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

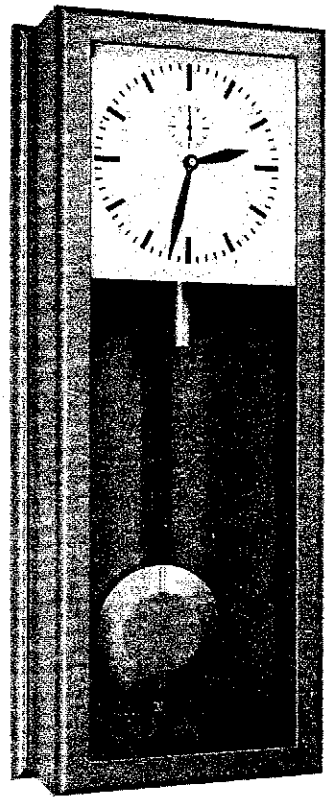
The whole pendulum assembly must be considered as a mass turning upon its point of suspension.

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.



MASTER CLOCK TYPE "C"

DESCRIPTION

Type C consists of a mechanical weight driven movement with $\frac{3}{4}$ pendulum of 1.5 seconds periodicity.

The weight is electrically rewound every minute by a modified version of Grau-Wagner slave movement. The Master Clock has a mechanical power reserve of approximately 15 hours.

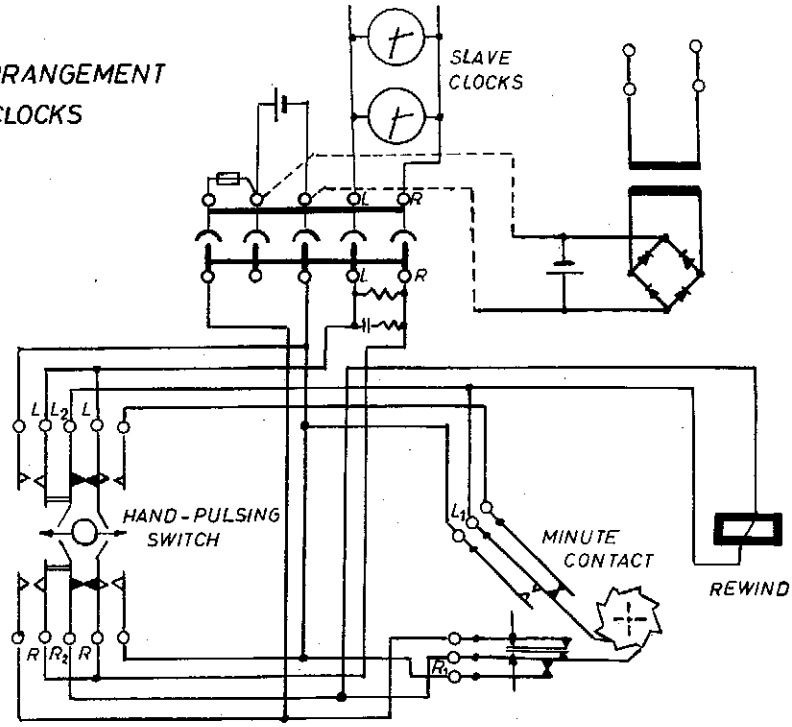
A cam located on one of the movements shafts actuates 2 contact assemblies in sequence which generate polarised minute pulses for slave clocks and rewind mechanism.

Contacts are capable of handling up to 50 slaves on a 24V DC system (12V or 6V system correspondingly less). It is recommended that a relay station be interposed for the protection of minute contacts where highly inductive load is anticipated.

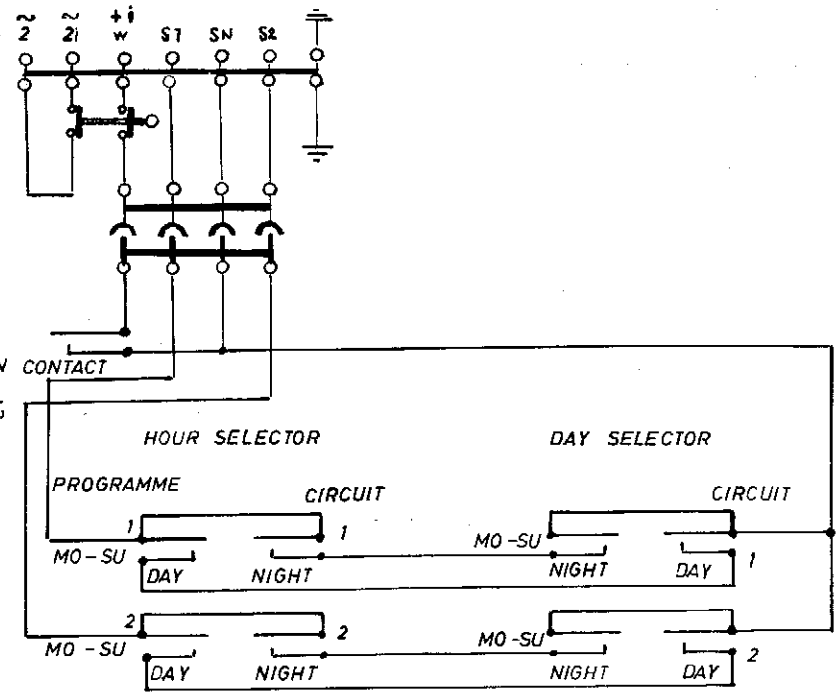
Master Clock "C" may be equipped with signalling device for a maximum of 6 separate programmes adjustable in steps of 5 minutes within 24 hours with possible differentiation between day and night and weekend switching. (Programming facility "J" is described separately).

Generation of seconds pulses by this type of Clock is not practicable.

MINUTE PULSING ARRANGEMENT FOR D.C. MASTER CLOCKS



SCHEMATIC DIAGRAM FOR SIGNALLING FACILITY TYPE J



ACCURACY

Type "C" is suitable for small to medium installation and depending on the type of pendulum used may be regulated to within ± 2 seconds or better per 24 hours under average circumstances. Provision of Invar Pendulum will substantially better the clocks performance especially when temperature fluctuations are anticipated.

Wooden rod standard pendulum is adjusted by a calibrated nut (with locking nut) which raises (or lowers) disk shaped bob. Each one of ten divisions represents an adjustment of 6 seconds per 24 hours (1 revolution = 1 minute/ 24 hours).

Invar pendulum rod has a vernier adjusting nut and weight dish allowing greater precision in adjustment independent of ambient temperature variations. Each of twenty divisions represents an adjustment of 2.5 seconds (1 revolution = 50 seconds/24 hours).

One set of adjusting weights consisting of 3 x 0.1, 3 x 0.5 and 3 x 1.0 seconds is supplied as standard equipment. Weights are laid on dish without stopping of pendulum.

Housing is of sheet metal construction, rust inhibited and supplied in baked enamel hammertone finish. The lid is of the lift-off type with glass front allowing full view of dial and pendulum with deflection scale. It is secured by two tapered pins at top and lock with key on the bottom. The approximate dimensions of the housing which is wall mounting (3 point suspension) are 13 x 32".

ELECTRICAL DATA

Master Clock "C" is a purely DC device and its own current requirements are –

SYSTEM	12V		24V		60V	
	Ω	mA	Ω	mA	Ω	mA
Rewind	250	48	1000	24	2500	24
Parallel Resistor	1000	12	4000	6	5000	12

Master Clock is supplied fully wired and ready for connection. Terminals for Slave clock line and power supply (as well as for signalling device if fitted) are provided in upper part of housing. Manual slave pulsing switch and fuse are incorporated.

The system may be operated off batteries preferably with floating charger or off mains AC supply with incorporation of suitable transformer and full wave bridge rectifier. (Refer circuit diagram).

The capacity of DC power supply will depend on the number of slave clocks connected. (Refer "Slave Clocks").

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^{o}. 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.

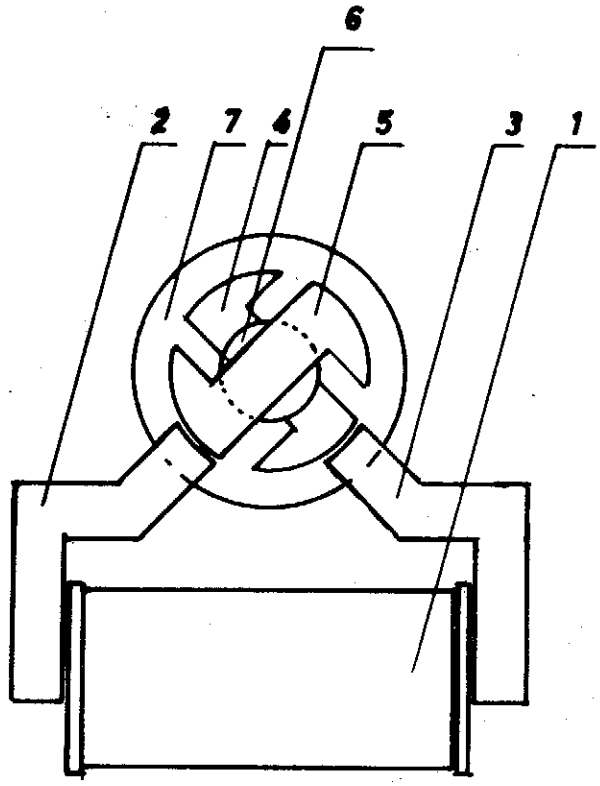


Fig. 1.
(schematic only)

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

DIGITAL SLAVE CLOCKS (Panel Mounting)

Type 1155 (for minute pulses only)
Type 06750 (for minute and seconds pulses)

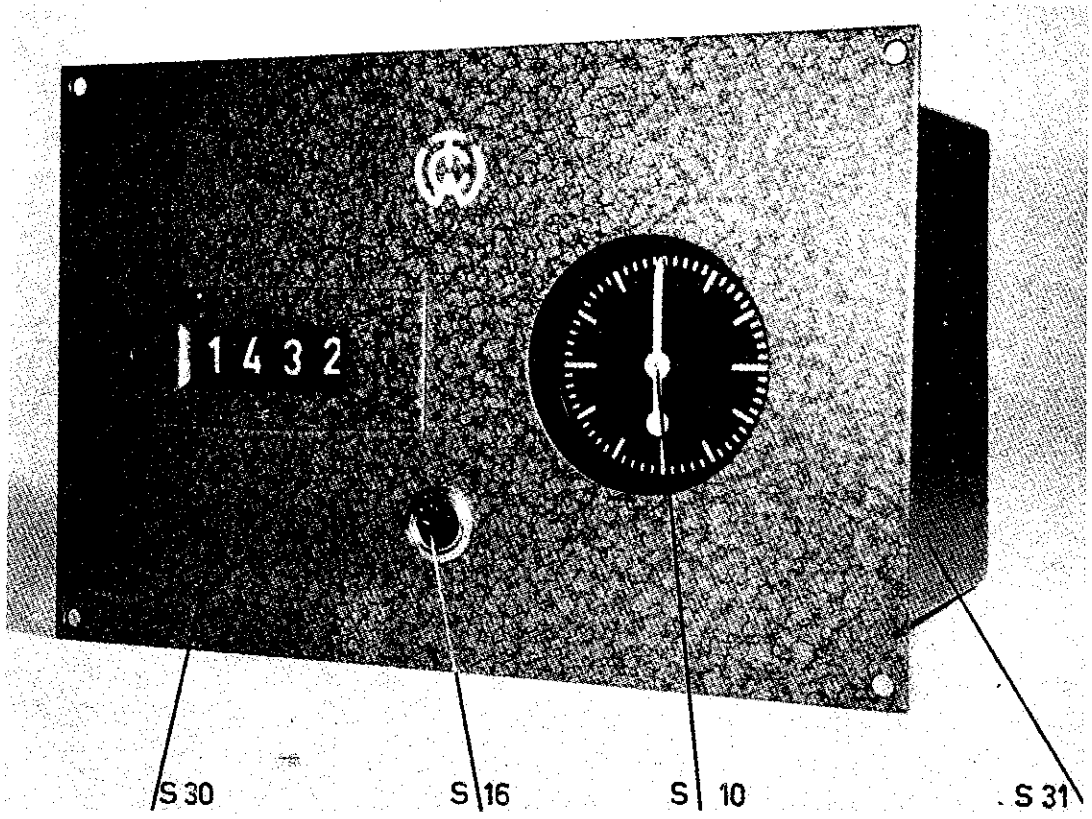
Time is indicated by figures appearing in a slot on face plate and is presented on 24 hour system. Seconds (if fitted on type 06750) are presented on dial (see illustration).

Movement is actuated by polarised impulses from Master Clock and are based on Grau-Wagner Principle (see section Slave Clocks). Special sound proofing of housing is available.

Standard finish of housing is green hammertone baked enamel. Magnifying lense for digits is optional.

ELECTRICAL DATA

Digital Slave Clocks may be supplied for 12, 24, 48 and 60V DC operation. Coils are wound for 12V DC with 100Ω for minutes and 130Ω for seconds with series resistor for higher voltages.



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 $\frac{5}{8}$" 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.

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.

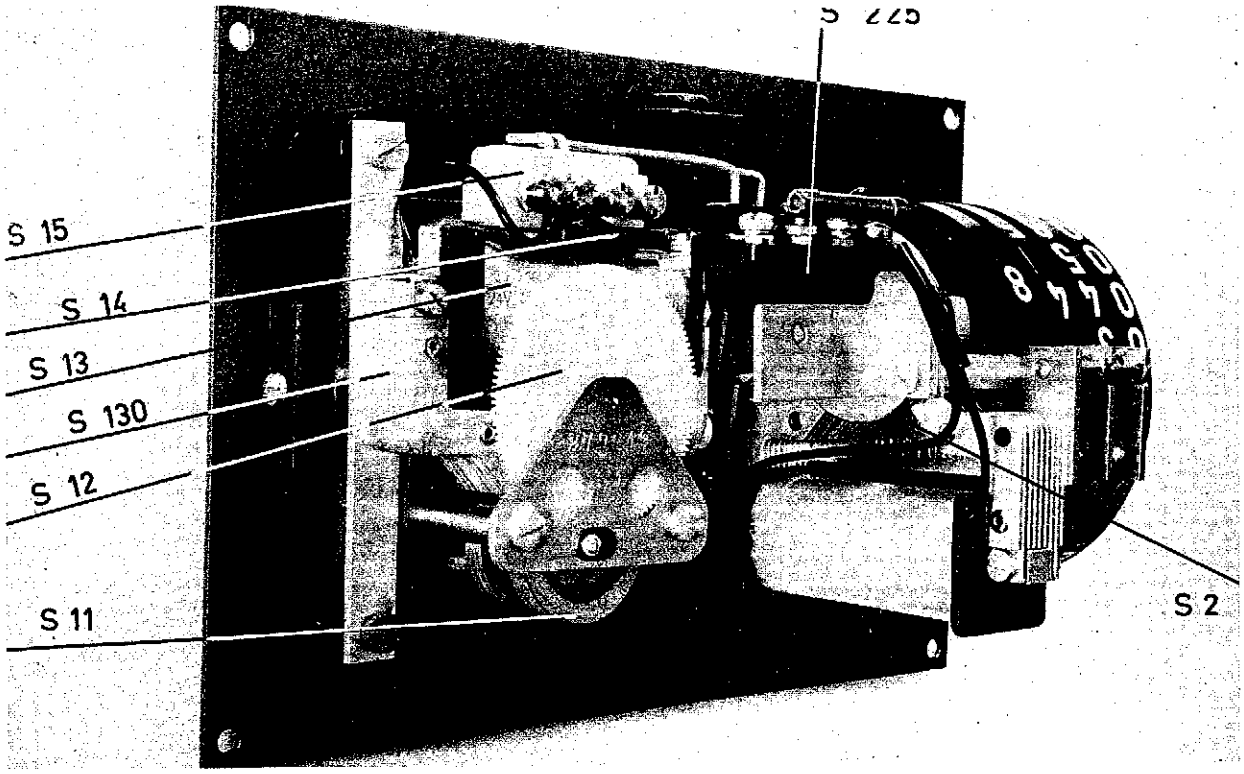
4 Friction clutch operates on magnetic principle. It consists of a brass balance disc (No. S 114) fitted with a ground steel bush (No. S 115) near armature sitting on main axle. In the lower part of the balance wheel is a steel plate (No. S 116) fixed with a small air gap over the magnetically influenced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

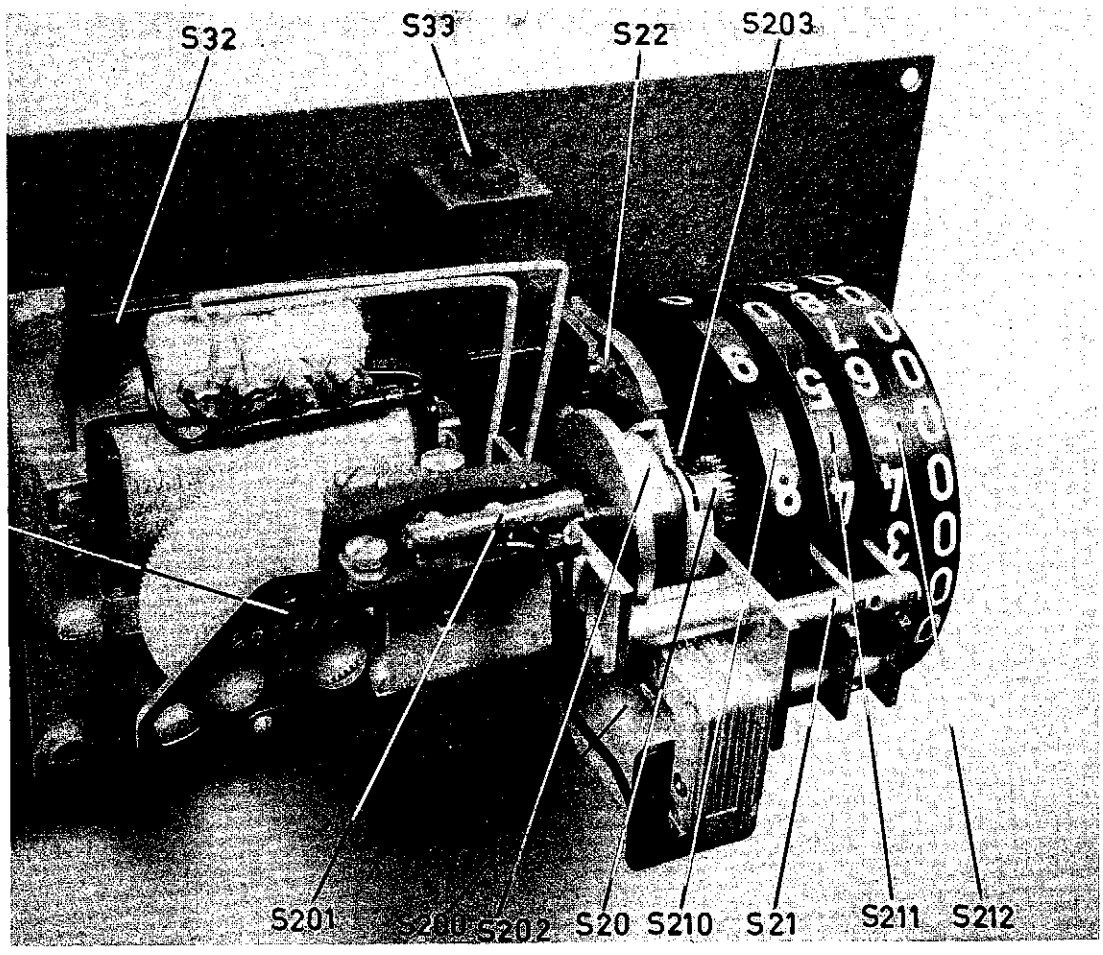
During the fast rotating motion of the armature from pole to pole, the balance wheel over-travels somewhat and "brakes" itself to a stop. During the over-travel the armature and the hands do not move.

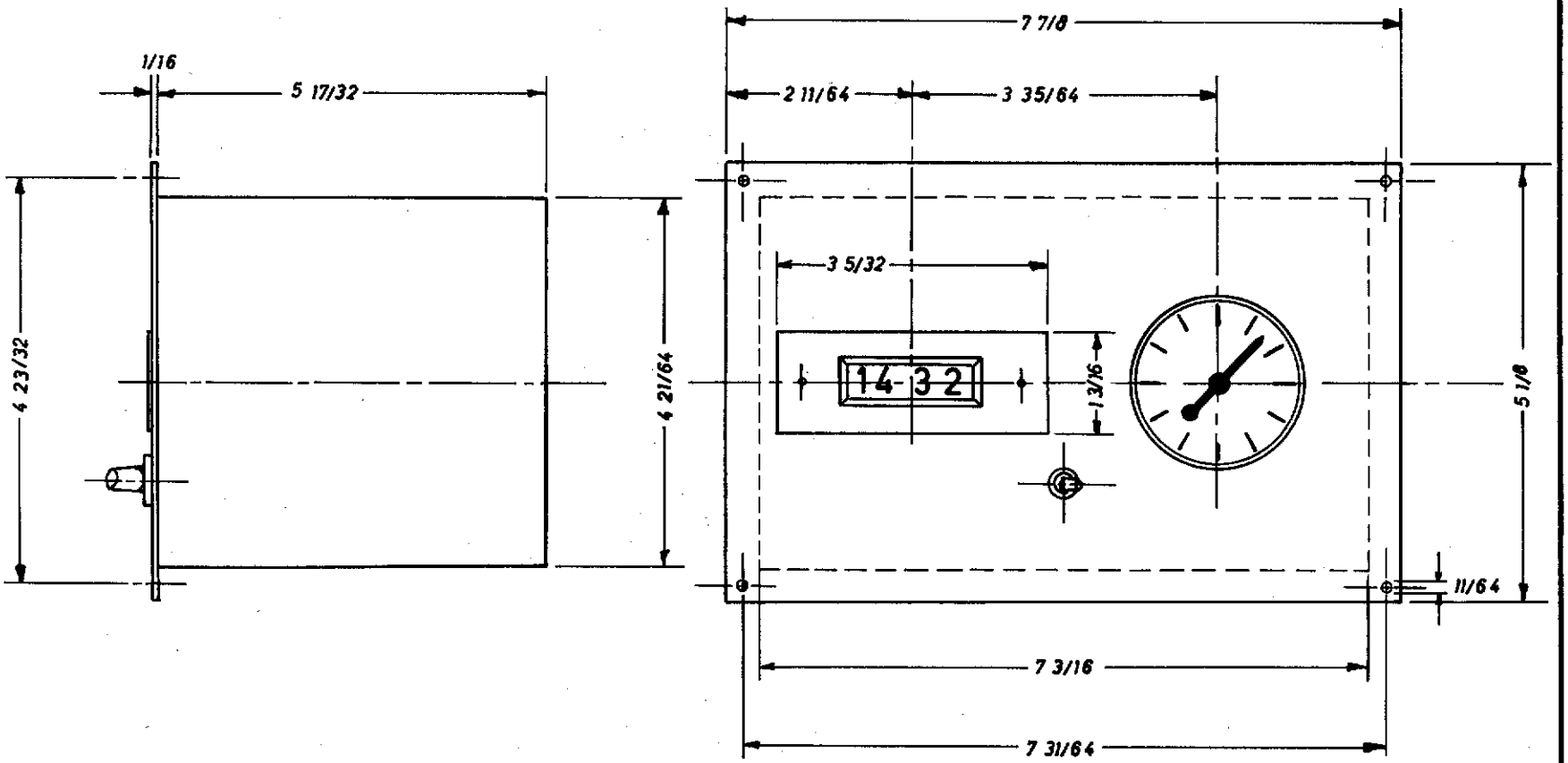
The magnetic forces are so balanced that movement operates satisfactorily from half to double-rated voltage.

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

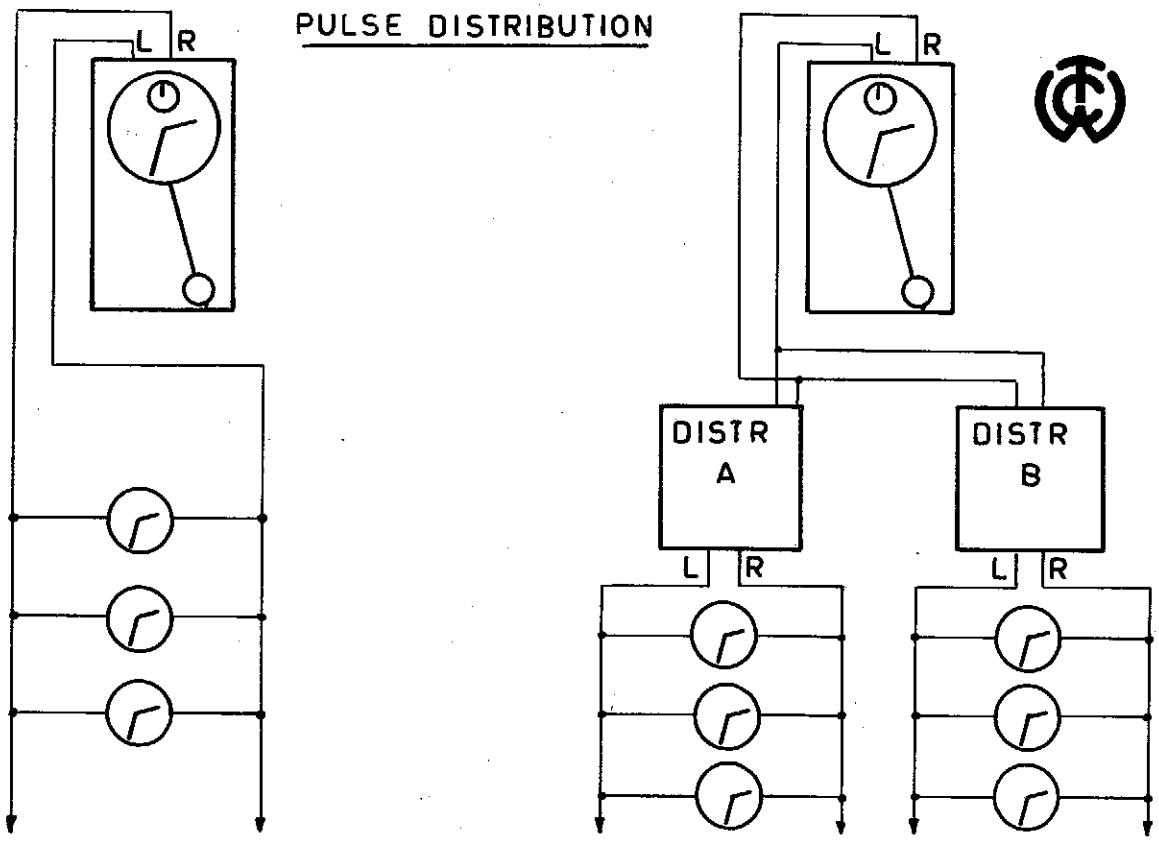

S 225
S 15
S 14
S 13
S 130
S 12
S 11
S 2


S32
S33
S22
S203
S201
S200
S202
S20
S210
S21
S211
S212

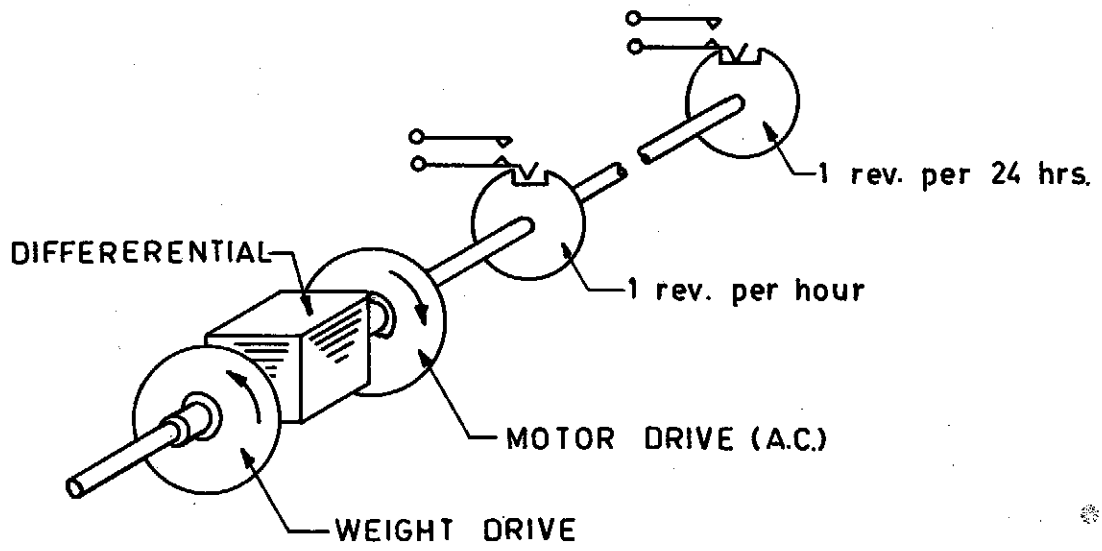

1/16
5 17/32
4 23/32
4 21/64
7 7/8
2 11/64
3 35/64
3 5/32
14 32
1 3/16
5 1/8
11/64
7 3/16
7 31/64

SCALE: 1/2

PULSE DISTRIBUTION



IMPULSE STORAGE PRINCIPLE



(FOR MASTER CLOCKS TYPE E.C.)