude (but not less than 33 divisions), it will gradually build up to a figure indicated above. Due to dust particles and thickening of oil within the mechanism over a period of time, the pendulum may reduce its swing to 32-36 divisions. The minimum swing to clear escapement is 26-27 divisions on scale.

It is essential that pendulum swings exactly the same distance from "O" on scale (refer "Installation of Pendulum").

Maintenance (i.e., supply of energy to pendulum) is effected through escapement lever (P/No. 24), which is the only connecting link between mechanism and pendulum. The lever lies on a pad opposite to knurled nut (P/No. 83). The lever is counter-balanced by a small weight affixed to shaft by grub screw. The correct position of the weight is determined by the force exerted on lever measured at point of contact with pad on pendulum. It is to be three gramms measured in a position where escapement is **not** engaged.

The counter-weight (P/No. 242) has been adjusted prior to delivery and need not be touched unless it is loose on shaft.

9.6 **Pendulum Spring** (P/No. 82).

This is the most sensitive part of pendulum and can easily be damaged or broken by twisting of bob during regulation. If the pendulum does not swing in a straight line, but yaws (travels in figure 8 path) it is a sign of damage to spring, which MUST BE immediately replaced.

Spare set of springs provided with each Master Clock.

9.7 **Weight Chain.**

Should it be observed that the chain fails to easily fall from pulleys it is a sign that it has been stretched and links are out of alignment.

Close inspection will reveal that some link is not closed and/or has an obstruction. Faulty links should be removed. When re-connecting links make sure that each locks into another at 90° and all are properly closed by use of duck bill non-serrated pliers.

Replace with a new chain as soon as possible.

9.8 **AC Motor** (P/No. 10).

Motor will perform satisfactorily within voltage range of 40-60v AC.
Motor suitable for temperature range — 40° . . . + 70° C.
Max. permissible temp. increase, 30° C.
Direction of rotation: right, 250 rev/min.
Cos. φ 0.8.
Current, approx. $<$ 30 mA.
Starting torque, 15 gcm.
Operating torque, 15 gcm.
Self-lubricating bearings.

10. MAINTENANCE.

It is recommended to inspect clock closely every twelve months. All contacts to be inspected every six months.

10.1 **Oiling and Cleaning.**

Inspect all bearings. If clean, may be re-oiled by qualified tradesman. If discolouration present in oil, the mechanism must be thoroughly cleaned before oiling.

IMPORTANT NOTE: USE ONLY OIL PROVIDED IN HOUSING.

It is very special synthetic watch oil suitable for tropics manufactured in Switzerland; brand SYNTH-A-LUBE, by Messrs. Moebius (obtainable from distributors). NO OTHER OIL MUST BE USED.

10.2 **Contacts.**

Inspect half-yearly for possible dirt, oxidation (by fumes) or discolouration. ISOLATE CLOCK FROM ALL ELECTRICAL CONNECTIONS.

Polish contacts with fine leather only. USE NO FILES OR ABRASIVES.

Replace burned contacts with spare contact assemblies.

Order as per parts list.

Contact sets will be supplied with special instructions for replacement.

10.3 **Contact Pressures.**

Contact ISCA1 closes at 40th second. Pressure operating spring 5-6g opposing spring 3g per half (6g total). Contact MCC1 closes at 60th second and opens at 15th-20th second, however, before ISCA1 closes. Pressure as ISCA 1. Minute contacts MCB 1 and MCB 2 close at 60th second when motor starts. Pressure operating spring 8g opposing sp. 4g each half (8g total).

Sequence, refer to Fig. 10. Contact rating 0.5A at 50v DC. Contact MCA1 opens when minute shaft cam has reached half-way between operating minute contacts MCB 1 and MCB 2. Pressure operating 8g opposing 4g each half (total 8g).

11. PARTS LIST.

		Part No.	Fig. No.	Ident. No.
1.	Motor	10	147	
	Differential	11	3	
	Drive Wheel	12	1	
	Differential Gear 60T	13	3	
	„ „ 45T	14	3	
	Intermediate Wheel	15	1	
	Cam ISCA/1	160	3–5	
	Spring Set ISCA 1	161	3	
	Cam ISCB/1	170	3	
	Cam ISC/1	171	3	
	Spring Set ISCB 1	172	3	
	Cam MCA/1	180	5	
	Spring Set MCA 1	181	4–5	
	Minute Shaft Impulse Cam MCB/2	190	4	
	Minute Impulse Spring MCB 1 set	191	4–5	
	„ „ „ MCB 2 set	192	4–5	
2.	Axle Complete.	21	—	
	Contact Shaft with gear	22	3	
	Star Cam MCC/1	220	1–7	
	Gear Assembly	23	1	
	Escapement with lever	24	1–5	
	„ pallets	240	1	
	„ lever counter-weight	242	1	
	Minute Shaft and Gear	250	3	
	Gear Assembly	251	3	
	Hour Shaft and Gear	252	3	
3.	Front Plate	50	3	
	Rear Plate	41	3	
	Upper Distance Bolts	480	3	
	Lower „ „	481	3	
	Screws, fixing	484	3–7	
4.	Chain	50	5	
	Weight Roller	51	3	
	Weight	52	3	
5.	Minute Contact Set MCC 1	60	7	
	Hand Pulsing Lever	61	5	
6.	Dial	70	—	
	Tension Springs	703	1–7	
	Hooks	704	1–7	
	Hour Hand	73	7	
	Minute Hand	74	7	
	Minute Hand Nut	741	3	
	Minute Hand Domed Washer	742	—	
	Seconds Hand	75	7	
7.	Support and Bed	80	2	
	Pendulum Spring Support	801	2	
	„ Spring	82	2	
	„ Nut	822	6	
	„ Counter-nut	823	6	
	„ Scale	824	6	
	„ Striking Assembly	83	2	
	Weight Dish	84	—	
	Contact Fork	85	2	
	Pendulum Bob	86	6	
8.	Wall Plate (Rear) Housing	90	2	
	Terminal Strip TSC	901A	2	
	„ „ TSB	901 B	2	
	„ „ TSA	902	2	
	Plug-in Terminal	903	2	
	Fuses	904	2	
	EMR Connecting Link	905	2	
	Housing	91	—	
	Glass Plate	911	—	
	Spring Glass Retaining	912	—	
	Key (Lock) Housing	913	—	

	Part No.	Fig. No.	Ident. No.
9. Seconds Contact Assembly	Z1	2	
Contact Spring SA (outside)	Z10	2	
„ „ SB „	Z11	2	
„ „ SA (inside)	Z12	2	
„ „ SB „	Z13	2	
Switch Seconds Isolating	Z2	2	
Relay A/1	Z3	2	
Spring Set A1	Z30	2	
Relay B/1	Z4	2	
Spring Set B1	Z40	2	
Relay C/2	Z5	2	
Spring Set C2	Z50	2	
Spring Set HC1	Z60	7	
Lever Hour Time Contact (HC1), adjusting	Z61	7	
Hour Contact Rider	Z62	7	
Hour Contact Rider, adjustable	Z63	7	
Transformer	Z7	2	
Switch, AC, Isolating	Z70	2	
EMR Permanent Magnet Assembly	Z8	2	
„ Coil, ARC	Z80	2	
„ Front Plate	R10	8	
„ Rear Plate	R11	8	
„ Housing Cover	R12	9	
„ Switch, three-position	R2	8	
„ Contact Set Switch	R21	8	
„ Lock-out Key	R22	—	
„ Potentiometer	R3	8	
„ Terminal Block	R4	8	

ACCESSORIES.

Synth-a-lube Oil, Bottle	Z 90
Oiler Pin	Z 91
Regulating Weights (Set)	Z 92
Regulating Weight, 1 sec.	Z 921
„ „ 0.5 sec.	Z 922
„ „ 0.1 sec.	Z 923
Pin, Pendulum, Adjusting	Z 93
Pendulum Spring	82

ORDERING SPARE PARTS: Please state part number and serial number of Master Clock.

11.1 NOTES TO PHOTOGRAPHS.

(Dial and Front Cover of Master Clock not shown.)

Fig. 1: Front view of movement with front plate (P/No. 40) and other components removed.

Fig. 2: Front view of rear mounting plate with movement removed, transformer housing cover removed, plastic cover of terminal TSC (P/No. 901A) removed and pendulum hung in position.

Fig. 3: View from left-hand side of movement. Support without pendulum suspension.

Fig. 4: View from right-hand side; otherwise same as Fig. 3.

Fig. 5: Rear view. Movement standing on support back-to-front.

Fig. 6: Bottom part of pendulum bob and scale.

Fig. 7: Front view of movement with dial face removed.

Fig. 8: EMR control with cover (R12) removed.

Fig. 9: EMR.

ADDITIONAL PARTS LIST.

12. PARTS LIST FOR EC/DC.

Parts interchangeable between types EC/AC and EC/DC have retained Part Numbers listed in Section 11.

	Part No.	Fig. No.
Minute Cam	H411	8, 9 & 11.
Micro-Switch Cam	H422	9.
Re-wind Armature	H45	11.
Re-wind Magnet Poles	H460	9.
Re-wind Coils	H461	8.
Terminal	H462	8.
Protecting Bracket	H473	8.
Top Minute Contact	H50	8.
Lower Minute Contact	H51	8.
Micro-Switch	H6	10.

Note: Figures 8 & 9 mentioned in Section 11.1 have been deleted.

Substituted:

Fig. 8 shows front view of D.C. movement.

Fig. 9 side view of D.C. movement.

Fig. 10 left hand side view of movement.

Fig. 11 D.C. movement with front platten removed.

12. PHOTOGRAPHS AND IDENTIFICATION.

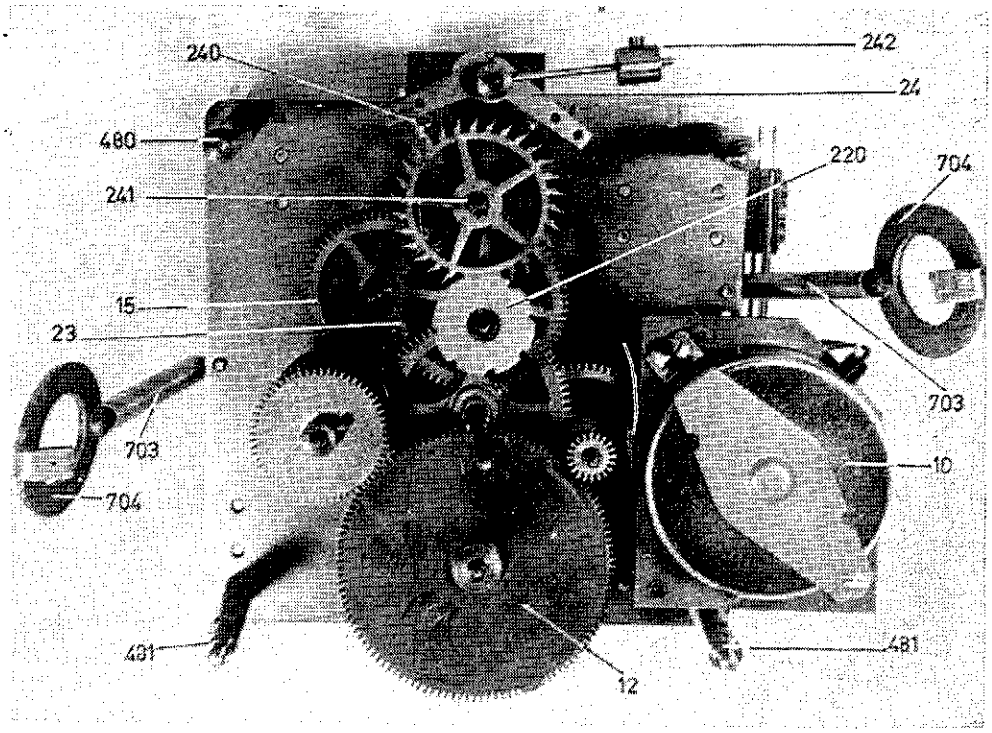


Fig. 1.

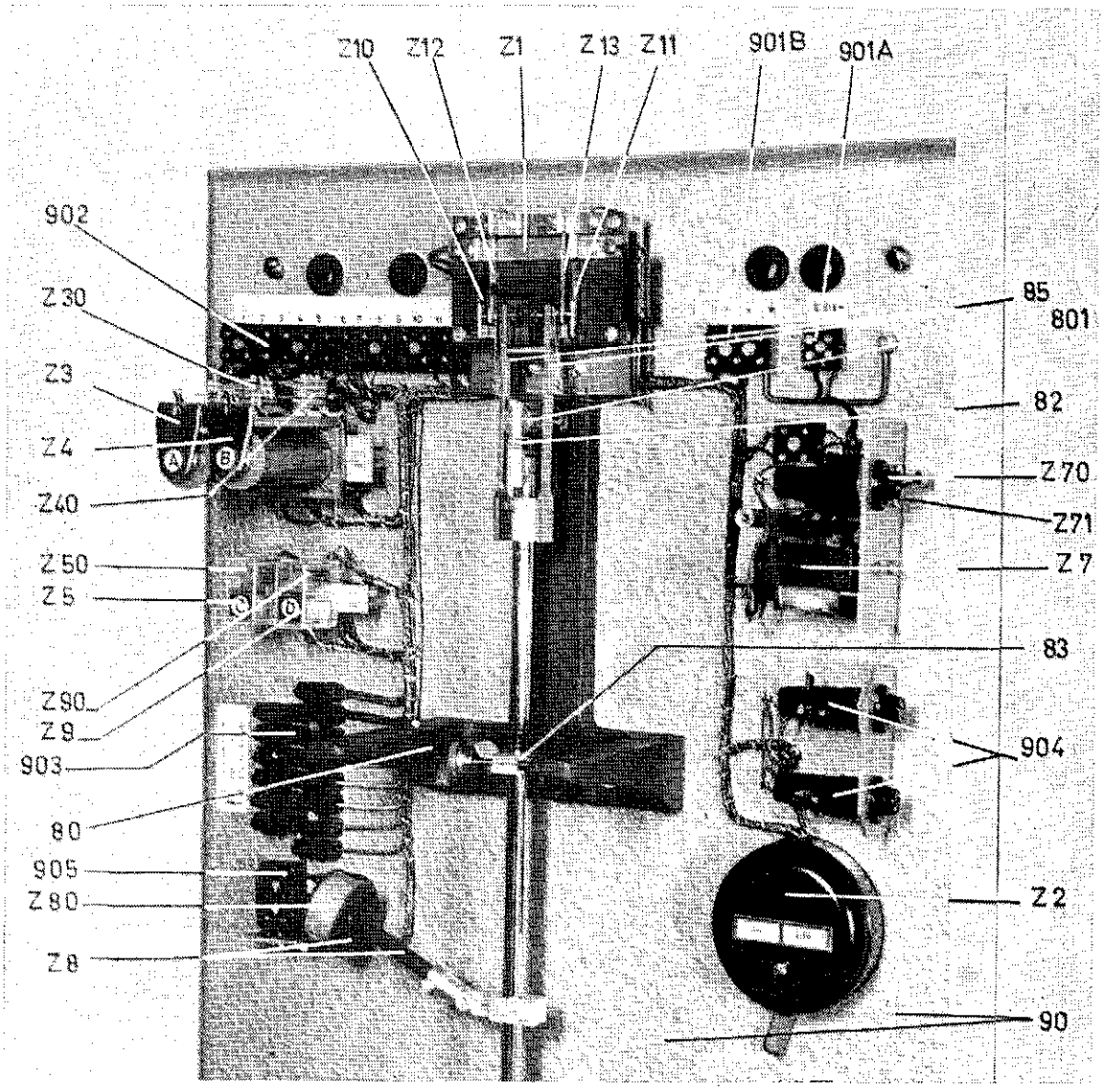


Fig. 2.

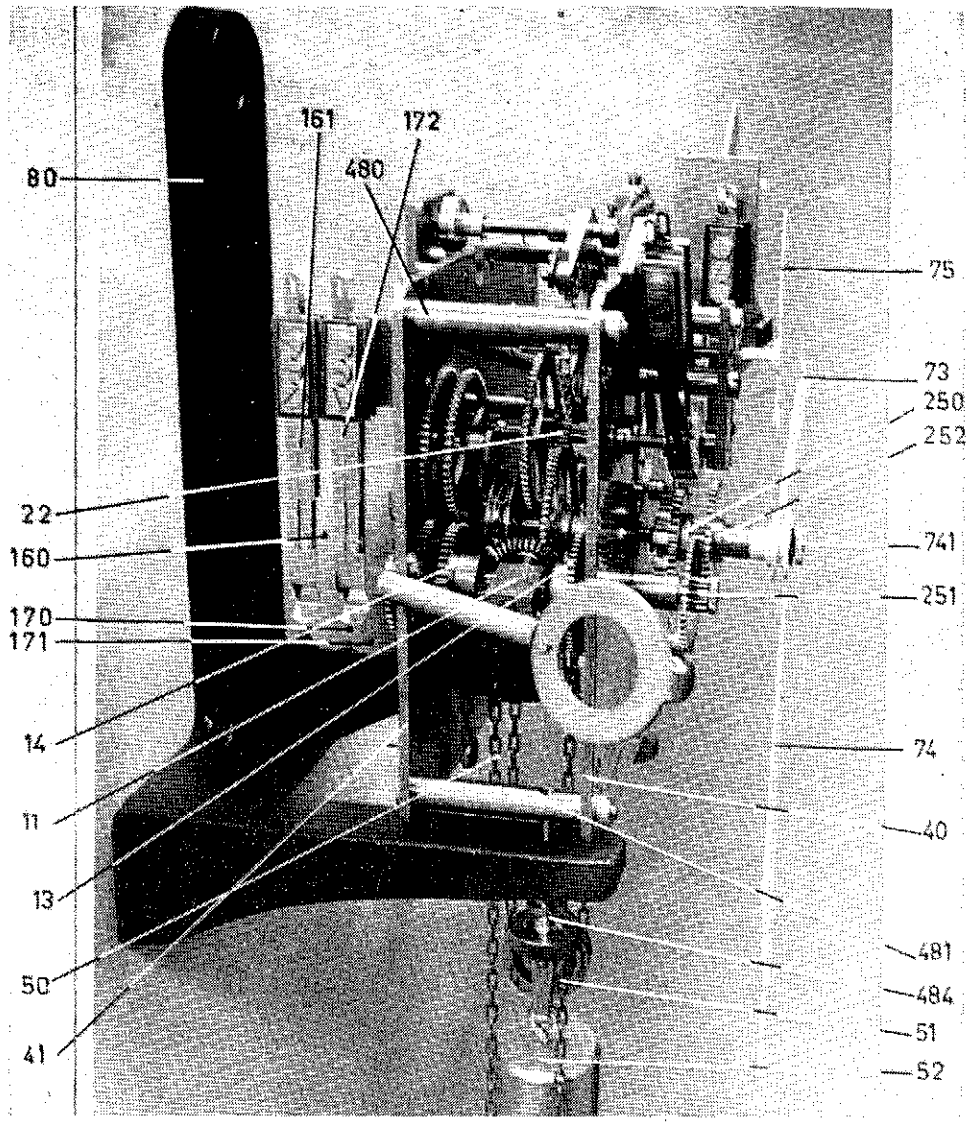
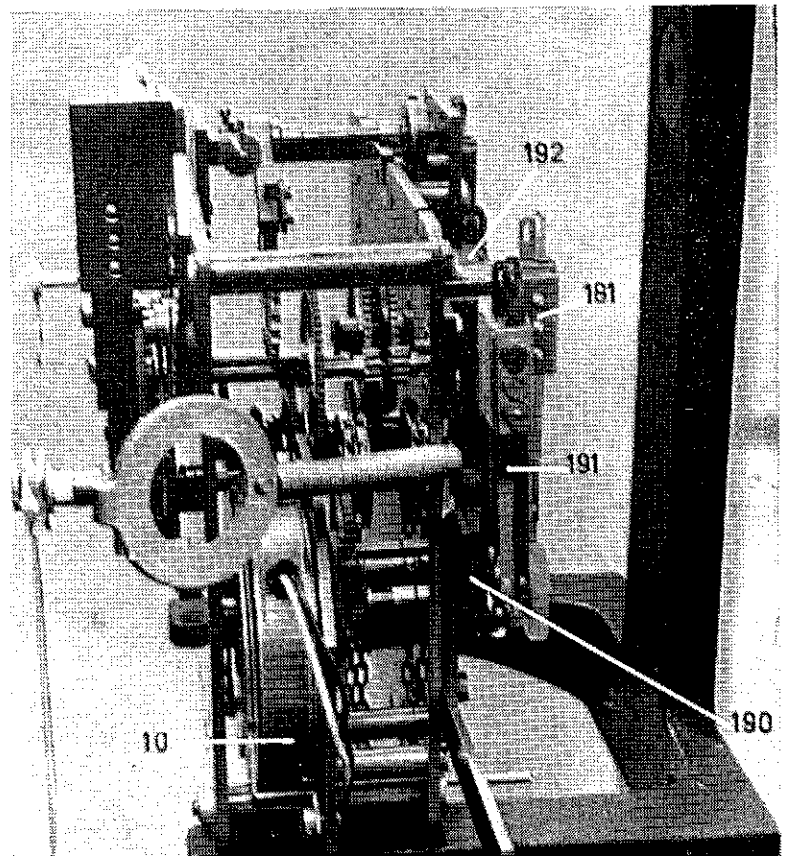

161
172
480
80
75
73
250
252
22
741
160
251
170
171
14
74
11
40
13
481
484
50
51
41
52

Fig. 3.


192
181
191
190
10

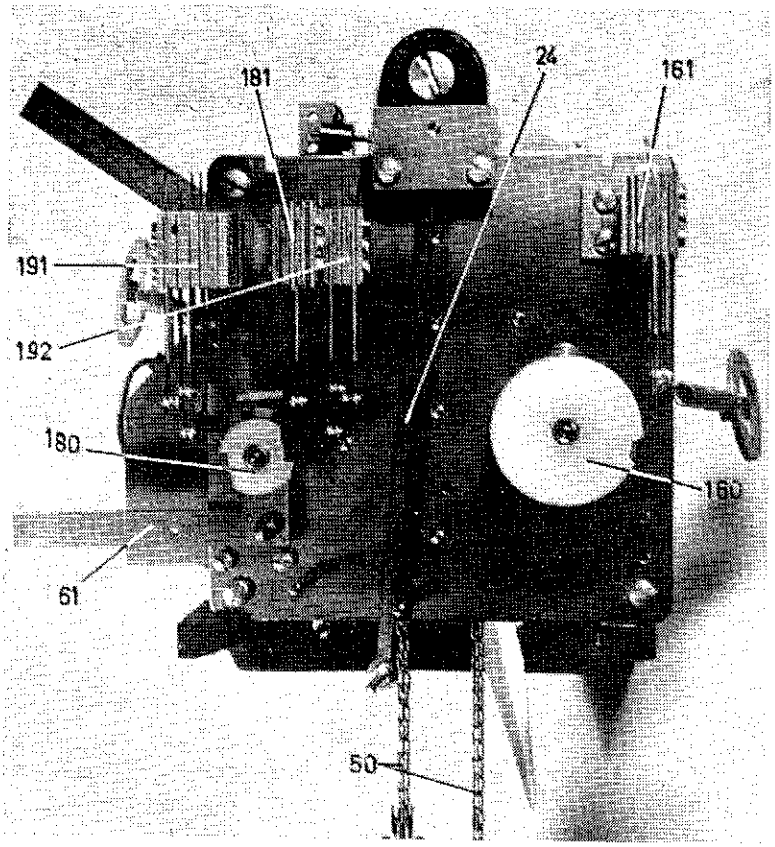

181
24
161
191
192
180
160
61
50

Fig. 5.

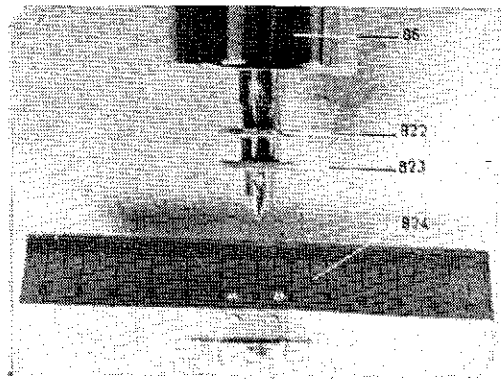
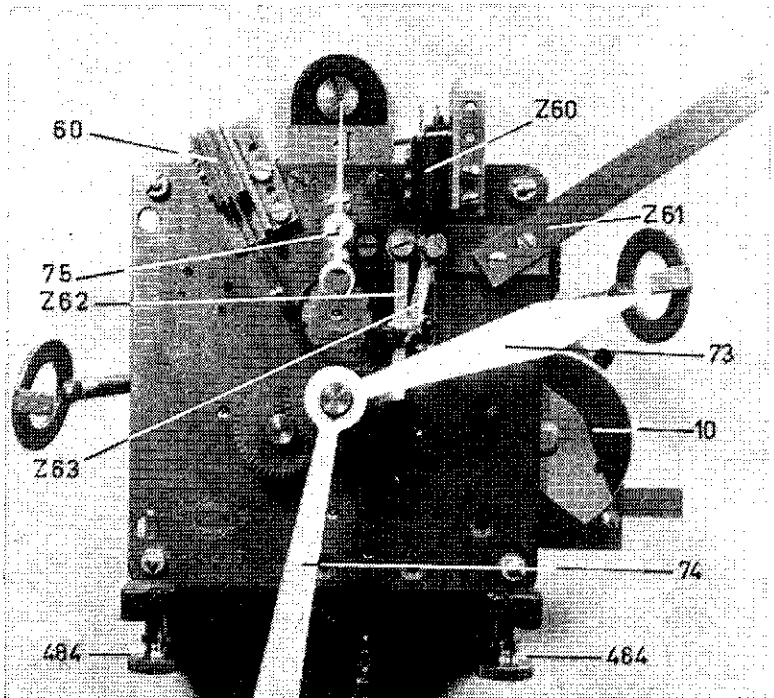

86
822
823
824

Fig. 6.


60
Z60
Z61
75
Z62
73
10
Z63
74
484
484

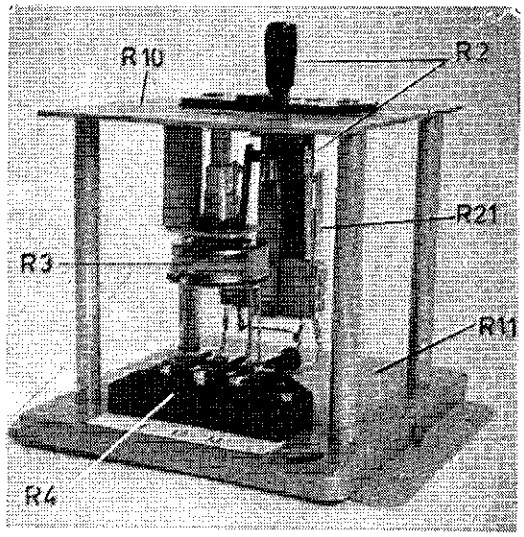


Fig. 8.

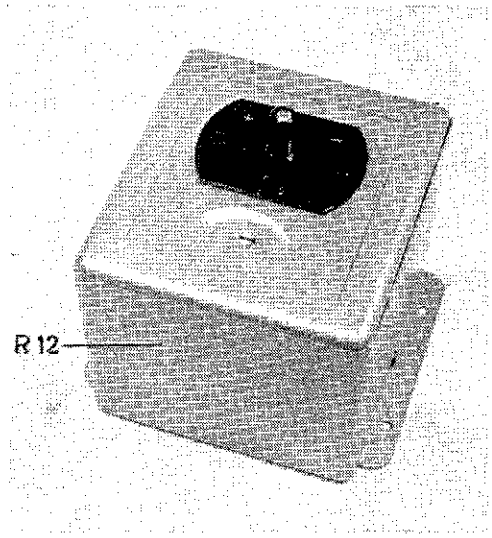
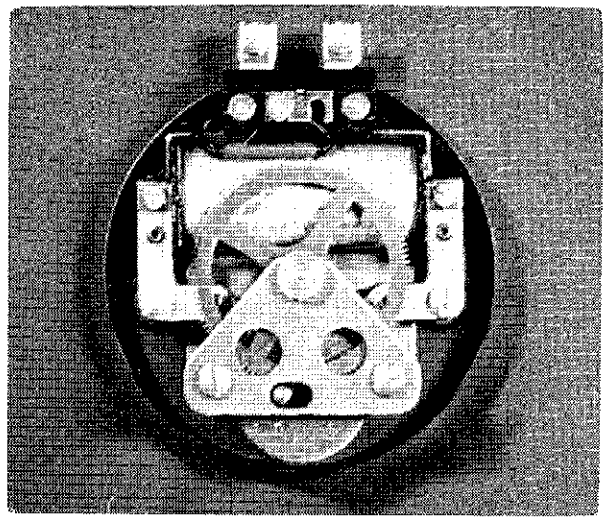
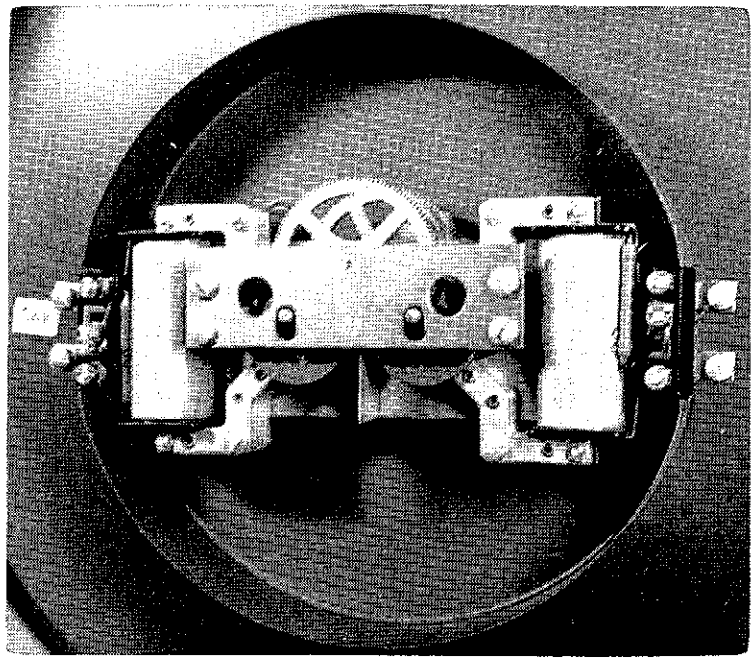


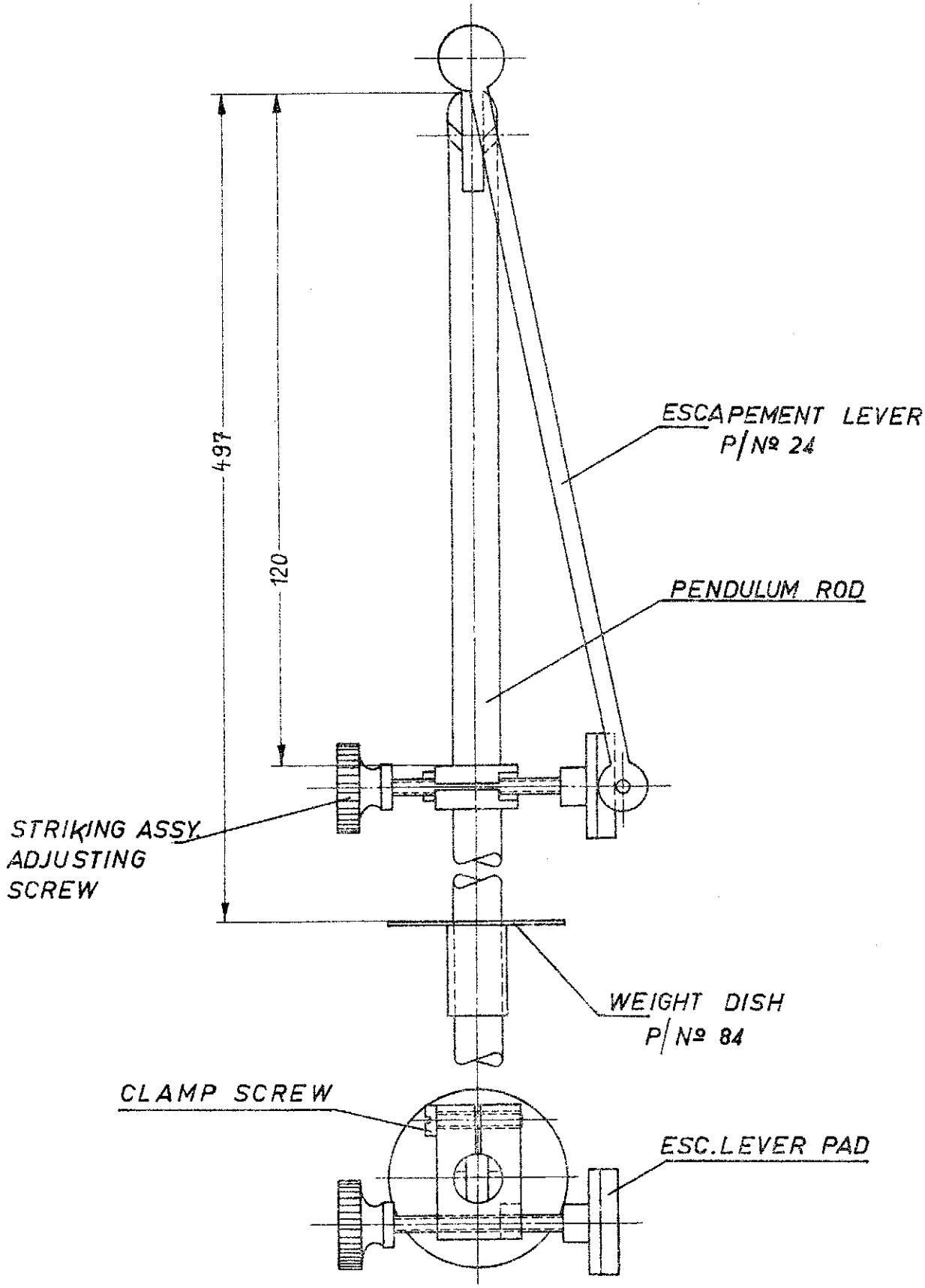
Fig. 9.



Mechanism of 24-hour Dial Slave Clock for minute impulses only. (DCA Indent No. V9/211.) Rear view.



Mechanism of 24-hour Dial Slave Clock for Minute and second impulses



	Datum	Name	Werkstoff:	C. Theod. Wagner A.-G. Wiesbaden
Gezeichnet	12. 3.62	Nicolay	Oberfläche:	
Geprüft			Auftrag:	

Maßstab
SCALE
1:1

E. S. RUBIN & CO. PTY. LTD. SYDNEY.

MASTER CLOCK EC 1/1 SEC. INVAR PENDULUM
POSITION OF STRIKING ASSEMBLY AND WEIGHT
DISH ON ROD.

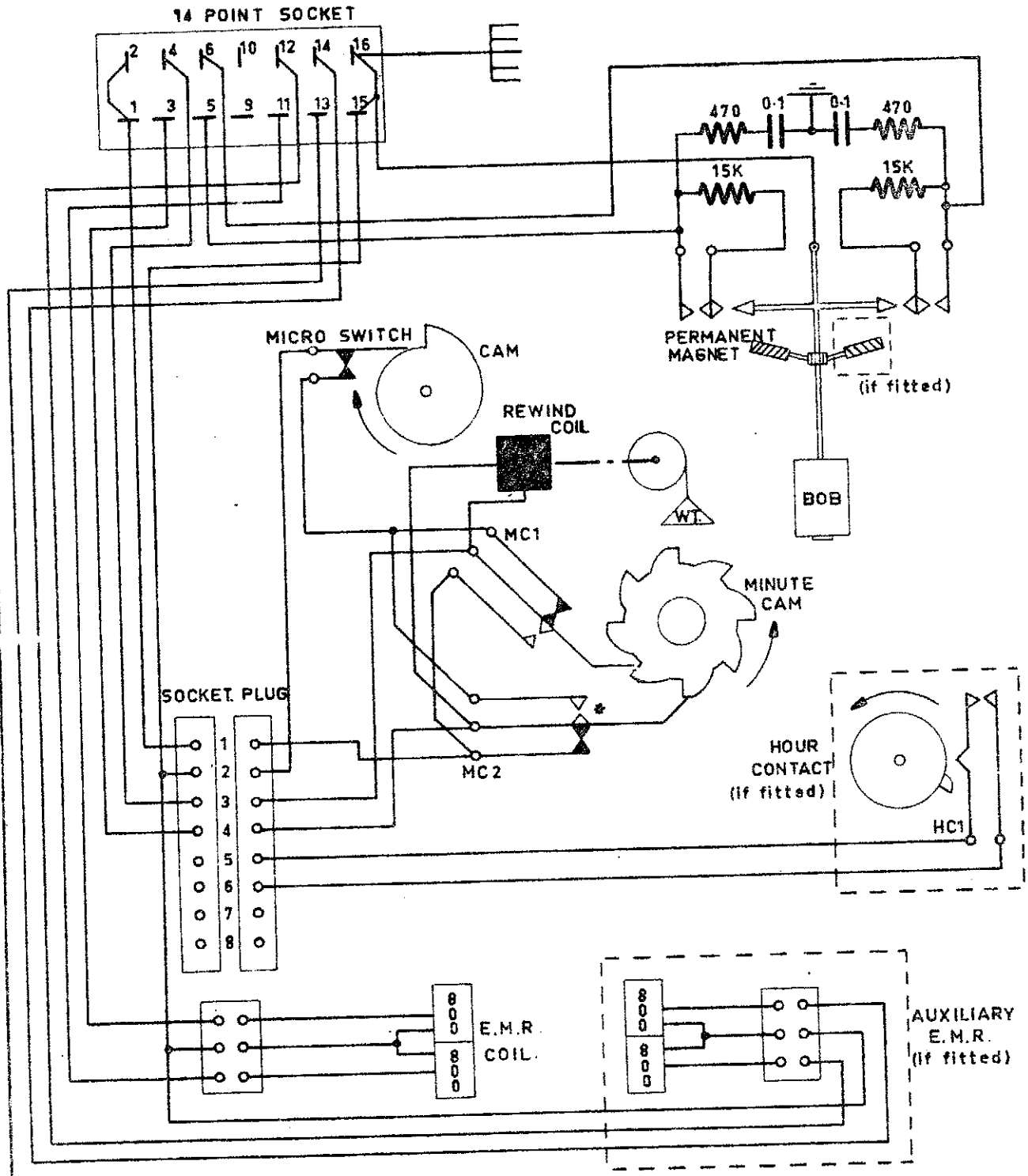
SIZES IN MM.

DRWG. Nº
Z. Nr. 4163

Ers. f. 3 12.60

Ablage:
8/5

Ers. d.



* NOTE:
CONTACT GAP 0·6mm.

E. S. RUBIN & CO. PTY. LTD.

C.T.W. MASTER. CLOCK.
TYPE EC/DC MOVEMENT WITH MICROSWITCH

DRAWN:	C.G.T.	DATE:	17 - 2 - 66
CHECKED:	Eda	AMENDMENTS:	
	No. 305		D2

15. DIAL SLAVE CLOCKS SYSTEM GRAU-WAGNER.

1. Introduction.

System Grau Wagner for operation of Slave Clocks (clocks stepped by polarised electrical pulses originating in master unit) was first patented on 8th November, 1881. It was further improved upon as new materials became available until present form was perfected in 1956. Each slave clock receives 525,600 minute pulses per annum, and if fitted with seconds movement, 31,536,000 seconds pulses.

2. Operating Principles:

2.1 Slave movement consists of electro-magnet in the form of a coil with laminated soft iron core

2.2 **Armature** consists of two "Z" shaped soft iron pieces between which is a permanent magnet. and a revolving double armature with gear train for operation of clock's hands.

Armature is connected with main drive shaft through a brass bush. The soft iron is magnetised by the permanent magnet and obtains north and south poles respectively.

2.2.1 When the coil receives a DC pulse from Master, opposite poles attract and same poles repel each other creating rotary motion turning armature 90°. This motion is taken up by the gear train and transmitted in appropriate ratio to minute and hour hands (or seconds hand if clock so equipped).

2.2.2 The pulses are polarised and will therefore move armature in the same direction each minute (or second as the case may be).

2.2.3 Surplus energy is dissipated by a magnetic friction clutch so that hands will travel only the pre-determined distance.

Friction clutch operates on magnetic principle. It consists of a brass balance disc fitted with a ground steel bush near armature sitting on main axle. In the lower part of the balance wheel is a steel plate fixed with a small air gap over the magnetically influenced soft iron.

During the fast rotating motion of the armature from pole to pole the balance wheel overtakes somewhat and "brakes" itself to a stop. During the over-travel the armature and the hands do not move.

The magnetic forces are so balanced that movement operates satisfactorily from half- to double-rated voltage.

3. The coil is supplied for 6/12V or 12/24V, but may be used with series resistance for up to 100V D.C. Clocks for 50V DC operation are supplied with 5,000 Ω in series.

4. Hands should be set to required time by turning of small knurled wheel at back of housing.

5. Maintenance and Adjustments.

5.1 **Slave Advances.**

Minute hand is loosened and each minute travels a little further. Secure hand by pushing firmly on to axle.

5.2 **Slave Retards.**

(a) Check electrical connections.

Check oil and inspect wiring from Master for short circuit. Replace coil is necessary.

(b) Minute and hour hands are touching. Check for free movement of both and bend hands to suit.

(c) Gears are full of dirt or old oil or lack thereof.
Clean thoroughly as per

5.3 **Cleaning and Oiling.**

Dismantle carefully. Wash gears and brass parts in clean petrol. Clean bearings with soft-wood point.

Check polish of bearing surfaces.

Remove foreign bodies.

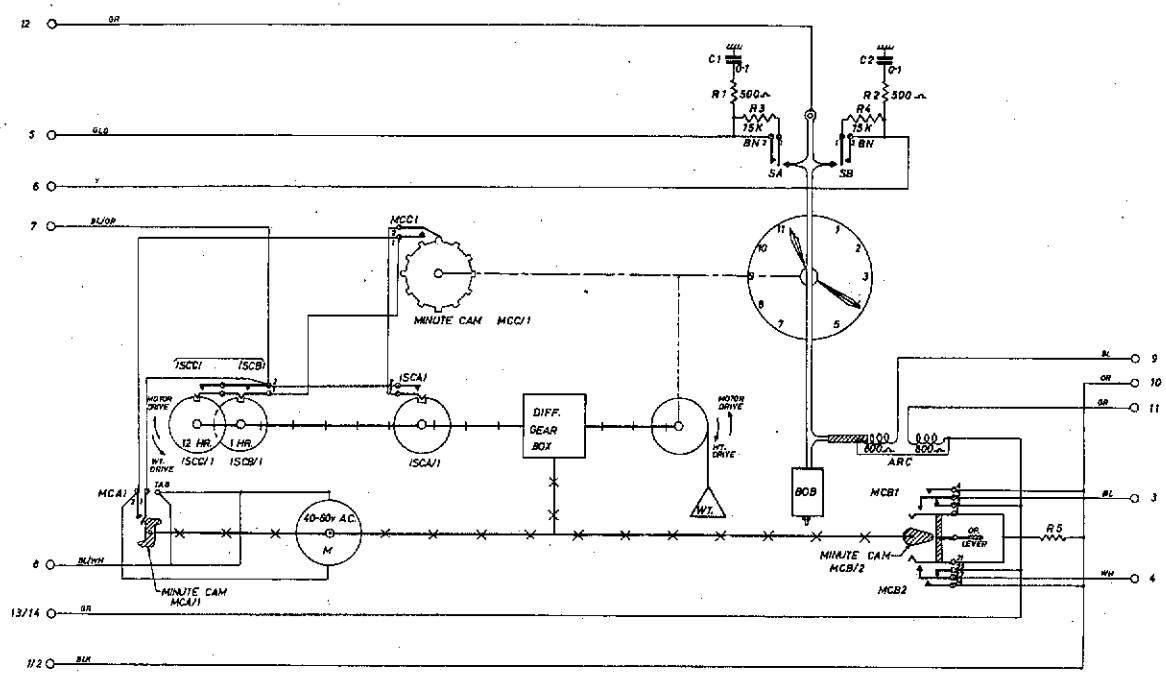
Oil with special lubricant available from C. T. Wagner or distributors. Re-assemble.

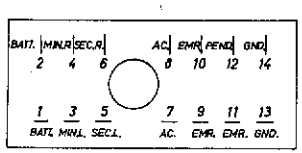
Tighten well all screws. Check electrically before installation.

6. Coil and Resistor Specification for 50V DC.

6.1 Dial Slave Clocks:

	Coil.	Series Resist.
Minute Pulse Movement	1,300 Ω ..	5,000 Ω
Seconds „ „	1,300 Ω ..	5,000 Ω



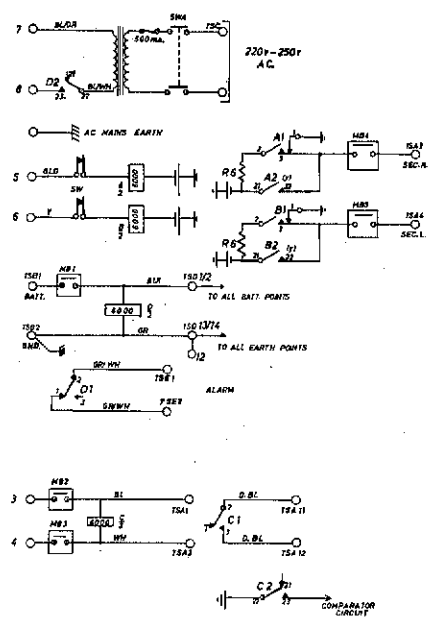


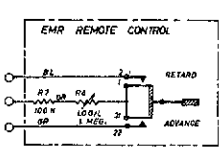
PLUG AND SOCKET
TERMINAL APPROPRIATION EC/2

NOTES :-

1. ONLY C/B MB1 INITIALLY FITTED.
2. PULSE SYNC. ALARM (COMPARATOR) SEE DRG. 219. (IF FITTED)
3. VALUE R5 & R6 DEPENDANT ON NUMBER OF SLAVE UNITS.

DISTRIBUTION CUBICLE





FOR MASTER CLOCK TYPE EC/AC WITH IMPULSE STORAGE

ISSUE 2

E.S. RUBIN & CO. PTY. LTD.

C.T.W. MASTER CLOCK CONTROL SCHEMATIC

DATE: 22-5-64

No. 218

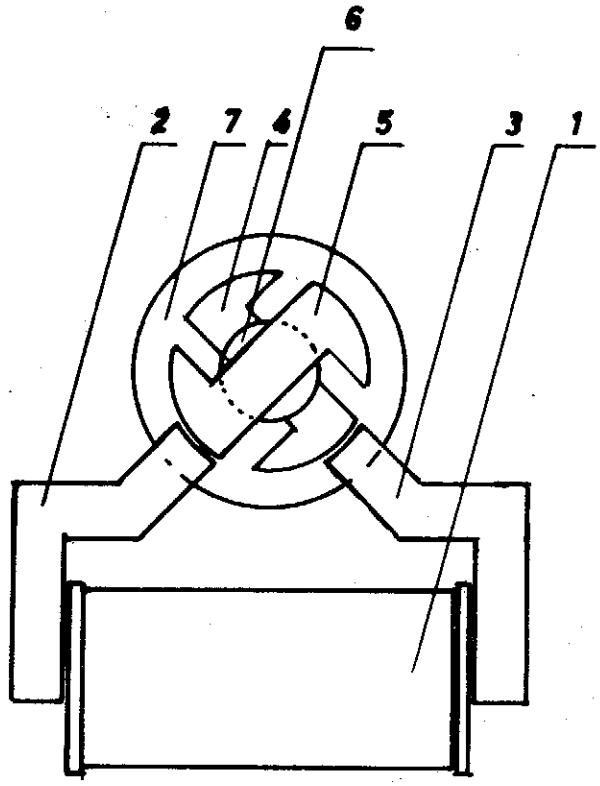


Fig. 1.
(schematic only)

TABLE OF RESISTANCES & CURRENT REQUIREMENTS
OF C.T.W. SLAVE CLOCKS

VOLTAGE		12V		24V		60V	
		Ω	mA	Ω	mA	Ω	mA
MOVEMENT	cm SLAVE SIZE						
1	40 ø	1300	9.2	2800	8.6	9800	6.1
	60 ø	1000	12	2000	12	6000	10
1B	40 ø	1450	8.3	2450	9.8	8450	7.1
	60 ø	1000	12	2000	12	6000	10
11B	80 ø	500	24	2000	12	6000	10
111	100 ø	600	20	2400	10	6400	9.4

PARTS LIST FOR DIGITAL SLAVE CLOCK

TYPE 1155

Armature (No. S 11) consists of two Z-shaped soft iron pieces (S 110) between which is a permanent magnet (S 111).

Armature is connected with main drive shaft (No. S 113) through a brass bush (No. S 112). The soft iron is magnetised by the permanent magnet and obtains North and South poles respectively.

1 When the coil receives a DC pulse from Master, opposite poles attract and same poles repel each other creating rotary motion and turning armature 90°. This motion is taken up by the gear train and transmitted in appropriate ratio to minute and hour hands (or to seconds hand if clock is so equipped).

2 The pulses are polarised and will therefore move armature in the same direction each minute (or second, as the case may be).

3 Surplus energy is dissipated by a magnetic friction clutch so that hands will travel only the pre-determined distance.

4 Friction clutch operates on magnetic principle. It consists of a brass balance disc (No. S 114) fitted with a ground steel bush (No. S 115) near armature sitting on main axle. In the lower part of the balance wheel is a steel plate (No. S 116) fixed with a small air gap over the magnetically influenced soft iron.

During the fast rotating motion of the armature from pole to pole, the balance wheel over-travels somewhat and "brakes" itself to a stop. During the over-travel the armature and the hands do not move.

The magnetic forces are so balanced that movement operates satisfactorily from half to double-rated voltage.

5 The rotary motion of the armature is transferred by gear train (No. S 203) in ratio 1:2.5 to minute drum (No. S 210) and turns it to next number (next minute).

Coil	S 13
Series Resistance	S 14
Armature Assembly	S 11
Z-shaped Soft Iron Pieces	S 110
Permanent Magnet	S 111
Main Drive Shaft	S 113
Brass Bush	S 112
Brass Balance Disc	S 114
Ground Steel Bush	S 115
Steel Plate (lower part of balance wheel)	S 116
Gear Train	S 203
Minute Drum	S 210
Ten-minute Drum	S 211
Hour Drum	S 212
Grove	S 218
Cam	S 214
Sprocket Wheel	S 215
Sprocket Wheel Plate	S 217
Ten-minute Drum's Gear	S 216
Actuating Lever	S 22
Gear Train	S 12
Seconds Hand	S 10
Front Plate	S 30
Rear Cover	S 31
Support for Seconds Movement	S 1
Support for Minute and Hour Movement	S 21
Glass Cover of Seconds Dial	S 32
Toggle Switch (seconds OFF switch)	S 16
Wiring Bush	S 33
Seconds Terminal	S 15
Minutes Terminal	S 225
Cover Fastening Lugs	S—
Plate	S 213

TIME (MINUTE AND HOURS) INDICATING MECHANISM.

The single minute drum (No. S 210) is rotated every minute. It carries figures 0 - 9 and moves the ten-minute drum (No. S 211) on the decimal counter principle. Drum (No. S 211) carries figures 0 - 5 and similarly moves hour drum (No. S 212) with figures 0 - 23 at the appropriate times.

During the minute steps 1 - 9 of drum No. S 210, drum No. S 211 remains in position. Step from 9 - 0 causes drum No. S 211 to step one number, etc.

Minute drum No. S 210 is equipped with a plate with groove (No. S 218) to which a cam (No. S 214) is riveted in such a way that the groove of the plate matches with that between two teeth of the cam.

A sprocket wheel (No. S 215), held in position by plate No. S 217, has eight teeth, four of which have a half-tooth milled away.

The sprocket lies on plate No. S 213 in such a way that two full teeth lie on its circumference, whilst the third (milled) tooth is below its plane.

The full sprocket teeth grip into ten-minute drum's gear, No. S 216.

The condition described above blocks completely any movement of the ten-minute drum during minute steps 1 - 9. At the ninth step, one tooth of cam No. S 214 reaches a full tooth of the sprocket (No. S 215).

During the step from 9 - 0 this tooth is allowed to pass through groove of plate and thus the sprocket is rotated two teeth and the ten-minute drum is stepped one figure further.

The same principle applies to the hour drum No. S 212.

MECHANICAL STEPPING OF SLAVE (MINUTES is possible through a small hole in front of clock's front plate located approximately ⅜" above the single minute digit. By pushing a pin through opening, a spring-loaded cylinder is moved back and forth actuating lever No. S 22, which engages gear No. S 203 and steps minute drum.

During normal operation of slave, lever mechanism No. S 22 is not engaged and does not interfere with clock's motion. A spring permits operation of mechanical stepping in horizontal position.

TIME (SECONDS) INDICATING MECHANISM.

Each second's pulse from Master Clock energises coil No. S 13, which rotates armature assembly No. S 11. The motion is transferred via gear train No. S 12 to hand No. S 10.

COMMISSIONING.

Remove back cover of installed clock. Connect minute pulse wires to terminal No. S 15.

Both terminations to be of correct polarity. If connected correctly it will be noted that when minute drum (digit) moves to next number, the seconds hand will be pointing to an **even** second (i.e., 0, 2, 4, 6, etc.); if not, reverse leads.

Rotate minute drum carefully by hand until clock shows the time a minute or so behind Master Clock. Switch off seconds.

Replace back cover.

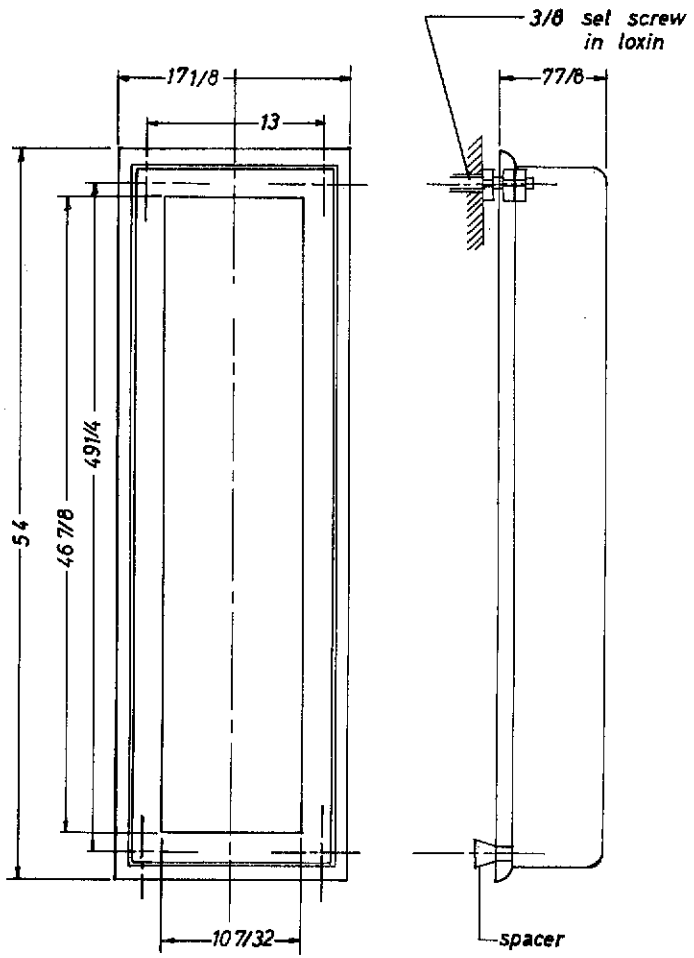
Advance clock by pin (through opening in front plate) to **one** minute **ahead** of Master and await next pulse, which should not move clock. The pulse following will commence correct operation of minutes. Synchronise seconds. Minute pulse should coincide with seconds hand moving from the 59th to 60th second.

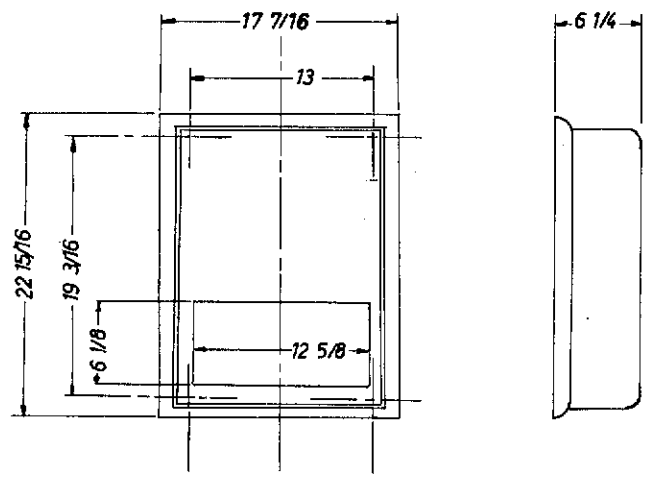
MAINTENANCE.

It is suggested that seconds movement be examined for dirt every two to three years. If oil in bearings is discoloured, clean thoroughly before re-oiling (there are over 30 million seconds per annum).

Minute and hour movement will operate satisfactorily almost indefinitely provided no dirt enters the movement, and even then cleaning will remedy sluggishness which may occur.

Cleaning: Use only clean petrol (lighter fluid). Bearings to be cleaned with softwood stick only. If necessary to oil, use only oil type Moebius No. 4, obtainable from C. T. Wagner or distributors.





NOTE 1. Hinges L.H.S.

2. Mounting holes –
25/64 Dia top,
1/4 Dia bottom.

E.S. RUBIN & CO. PTY. LTD.

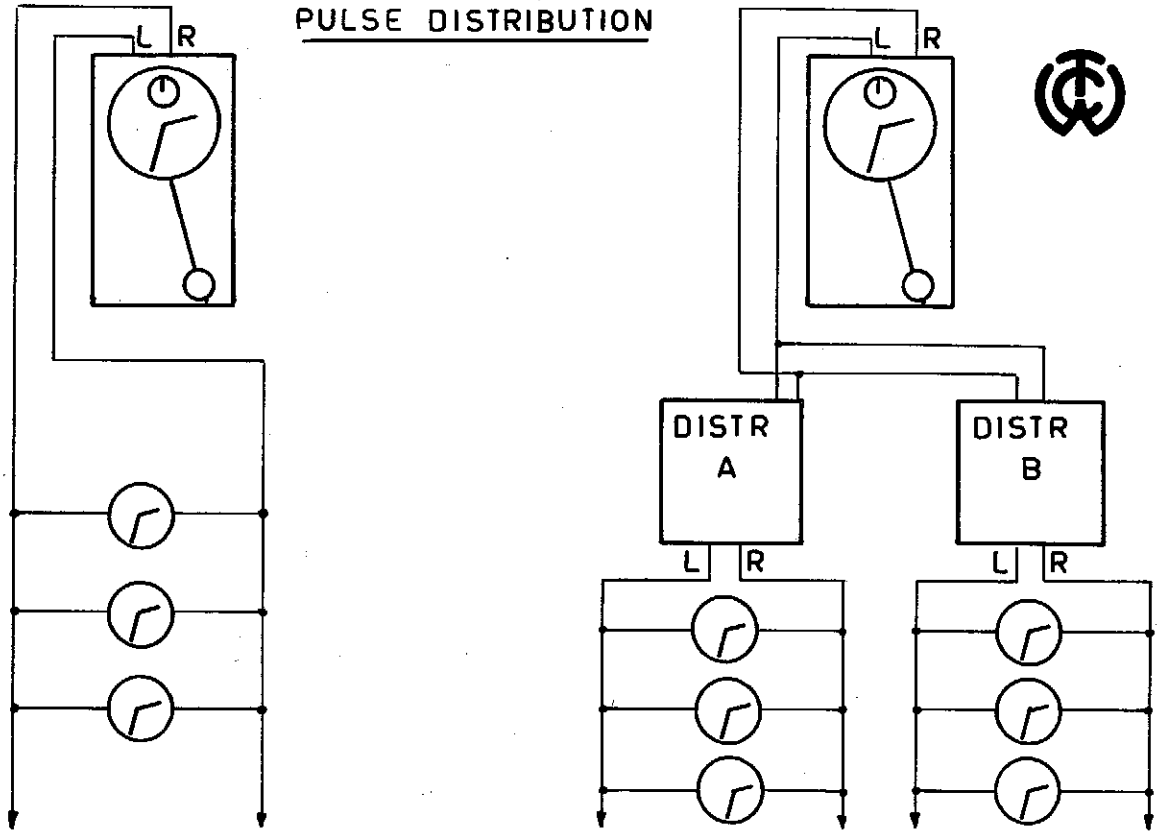
SYDNEY

C.T.W. MASTER CLOCK HOUSING, TYPE ECH & DISTRIBUTION CUBICLE

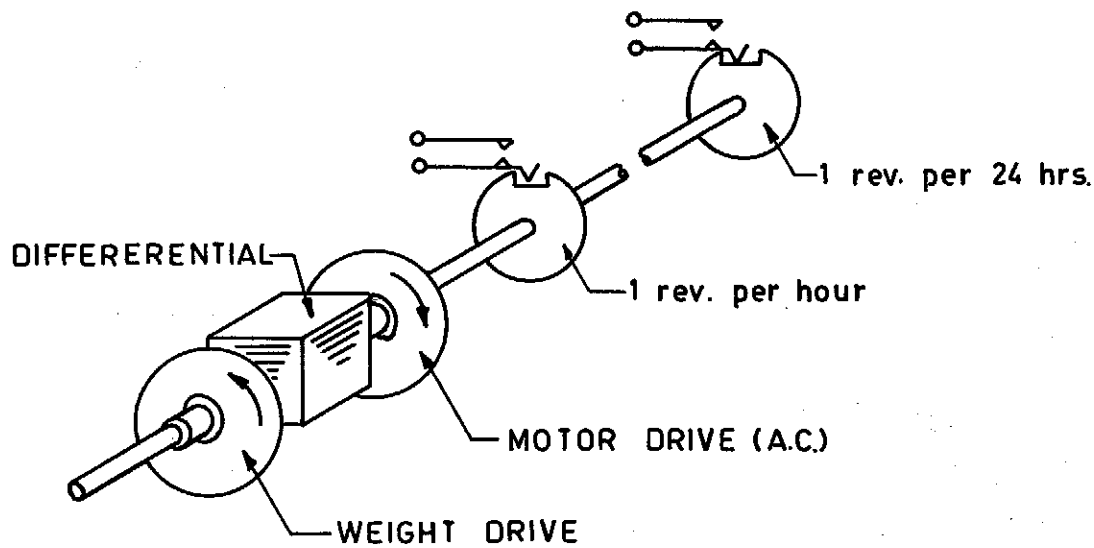
SCALE: 1:10			DATE: 18.5.64
DRAWN:	G.R.H.	APPROVED	
CHECKED:		AMENDMENTS	

No. 217

PULSE DISTRIBUTION



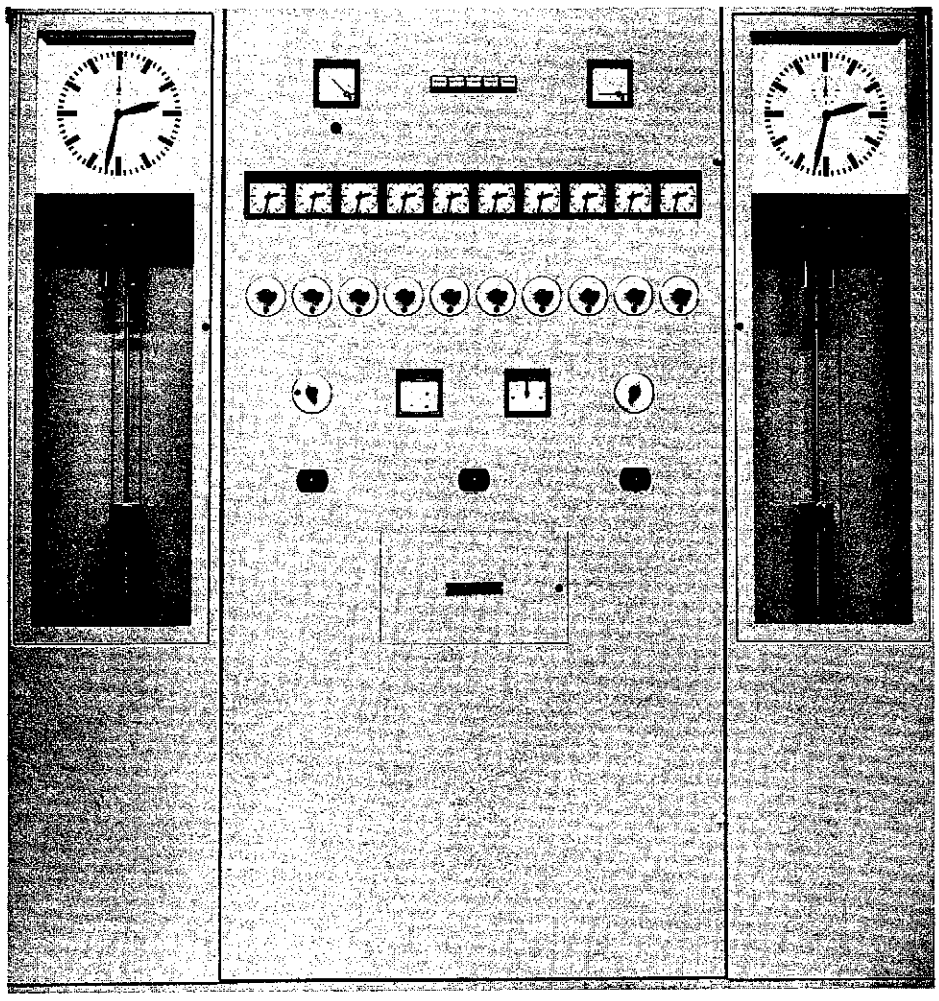
IMPULSE STORAGE PRINCIPLE

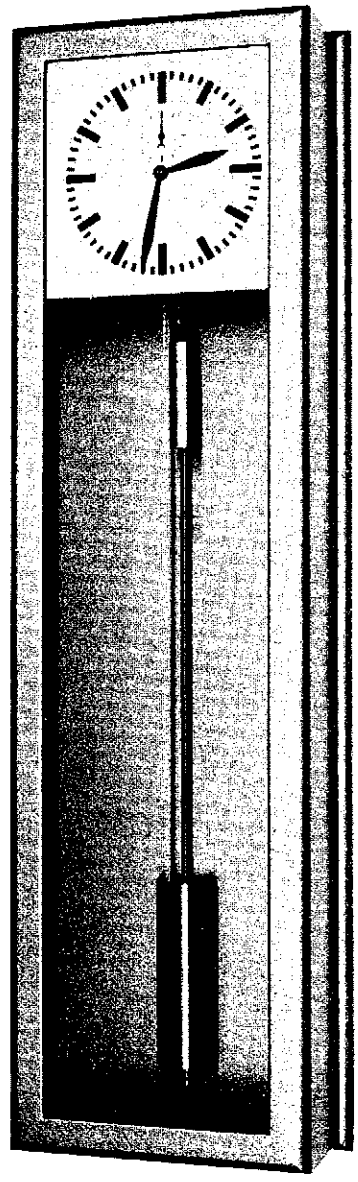


(FOR MASTER CLOCKS TYPE E.C.)

C. THEOD. WAGNER A. G. WIESBADEN

(Established 1852)





MASTER CLOCKS 'E.C'

The Manufacturers and Distributors reserve the right to effect changes and modifications to products described herein without notice.

C.T. WAGNER MASTER CLOCKS

Master Clocks are mechanical time pieces with auxiliary contacts for generation of electrical pulses transmitted to a network of electro-mechanical repeating stations connected ("slaved") to it. The accuracy of the whole system is equivalent to that of the Master Clock.

PULSES

The C.T.W. Master Clocks are designed to supply DC pulses of reversing polarity every full minute of approximately 2 seconds duration. Master Clocks so equipped will also produce pulses every second (approximately 250 m/seconds duration) as well as other specific signals described elsewhere.

Polarity reversal pulses are used to operate the system (see chapter "Slave Clocks") over a two wire network to which all slaves are connected in parallel. This ensures that upon installation and synchronisation of all clocks, the entire system will be stepped by the Master in unison and no "correcting" mechanism is required. Even if a "false" pulse would be sent through the network (which would have to be introduced from an external source as it cannot be produced by the Master) it would have to be of the correct polarity at the time (i.e. opposite to that last sent by Master) to have any effect at all. Assuming that false pulse <u>was</u> of correct polarity, it will step slaves by one minute (or one second if this happens on the seconds distribution). Repeated application of this current will have no effect within that minute whatsoever. The next correct pulse from the Master will be (as it must) of the same polarity as the "false" pulse and therefore, will not operate the Slave Clock movements thus the Slaves will be again showing Master Clock time.

Pulsing contacts of the Master Clocks are so arranged that during periods between pulses, both legs of slave lines are connected to ground (positive terminal of battery).

All Master Clocks are equipped with internal pulsing switch for simultaneous manual stepping of Slaves. (Refer Distribution of Master Clock pulses).

MASTER CLOCK TYPES

We can offer two basically different types according to their basic movements i.e. Pendulum, Balance Wheel.

The selection of the right type for your requirements will mainly depend on the required accuracy of the system, its size (i.e. number of Slave Clocks to be connected), special functions if any and the clocks own mechanical power reserve.

MASTER CLOCK TYPES (cont'd)

Balance Wheel Master Clocks are suitable only for small installations of up to 12 Slaves connected directly with an accuracy of ± 2 seconds per 24 hours. Power reserve approximately 6 hours. Minute pulses only.

Pendulum Master Clocks can drive up to 100 Slaves with an accuracy of better than 0.3 seconds per 24 hours with power reserve up to 25 hours and to provide minute, seconds and special pulses.

PENDULUM MASTER CLOCKS

Time in these devices is measured by the swing of a suspended weight (Pendulum) which, during its travel, releases one tooth of escapement wheel at regular intervals. The rotary motion is transferred through a gear train to clock hands indicating time and to contact sets providing paths for battery current in predetermined sequence.

The pendulum receives its maintenance (i.e. energy) through the escapement and gear train by force exerted by a descending weight which also provides storage of mechanical power. All C.T.W. Master Clocks electrically rewind weight every minute by exactly the distance descended during this time.

It will be obvious that the pendulum is the governing factor as the accuracy of its swing period determines the accuracy of the system. Some basic facts must be, therefore, considered:

PENDULUM THEORY

The whole pendulum assembly must be considered as a mass turning upon its point of suspension.

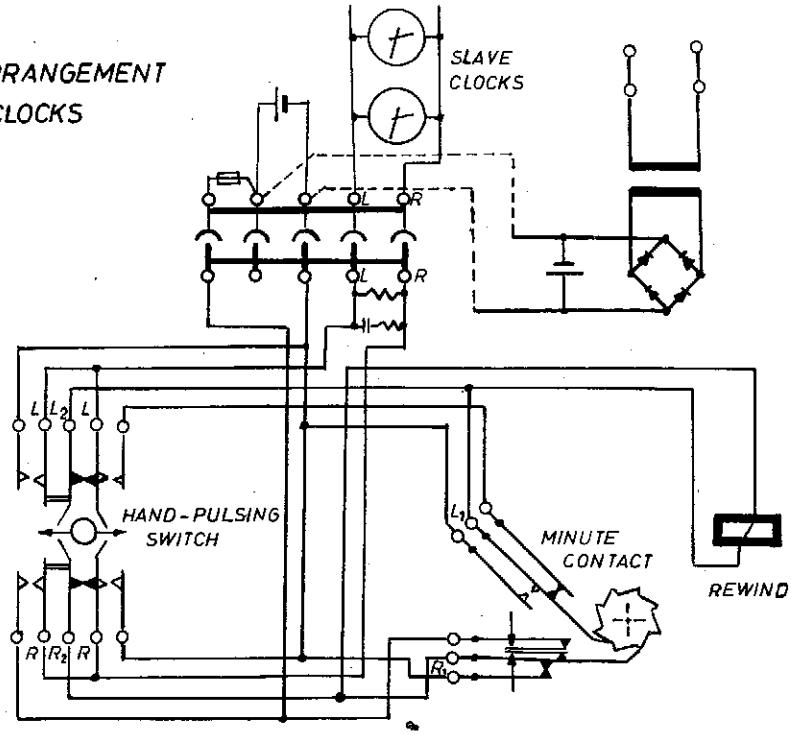
The period of swing depends on:

a) The turning effect of the weight about the point of suspension increase of which causes acceleration.
b) The opposition to change of motion (moment of inertia) an increase of which slows the swing.

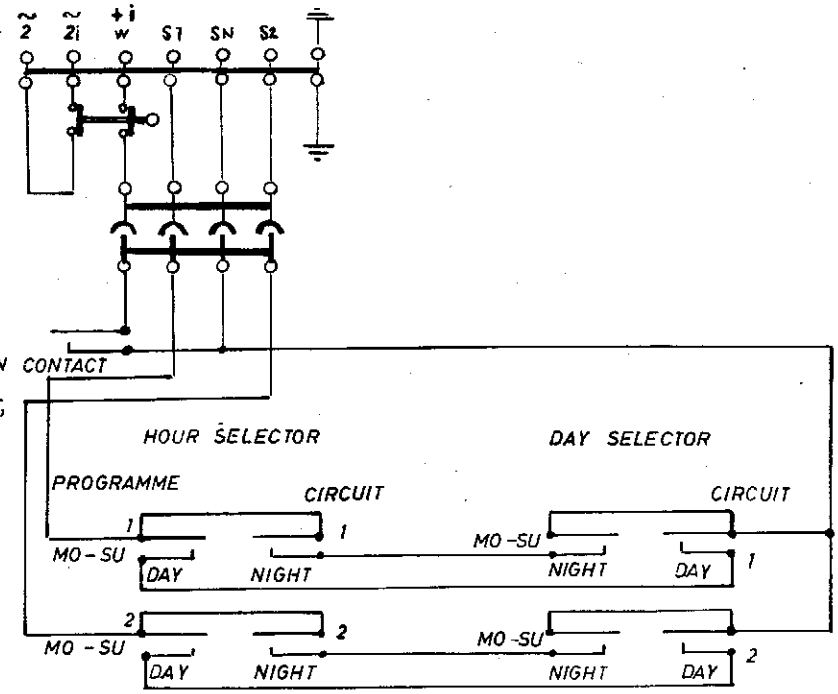
The increase in turning effect is directly proportional to the depth of the added weight below the point of suspension; but the increase of moment of inertia about the point of suspension is proportional to the square of this depth.

The acceleration effect is much greater than the retarding effect.

MINUTE PULSING ARRANGEMENT FOR D.C. MASTER CLOCKS



SCHEMATIC DIAGRAM FOR SIGNALLING FACILITY TYPE J



SLAVE CLOCKS - SYSTEM GRAU-WAGNER

Slave Clocks of all sizes are stepped by polarised electrical pulses originating in master unit. System Grau-Wagner, first patented in November 1881, utilises the polarity reversal of DC current to obtain rotary motion through magnetic forces which is transferred in the appropriate ratio to clocks hands. These movements may be operated off polarised minute or seconds pulses and if seconds indication is required to be shown, two movements are used in such clocks. Each of the movements is supplied by two wires from the master unit.

The Slave Clocks movements are robustly constructed to operate satisfactorily for many years. In the absence of any contacts or complicated gearing, the movements will easily cope with 525,600 minute pulses or 31,536,000 seconds pulses per annum.

OPERATING PRINCIPLES

Slave movement, Fig. 1 (for minutes or seconds) consists of an electro-magnet in the form of a coil (1) with a soft iron laminated core (2 & 3). The ends of the core are imparted magnetic polarity according to the direction of the current passing through the coil. The armature consists of two Z-shaped soft iron pieces (4 & 5) between which a permanent magnet (6) is located. Part 4 becomes the North and Part 5 the South pole of the magnet permanently.

When the coil receives a DC pulse from the master, core (3) becomes temporarily North pole of the electro-magnet and will repel armature (4) adjoining it but this will be attracted to core (2) which is of opposite polarity. At the same time, armature (5) will be repelled by core (2) whilst the other end will be attracted to core (3). Each of the two parts of the armature which adjoin the core are subject to four forces which cause rotation of the armature by 90°. When the next pulse arrives from the Master Clock, the polarity of the cores is reversed and the same process is repeated.

During the fast rotating motion of the armature from pole to pole, some over-travel occurs. To ensure that the excess motion is not transferred to the hands of the clock, a magnetic friction clutch (7) is arranged to dissipate surplus energy. This again is achieved by magnetic forces, so that no wear of parts occurs, and Slave Clock hands travel only the predetermined distance.

The magnetic forces of the Slave movement are so balanced that movement operates satisfactorily even 30% below its rated voltage.

Coils of Slave Clocks are supplied for 6, 12 and 24V but may be used with series resistance up to 100V DC.

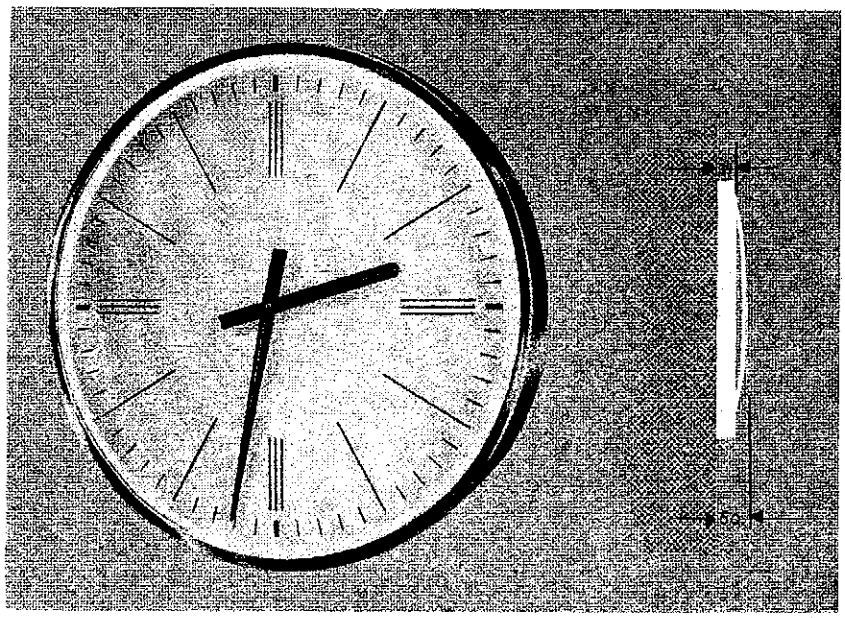


Fig. 151

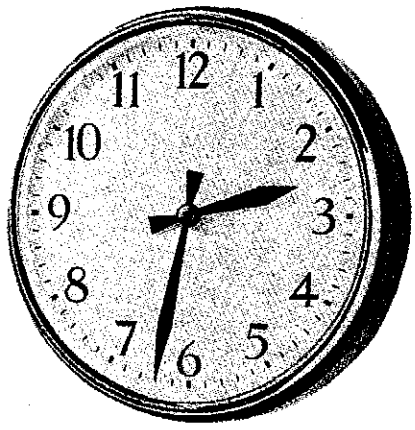


Fig. 152

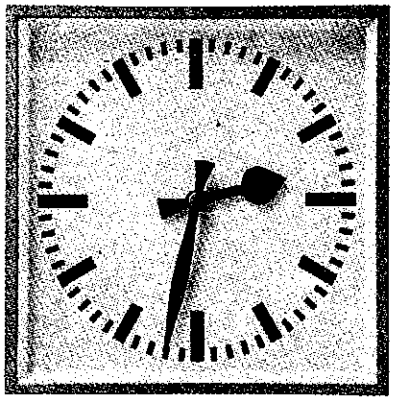


Fig. 158

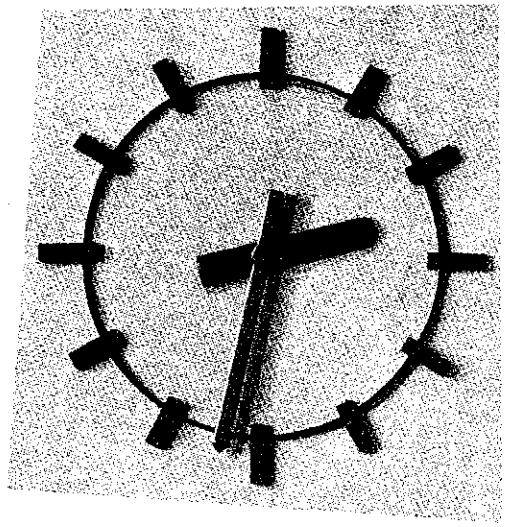


Fig. 94

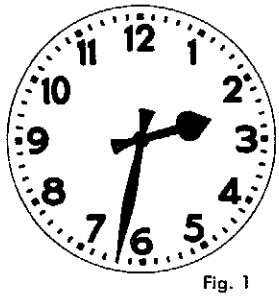


Fig. 1

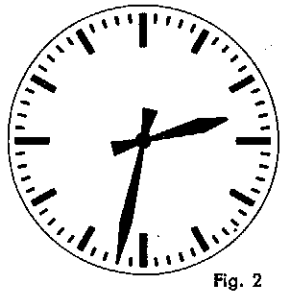


Fig. 2

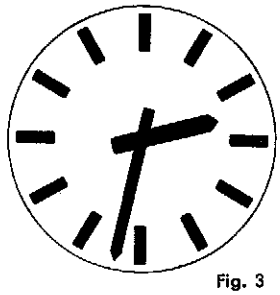


Fig. 3

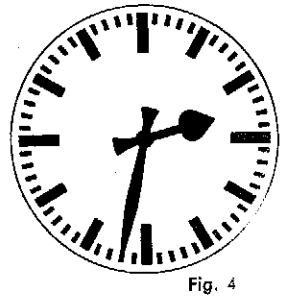
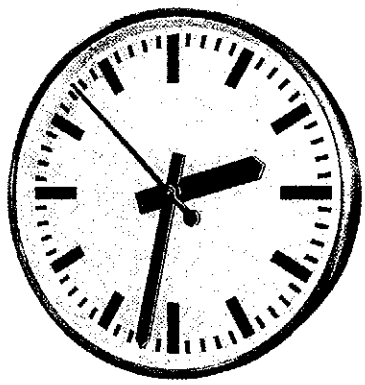


Fig. 4

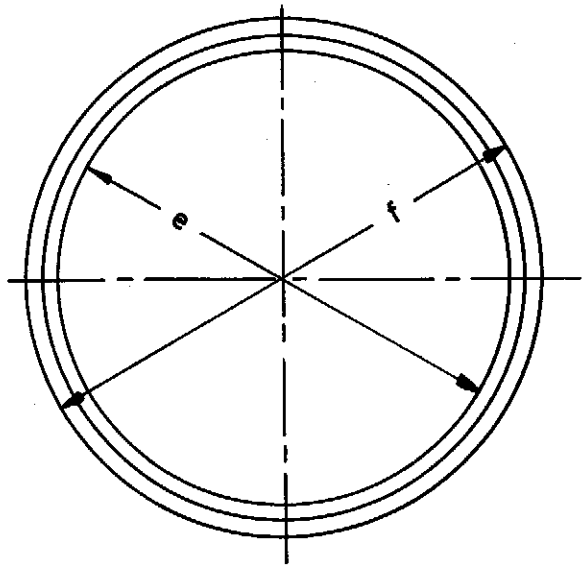
SLAVE CLOCK Nº 120 (minutes only)

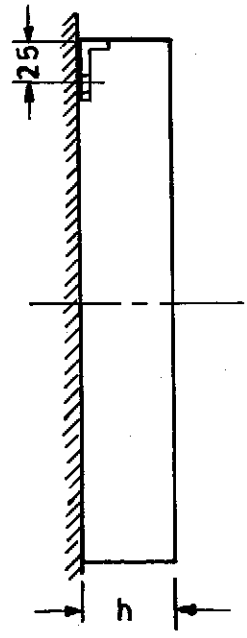
Nº 1116/120 (minutes & seconds)

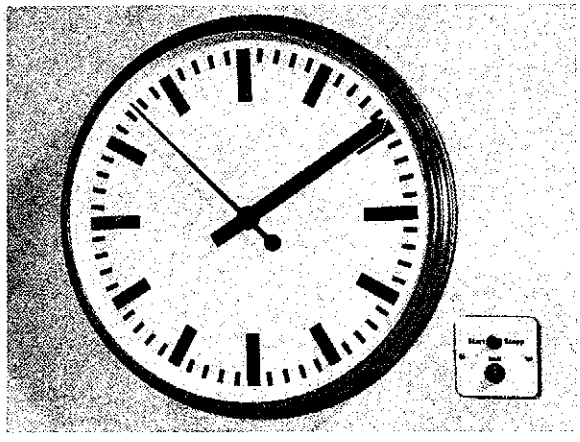


1116/120

DIAL DIAM. e (mm.)	MOVE-MENT.	f (mm.)	h min.	h min/sec.
250	I	282	63	80
300	I	344	63	80
400	I	424	80	80
500	I_3	553	80	90
600	I_3	653	80	90







STOP-CLOCK FOR SPORTING ARENAS.

FROM 1ft. TO 7 ft. DIAMETER.