The Gent DAC Chronometers

Gijs Veraart Leidschendam, November 2018

Introduction

With the growth of the UK synchronised AC grid from 1933 onwards, clock manufacturers adopted the AC synchronous motor as the driving force in fully new designed master transmitters to take advantage of the 'long term accuracy of the mains'. However, they soon realized the necessity for a back-up system to overcome the problems occurring during mains failures. Synchronome made the Synpulse clock, Smiths the bi-synchronous master and Gents' introduced the DAC Chronometer. Still, even with a back-up fitted, this type of clock probably wasn't a commercial success for any of these makers because all together less than a dozen still are known to exist.

Fig. 1 Gents' DAC Chronometers, with pendulum back-up and motor back-up

The Gent DAC Chronometers are master clocks, using a synchronous AC motor but also equipped with a DC back-up system to provide against mains failures. DAC thus stands for DC/AC.

In 1935 the DAC master with a DC motor back-up was introduced and in 1937 the DAC with a DC-maintained half-second pendulum back-up. It is remarkable that both models had the same model number: Fig. C283. Sadly the reason for this is unknown. Also a DC back-up option (Fig. C322) for the heavier types of synchronous (turret) movements is shown in the 1935 and 1937 catalogues.

Very few DAC Chronometers seem to have survived: four clocks with the motor back-up (these have no serial numbers) and three clocks with the pendulum back-up (serial numbers: 123, 124 and 138).

One may perhaps conclude that not many were made. The DAC with motor back-up has a rather delicate action and proves difficult to adjust, while the accuracy of the DC back-up motor is relatively poor. The DAC with the pendulum back-up is much more reliable and the back-up is pretty accurate. The downside was its price: nearly twice as expensive as the then well- known standard C7 Transmitter (see Table 1).

Gents' masters compared:	**height**	**weight**	**price**
DAC motor back-up	18 3/4 inch	17 lbs	£ 20 - 0 - 0 1935
DAC pendulum back-up	29 inch	42 lbs	£ 29 - 10 - 0 1937
Standard C7	53 inch	45 lbs	£ 16 - 00 - 0 1936

DAC Chronometer with motor back-up

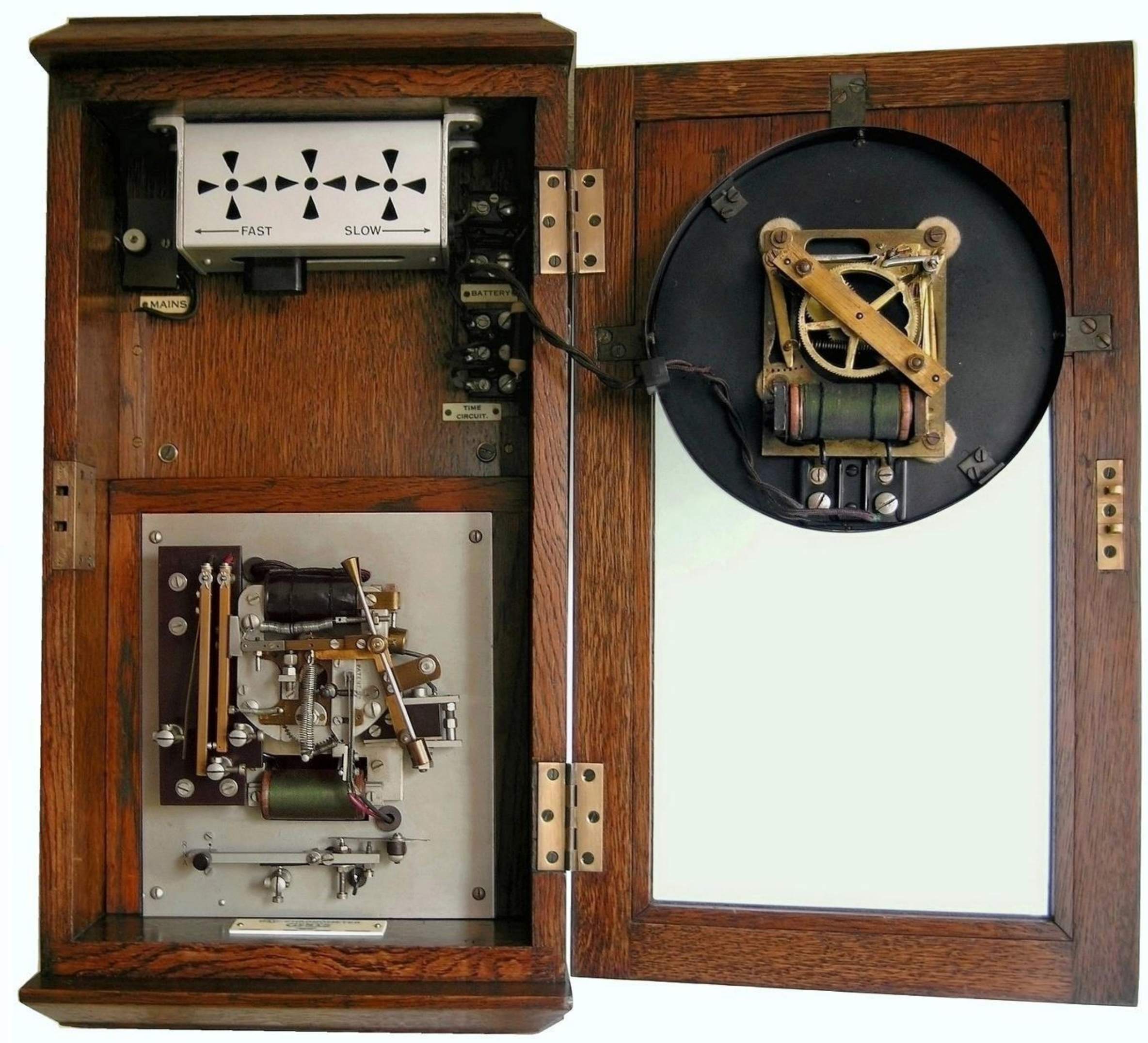

Fig. 2 The DAC Chronometer with motor back-up.

How the Transmitter operates

The Gent DAC master utilizes a synchronous motor that has two rotors, two sets of pole-pieces and also a toothed wheel which forms one contact of the switch for the DC coil. These two rotors and the toothed wheel all sit on the same rotor shaft.

With the mains on, a double cam wheel, driven by the AC synchronous motor, slowly lifts a gravity arm every half minute. When the arm drops from the cam it closes a set of contact arms and advances a series circuit of impulse clocks one step. In case of mains failure, a contact arm, normally attracted by the AC coil, falls off and sets free a phosphor bronze spring, allowing it to make contact with the toothed contact wheel from the DC motor. Now the DC rotor continues the action of the motor.

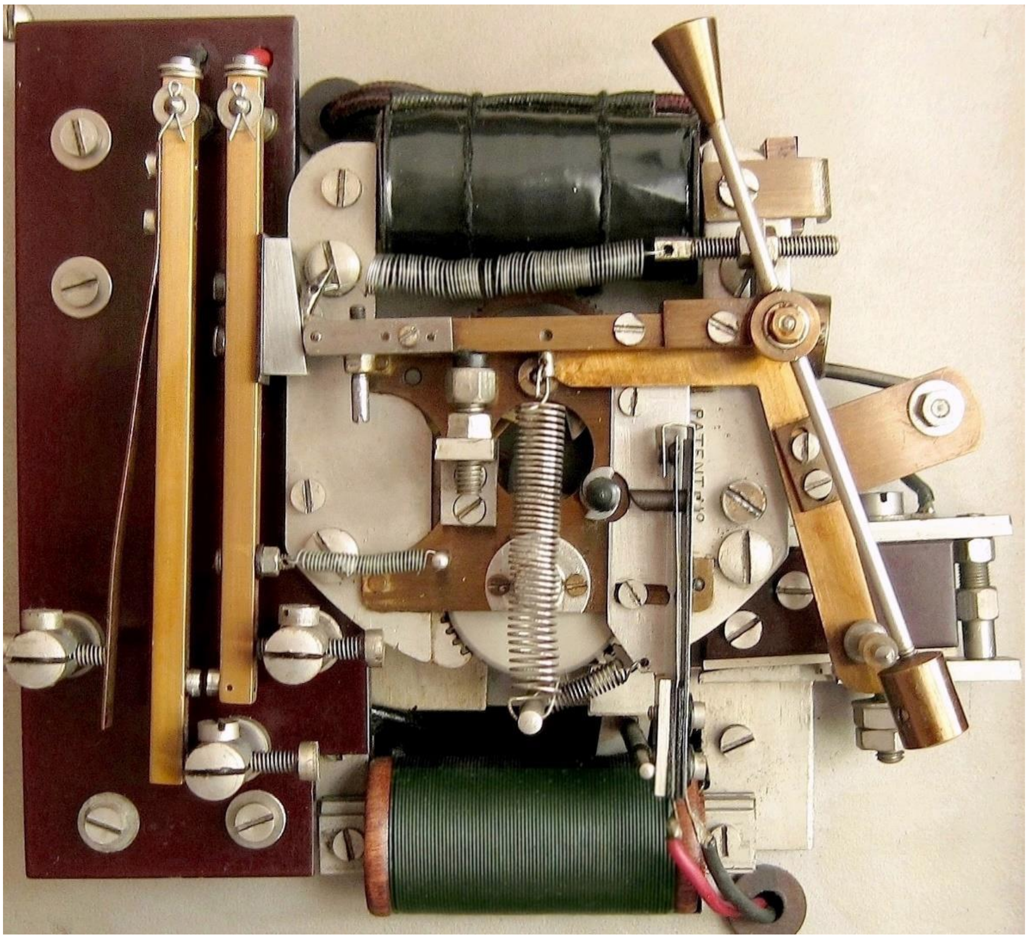

Fig. 3 The main components of the DAC Chronometer (motor back-up)

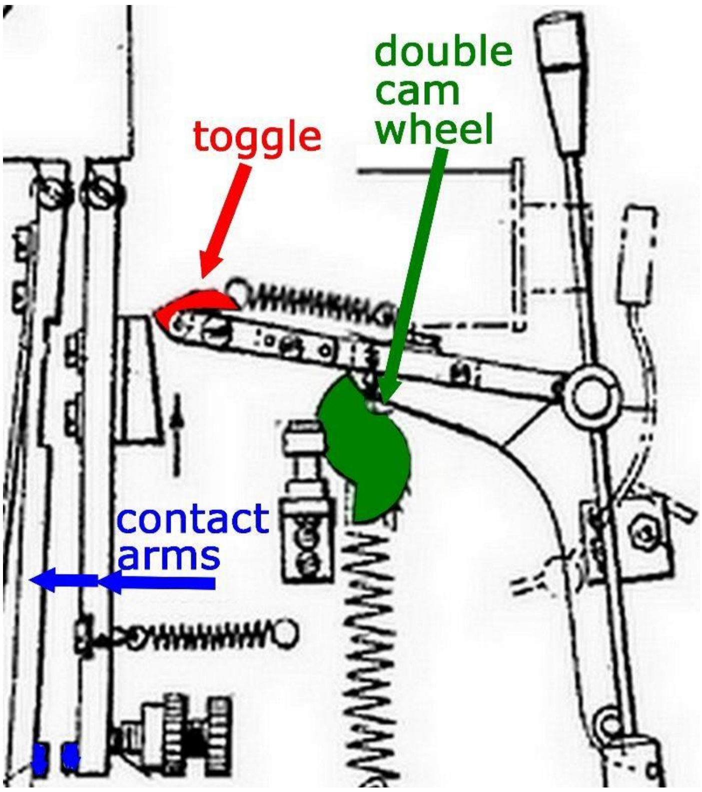

Fig. 4 Operation of the double cam wheel

Components and their function The AC/DC motor: the AC mains coil is at the top and is the front set of the two pole-pieces. This forms a conventional non-self-starting 50 Hz 240 volt synchronous motor. The resistance is 3.4K ohms. The rotor has fifty poles. The lower green DC coil (4.3 Ohms) is on the back set of the pole pieces and is again a typical synchronous motor with its rear rotor. The DC rotor has half the number of poles on the AC rotor. The AC/DC motor drives a reduction gearing to a wheel which rotates once a minute.

This wheel has a double cam (inside the movement) (see Fig. 4) which operates the contacts every half minute. The cam slowly raises the gravity arm. As it rises, the toggle at the left end of the gravity arm parts from the ramp on the contact arm and flips into a horizontal position, pulled by a spring (A on the picture below).

The cam then lets the gravity arm drop and as the toggle runs down the ramp it pushes the right hand contact arm to the left hand arm and closes the contacts (B). The counterbalanced delay arm moves slower than the gravity arm and rotates clockwise until it hits the pin at the lower end on the gravity arm. The impulse given jolts the gravity arm and the toggle flips over into the vertical position allowing the contacts to open (C). The pictures A, B and C were made manipulating the gravity arm by hand; in reality all the action takes place within a fraction of a second.

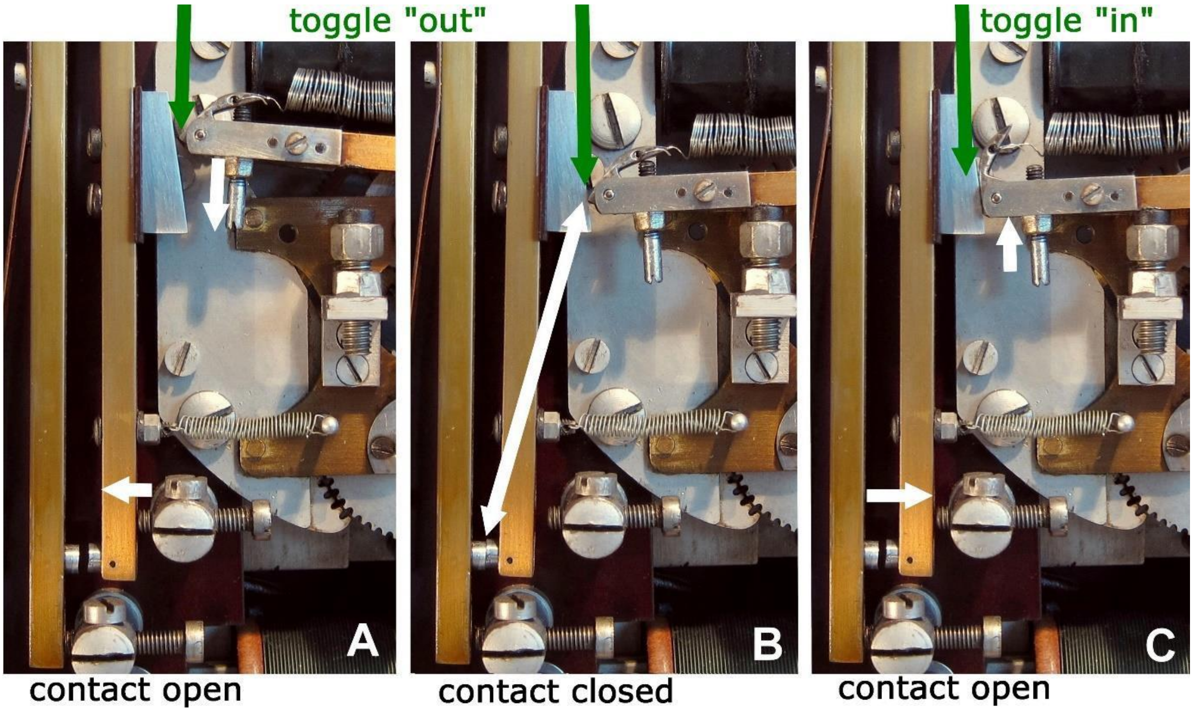

Fig. 5 Sequence showing action of the gravity arm and the open/closure of contacts

The little black knob in the centre of the movement is used to start the clock by turning it anti-clockwise. A small double cam on this arbor operates the vertical contacts which are brought into contact with the cam by the retard / normal / advance switch lever under the movement. The switching in of the DC motor on the failure of the mains supply is effected by the weighted lever at the top right of the movement.

When the clock is running from the mains, the block on the top of the lever is held against the right hand top pole piece of the AC coil by magnetic attraction (see Fig. 6). The other (lower) end of this weighted lever holds an isolating block that, as long as the block on the top of this lever is attracted to the AC coil end, prevents a phosphor bronze spring from making contact with the toothed contact wheel of the DC motor. In the event of mains failure, the block at the top is released and the weight falls. This moves the insulated other end of this weighted lever away from the phosphor bronze contact spring, allowing contact to be made between the end of the spring and the toothed wheel (see Fig. 7).

The position of the phosphor bronze spring can be adjusted by turning the little screw above the massive Pertinax block at the right of the movement. This is very sensitive: too far from the star wheel will cause a flimsy and unreliable contact, too far towards the star wheel will cause too much friction and the motor tends to stop, especially during the short period that both the AC and DC coils are activated. As the contact is successively made with each tooth of the wheel, a current flows through the lower coil, causing the rotor to rotate at a speed that will more or less mimic the frequency of the AC mains.

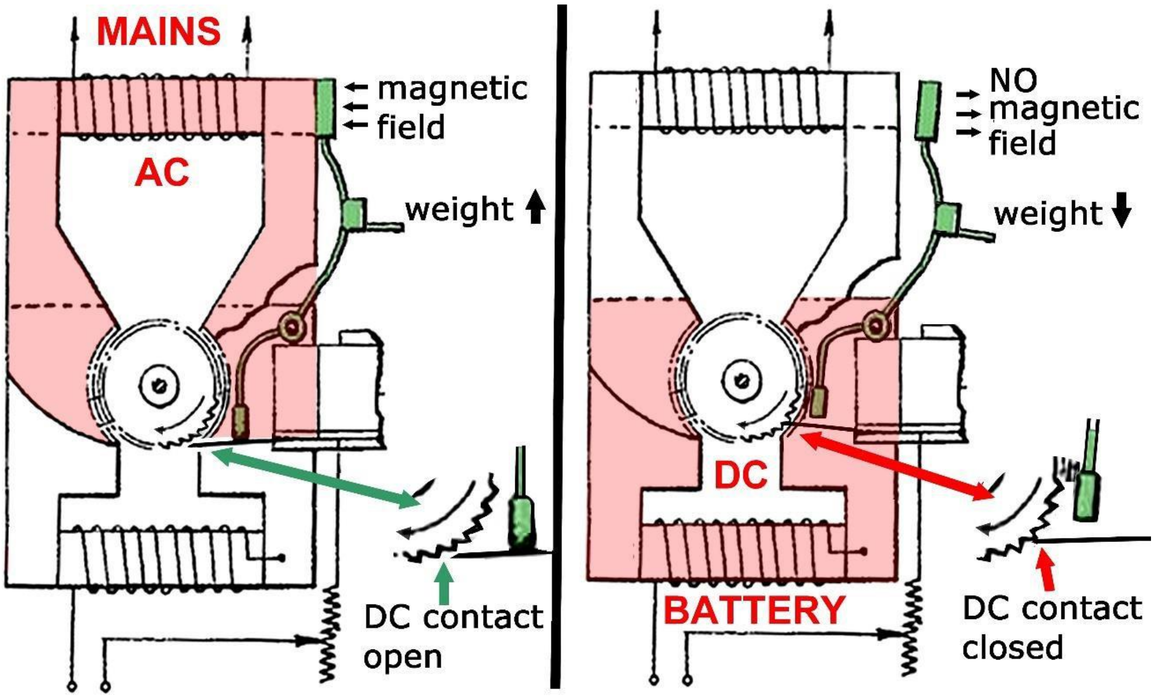

Fig. 6 Mains on (left), and mains off (right) resulting in CD flow to the motor

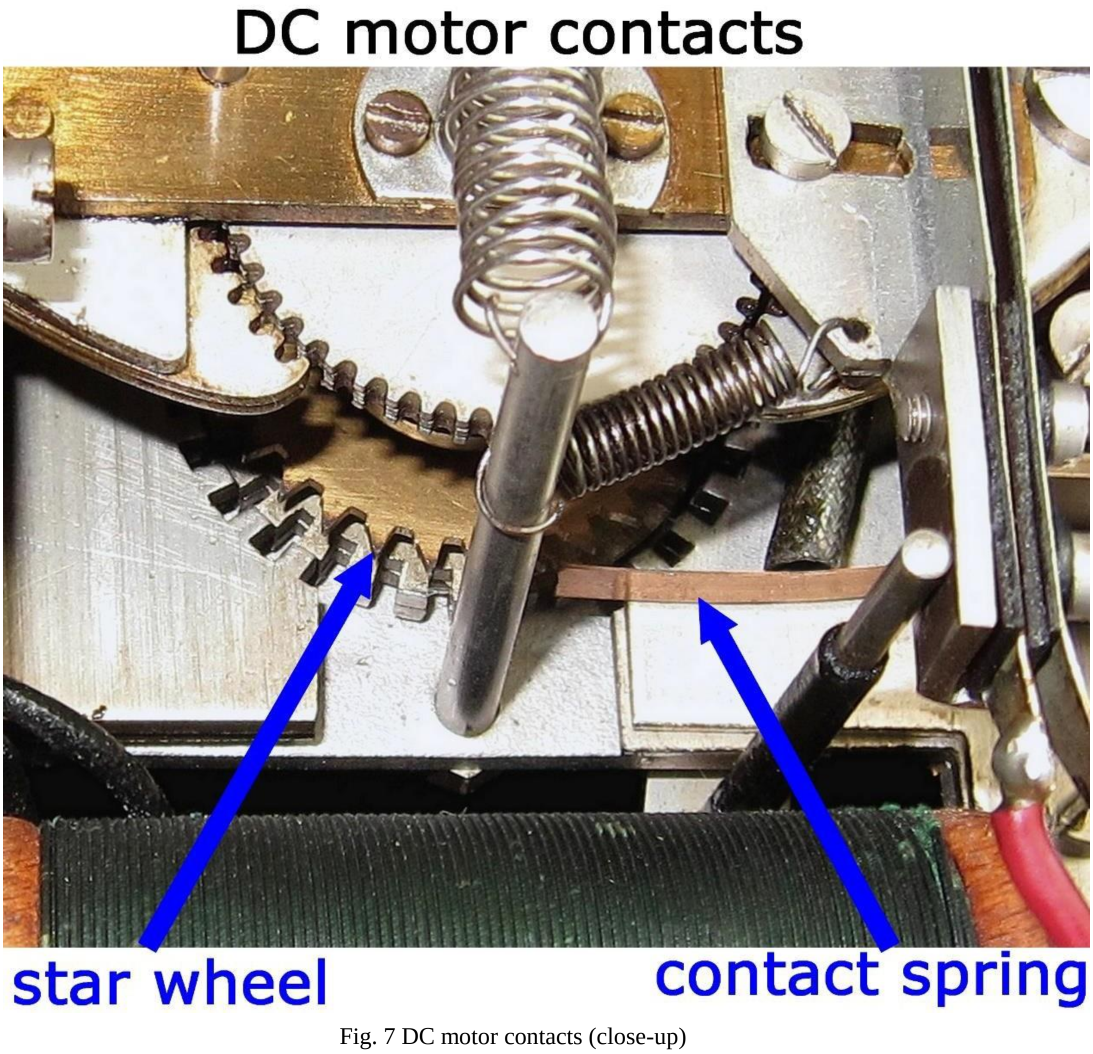

Fig. 7 DC motor contacts (close-up)

A 25MF electrolytic capacitor is connected across the contacts. The adjustable resistor (40 ohms) that is used to adjust the speed of the motor is an absolute necessity because the speed of the back-up movement is directly influenced by the actual power in the back up battery.

When the mains supply is restored, the motor runs for a while on both AC and DC systems. This is a critical moment as both the AC and DC rotors are magnetically energised. Since they run hardly ever at exactly the same frequency they tend to work against each other.

At the closing of the half-minute contacts, the weighted lever is given a flip upwards by a pin on the gravity arm and the block is once again held against the top pole-piece of the AC coil. The contact spring is moved back from the contact wheel and the rotor is again mains driven (see Fig. 8). The slave dial circuit, including the retard/ normal/ advance feature, is entirely separate from the other circuits and a series battery is needed to operate the slave dials. This could be the same battery as the one that drives the clock when the mains fails.

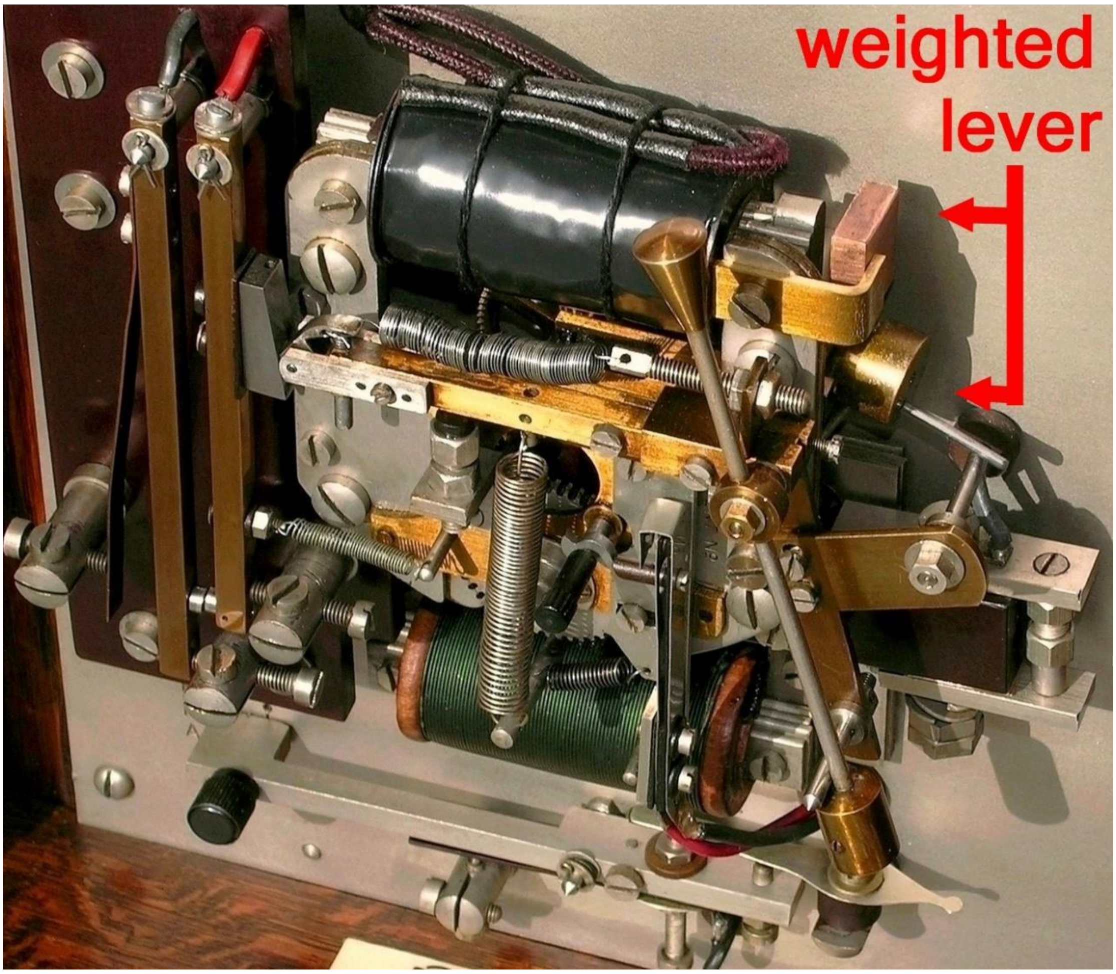

Fig. 8 Weighted lever now re-lifted, AC operation is restored

The Normal/Advance/Retard feature (to adjust the slave circuit for BST)

This is the long horizontal lever under the movement. This lever serves a combination of two contacts, as well as mechanically moving the frame on which the contacts sit, to or away from a cam on the on the starting knob shaft. In the normal position, the main contacts on the two large vertical contact arms are in series with the internal dial (see Fig. 9). In the advance position, the advance contacts operated by the cams on the start knob shaft are in series with the internal dial. It takes four minutes to advance the slaves one hour. In both cases, the same in series resistance/capacitor spark suppressor is connected across the contacts. In the retard position, the circuit is open.

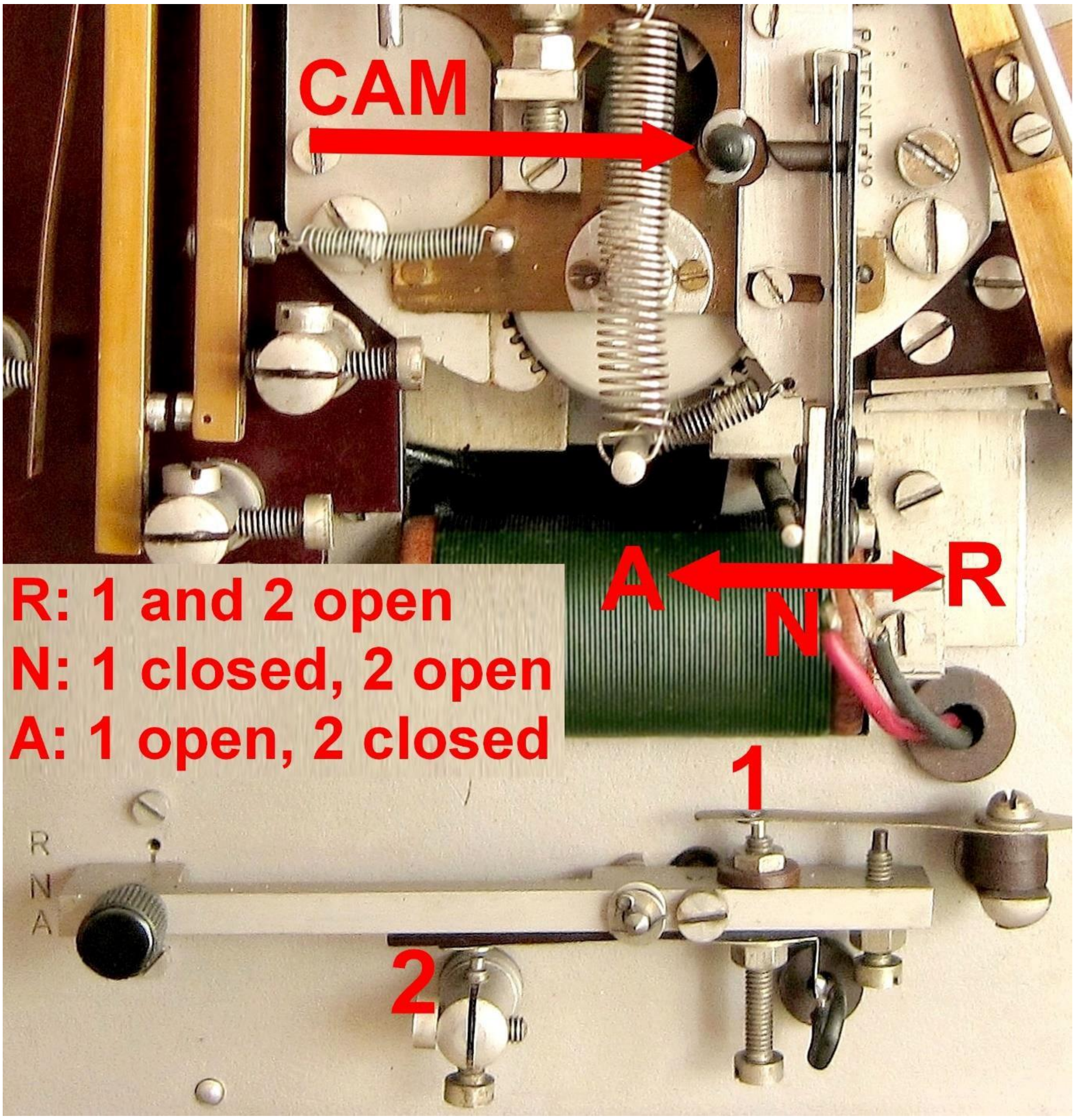

Fig. 9 Contact positions, normal operation

The pilot dial has the standard MkIII S type movement with a 4 Ohm coil (see Fig. 2).

To start the DAC Chronometer, the AC power supply, the battery for the slaves circuit (this can be the same battery as used for the DC motor provided that only a small number of slaves is connected in the circuit) and the battery for the DC motor must be connected to the clock, in that order. Turn the starting knob anti-clockwise, and the clock will run on the DC motor. When for the first time the half-minute contacts are operated, the weighted lever is given a flip upwards by the pin on the gravity arm and the top block of the lever is once again held against the AC top pole-piece of the AC coil. The isolated block at the lower end of the weighted lever moves the contact spring from the DC contact wheel and the rotor is now mains driven.

AC power supply: only the upper coil is at mains voltage with no switches or any additional wiring. **DC power supply:** a battery of minimum 6 volt, 0.5 amp capacity is required to operate the back-up motor and the slave circuit.

DAC Chronometer with pendulum back-up

Fig. 11 The DAC Chronometer with pendulum back-up

How the Transmitter operates

At the bottom of the transmitter is a self-starting mains movement, which closes a pair of contacts every second. These contacts operate a ‘silent-triangle’ impulse movement, which in turn closes a pair of contacts every half-minute and advances a series circuit of impulse clocks one step. In addition, should the mains movement stop owing to mains failure, the pendulum supplies seconds impulses to the impulse movement, and impulses continue to be transmitted during the power supply failure. When the AC is reinstated, the transmitter automatically brings the seconds impulses from the mains movement into circuit again.

Components and their functions

The pendulum in this clock is a copy of the standard C7 pendulum, although the total length is 13” and the height of the bob is only 3” against 10” in the C7 (see Fig. 12). However, any similarity between a C7 and the DAC stops there.

Fig. 12 Comparison of C7 bob with DAC bob.

The half-seconds pendulum operates two sets of contacts (see Fig. 13). The set at the top is closed every alternate swing, i.e. each second, and is used to operate the ‘silent-triangle’ seconds impulse movement when the mains supply fails. The lower pair of contacts is closed by the pendulum when its arc drops to the minimum, using a so-called Hipp contact. The closing of these contacts energises the coil, which is fitted beneath the pendulum bob, and by attracting the armature fitted to the pendulum, supplies energy to maintain it (see fig 14).

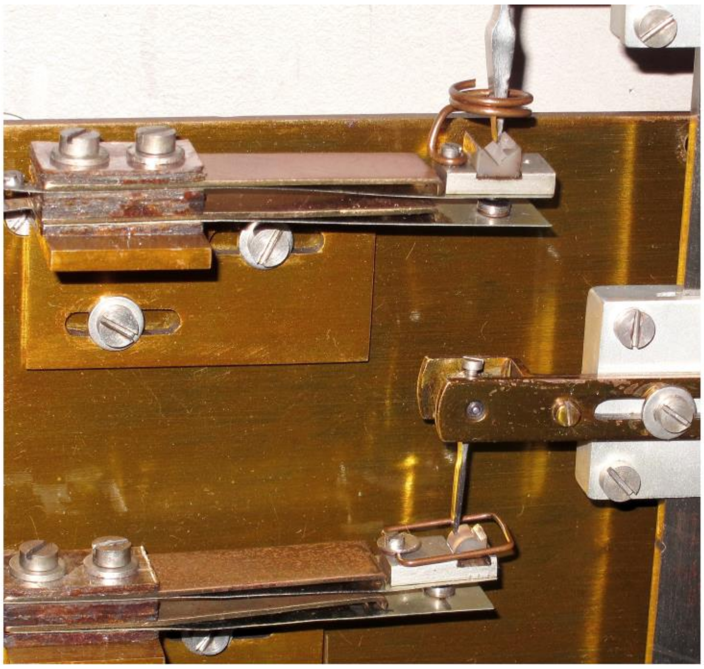

Fig. 13 Contacts operated by the DAC pendulum

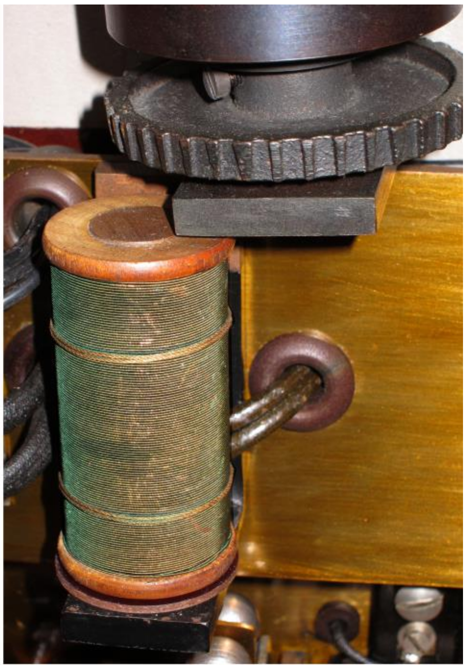

Fig. 14 Drive coil for the pendulum

Fig. 15 Bridged double switch for BST changeover

The Normal/Advance/Retard feature (to adjust the slave circuit for BST)

The bridged double switch which is fitted to the right of the pendulum is used for advancing or stopping the clock circuit at the changes between Summer and Winter time (see Fig. 15). With the switch in the lower Normal position, the clocks operate normally. In the upper, Advance position, the clocks in the circuit are impulsed directly from the seconds contacts on the pendulum, and advance therefore one half- minute step every second, while in the middle or Retard position, the accumulator circuit is broken and the system is stopped. A second (single) switch, fitted to the right of the pendulum coil, is merely for the purpose of disconnecting the AC from the mains synchronous motor and relay, in order that the system may run on the pendulum, so its length can be adjusted to keep correct time.

On the left of the pendulum magnet is a relay (5K ohms) energised by the AC mains (see Fig. 16). While the relay armature is held up, attracted by the mains to the two coils, current from the battery is allowed to flow through the seconds contacts operated by the mains movement. When the supply fails, the armature falls away and allows the battery current to flow through the seconds contacts operated by the pendulum.

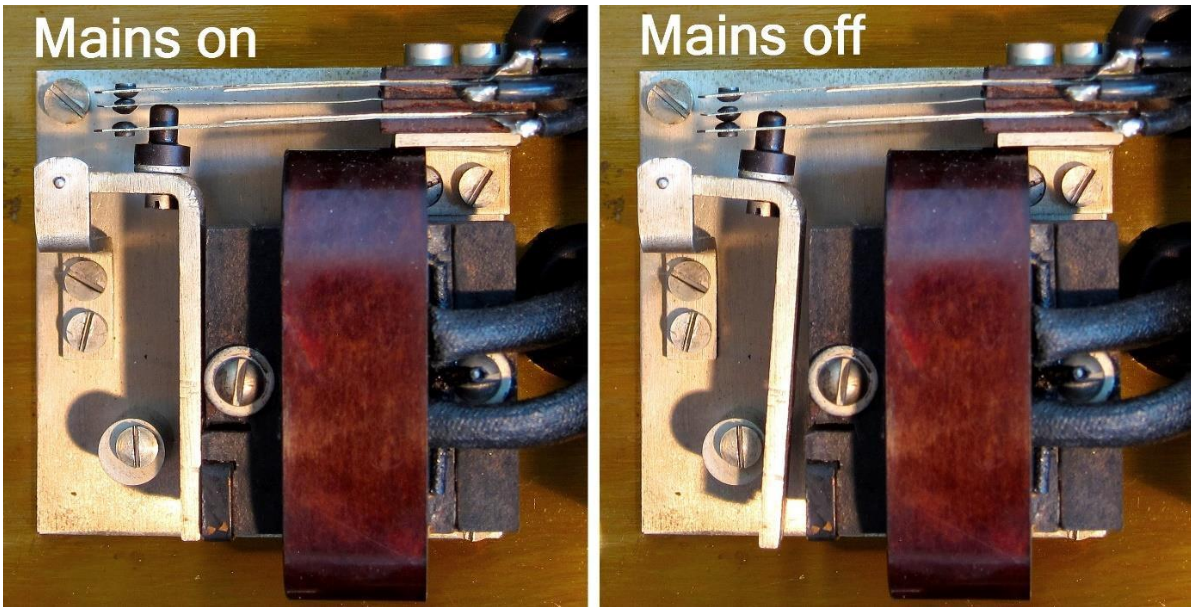

Fig. 16 Relay armature, allowing either mains or DC impulses to the seconds dial

The ‘silent triangle’ impulse movement (220 Ohms), sitting on the contact-relay beneath the pendulum, is fitted with a four-drop cam which advances one quarter-turn each half minute, which in turn produces a half-minute impulse (see Fig. 17) Bearing on this cam are two contact levers which are connected to a pivoted arm. At half-minute intervals the upper contact arm falls on to the lower one, and completes the impulse clock circuit. An electro- magnet (coil 30 Ohms) which is in series with the clock circuit attracts an armature fitted on the arm to which both contact levers are connected, moving both away from the top of the cam until the lower lever also falls off the cam and breaks the circuit.

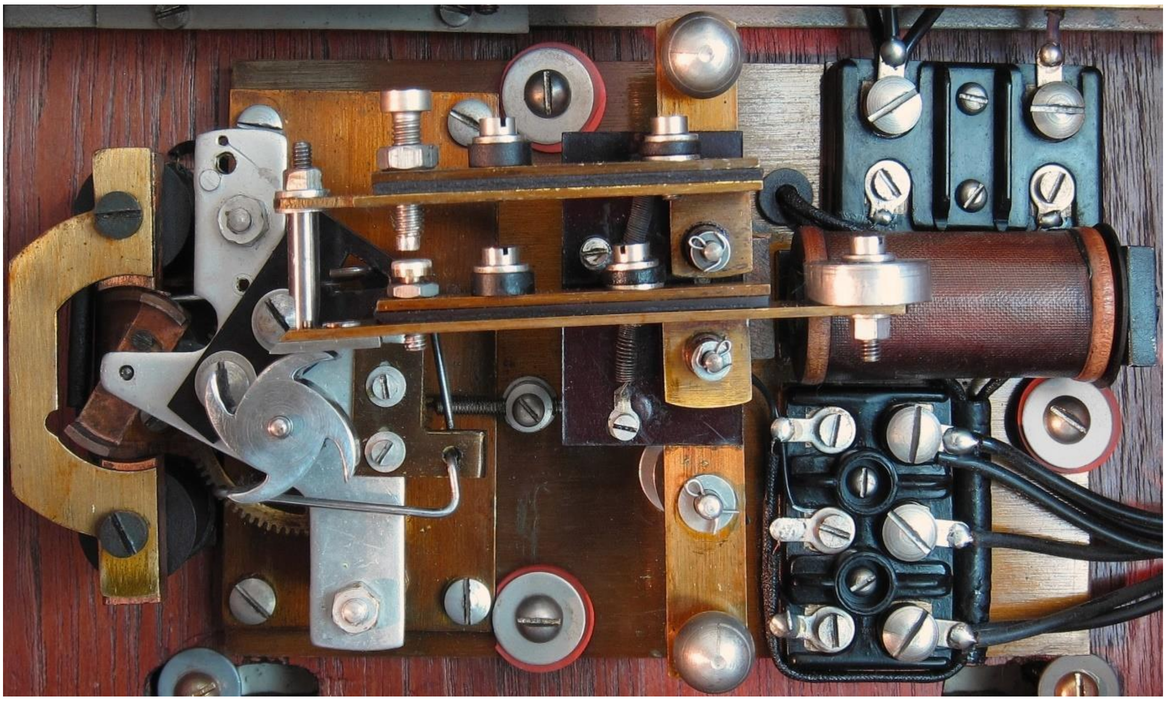

Fig. 19 Four arm cam, producing half-minute impulses

The self-starting SEC mains synchronous movement (6K ohms) with seconds contacts is fitted at the bottom of the case (see Figs 18 and 19). On either side there are Varley adjustable resistors, the one on the right (100 Ohms) for the half-minute clocks circuit and the one on the left (300 Ohms) for the pendulum coil and the 'silent triangle' movement (see Fig. 20). Note the charming little bucket under the contact wheel. It contains a cotton wick arrangement which must be kept soaked in oil to permanently lubricate the teeth of the contact wheel.

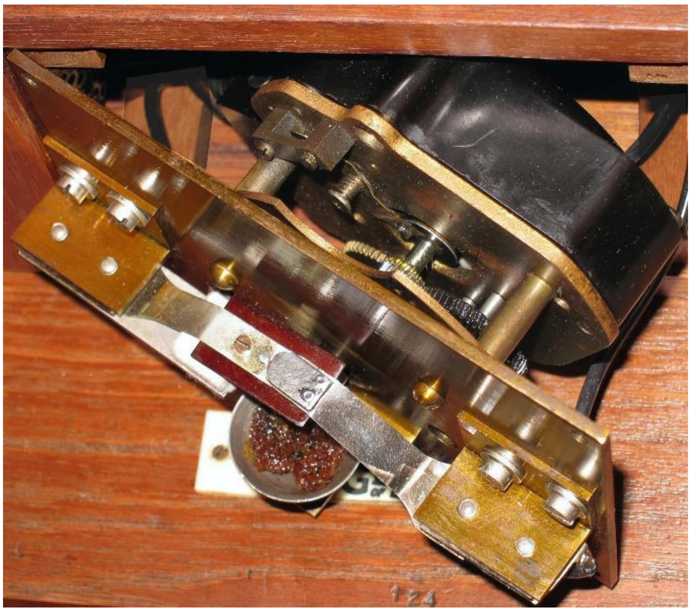

Fig. 18 Smiths synchronous motor, note lubrication cup/bucket

Fig. 17 Smiths synchronous motor

Fig. 20 Lubrication cup/bucket required to lubricate the teeth of the contact wheel

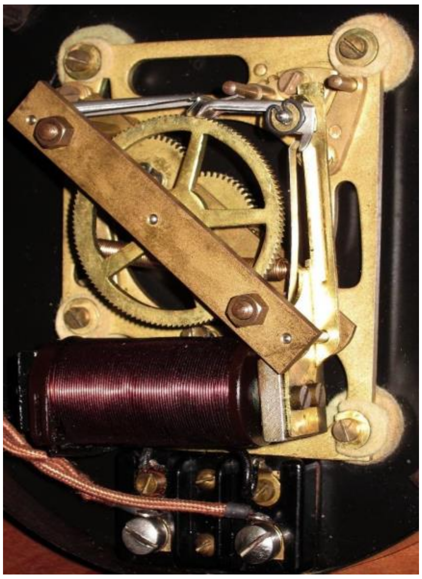

Fig. 21 Pilot dial, MkIII S type

The pilot dial in the door has the standard MkIII S type movement with a 4 Ohm coil. In this clock it's already the Bakelite coil version (see Fig. 21).

To start the clock

The DC power supply for the slave circuit (this can be the same battery as used for the DC back-up pendulum, provided that only a small number of slaves are connected in the circuit) must be connected. Give the pendulum a swing so that the toggle on the lower contact on the pendulum just fully passes the agate V-block. The clock now runs on its DC back-up pendulum. Once the mains power supply is connected the AC synchronous motor will automatically take over from the pendulum.

Power supply

AC power supply: the synchronous motor and the AC/DC selector relay are at mains voltage together with two further switches and quite some quantity of wiring. AC and DC wires run side by side between the steel and brass frame plates; by modern standards

the clock can be regarded as pretty unsafe. In the Restoration appendix at the end of this paper one can see why. DC power supply: a battery of minimum 20 volt, 0.5 amp capacity is required to operate the transmitter. The left adjustable resistor should be set so that, with the contacts held together, 220 mA passes in the half-minute circuit, and the resistor to the right so that 80 mA is passes across the seconds contacts. The charging rate should be set by means of the adjustable resistance on the panel to 45–50 mA.

Here is a link to a movie of the DAC with pendulum back up https://youtu.be/YuWv-RnHLzc

Conclusions

In this paper I have tried to give an accurate description of the DAC clocks. Perhaps my enthusiasm for these totally new designs of Gents' masters made me go occasionally into too much detail. Both clocks are now running fine. A (manipulated) mains failure proves no problem for their continuity. However I do understand why the standard C7 was the all-time winner. The C7 is a master with authority and sturdy industrial looks while the DACs are too complicated with too many small parts to generate that same feeling.

Any comments on this paper as well as additional information on these clocks is very welcome at: pulsynetic@gmail.com

Acknowledgments
I would like to express my gratitude to:
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Jan Wright for sending me photographs of the DAC with the pendulum back-up.
James Nye for converting this article into an AHS / EHG Technical Paper.

Appendix - Restoration

The DAC with motor back up

This clock was in a rather poor condition when it arrived. The weighted lever and also the adjustable resistor were missing. New ones had to be made. Owing to the sawing action of the star wheel the phosphor bronze DC contact spring looked like a kind of fork and a fresh spring was needed. The half minute contacts were already poor replacements; new contacts of hard silver were made. Both coils had to be rewired, the AC coil measured on arrival a rather dangerous 600 ohms instead of the required 3.4K ohms and the DC coil was 'dead'. Otherwise some cosmetic work was needed to the case: the lock was broken out and the doorplate was missing. There follow some pictures before and after the restoration. They tell more than a thousand words.

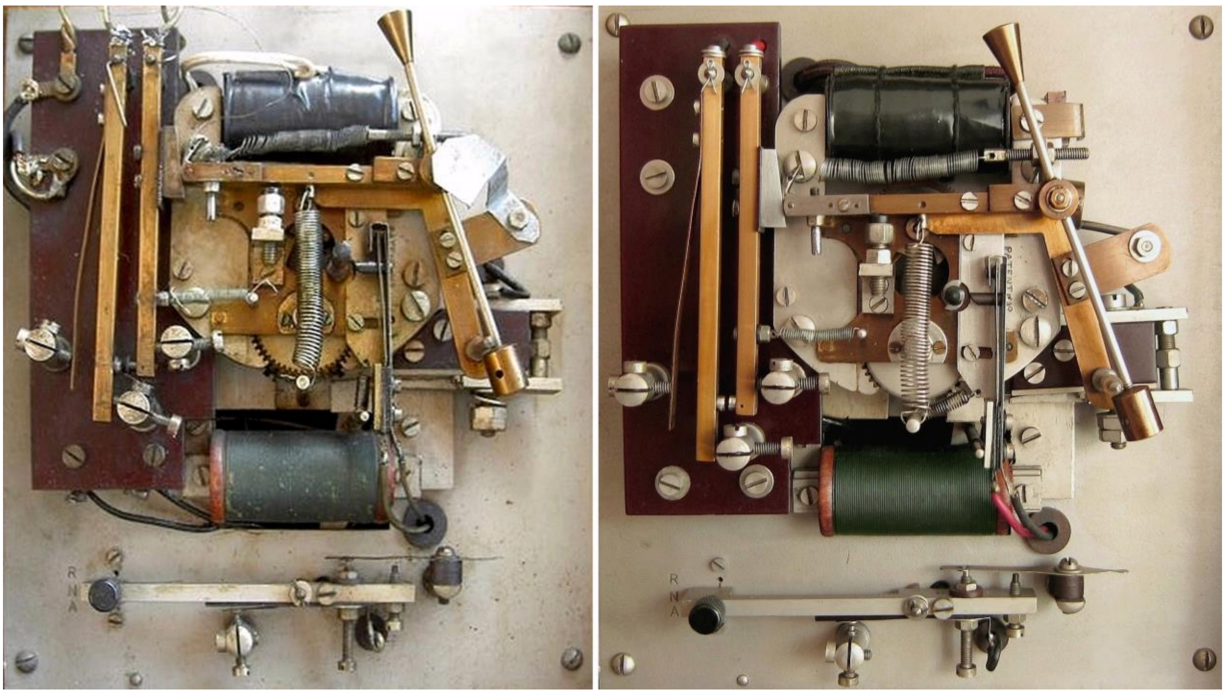

fig. 22 the movement before and after.

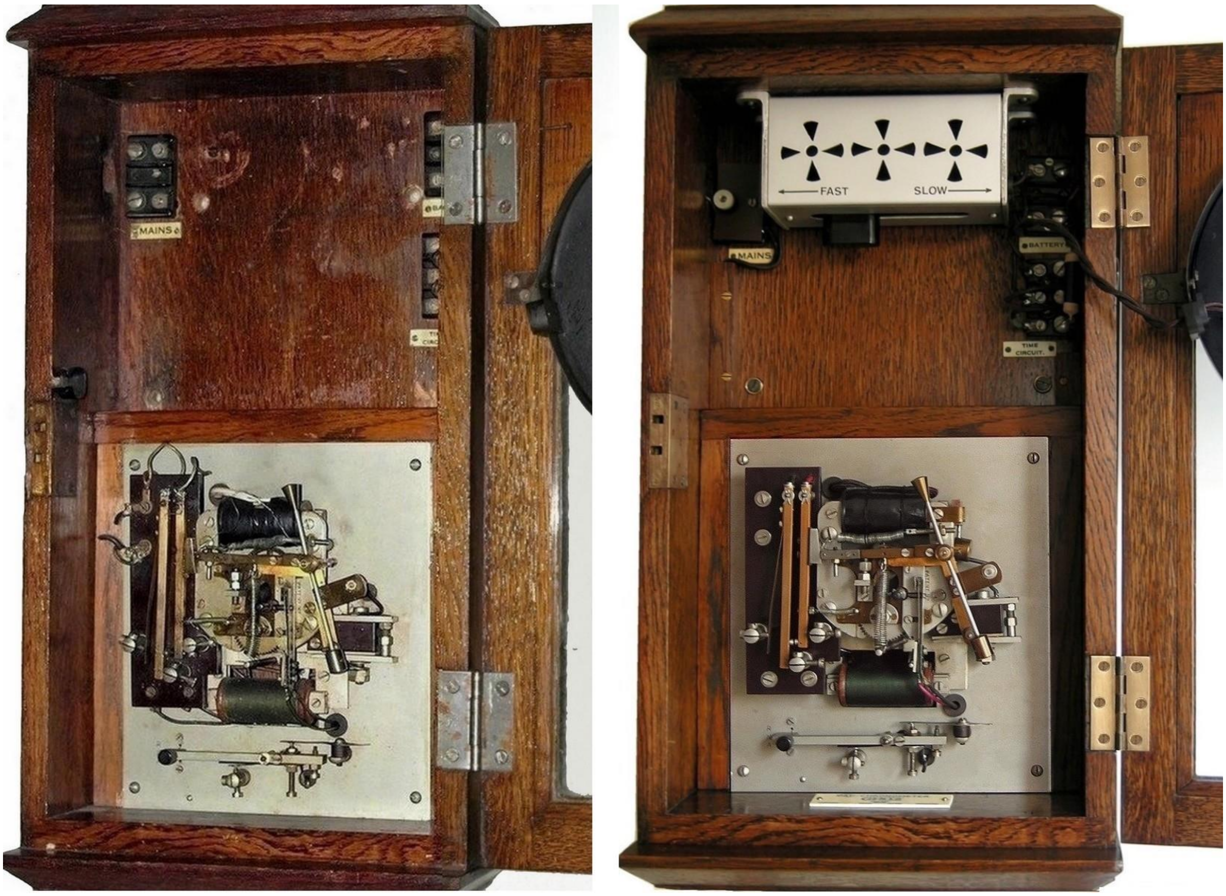

Fig. 23 DAC with motor back-up before restoration and after

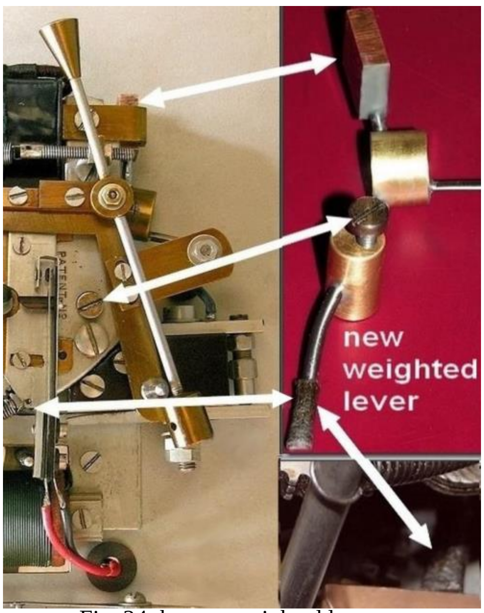

Fig. 24 the new weighted lever


Fig. 25 The contact arms, before and after

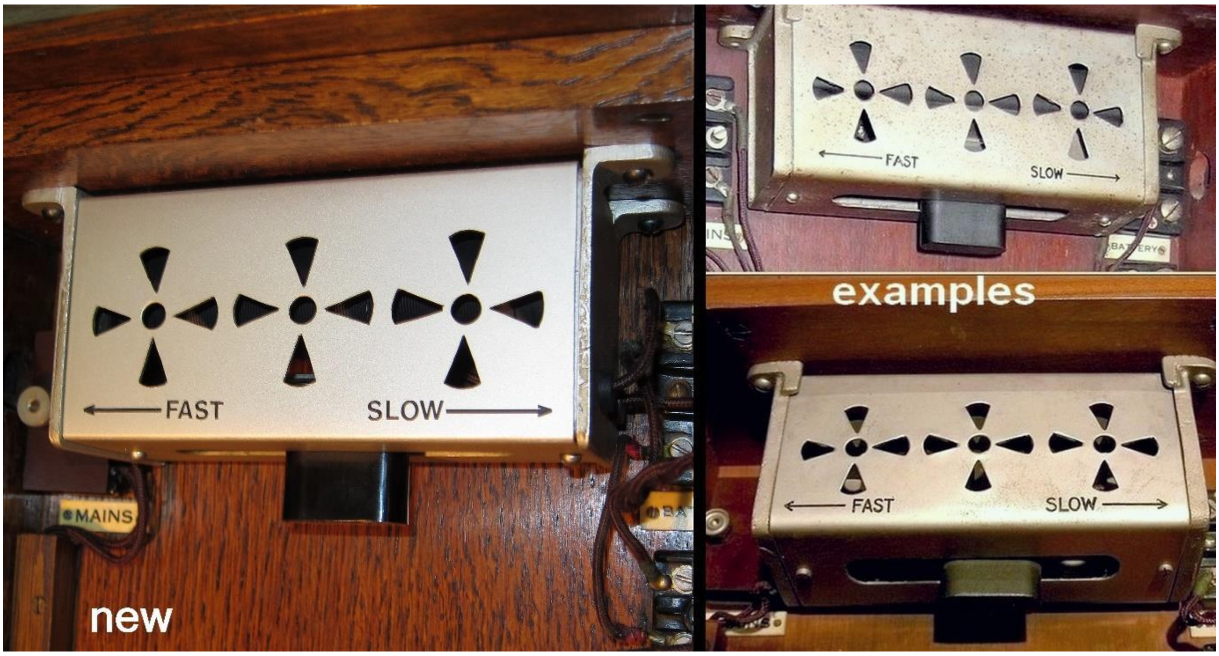

Fig. 26 New adjustable resistor (left), fabricated to the pattern of original samples (right)

The DAC with pendulum back-up.

The main problem with this clock was the wiring: parts of it were missing and some new wires had been added. All of the rubber isolation was very brittle and most wires had large parts where the isolation was fully gone. In total this clock has some 30 wires with a total length of over 10 meters. In the end a complete rewiring proved to be the only option.

Otherwise the clock movement parts were very dirty, most probably caused by an excessive use of grease and oil in combination with the very hot climate in Australia. The already replacement contacts (metric instead of BA) were heavily worn and burnt. Again some before/after pictures.

Fig. 27 DAC Chronometer with pendulum back-up, before restoration and after.

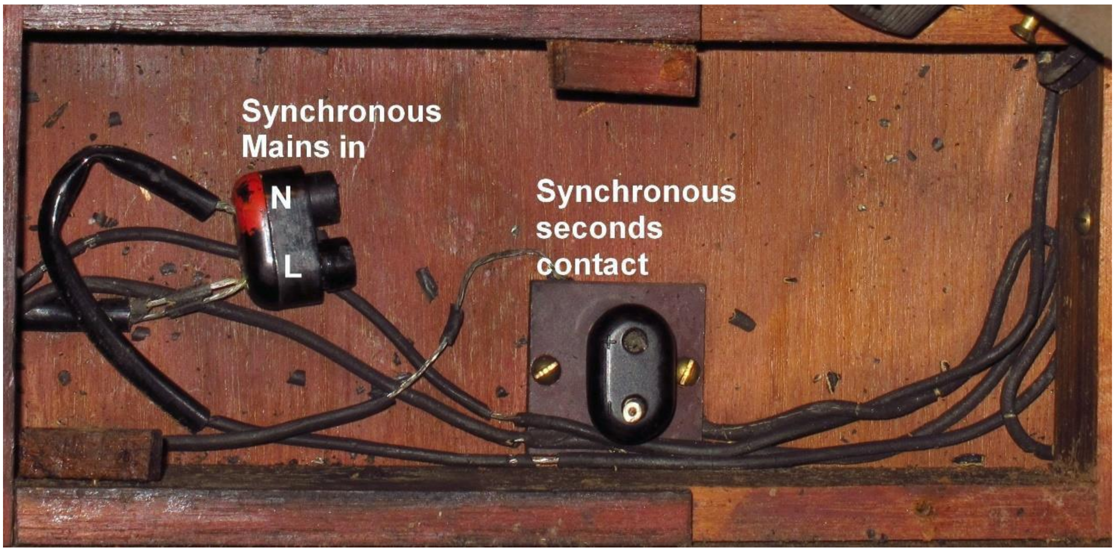

Fig. 28 Examples of wiring problems

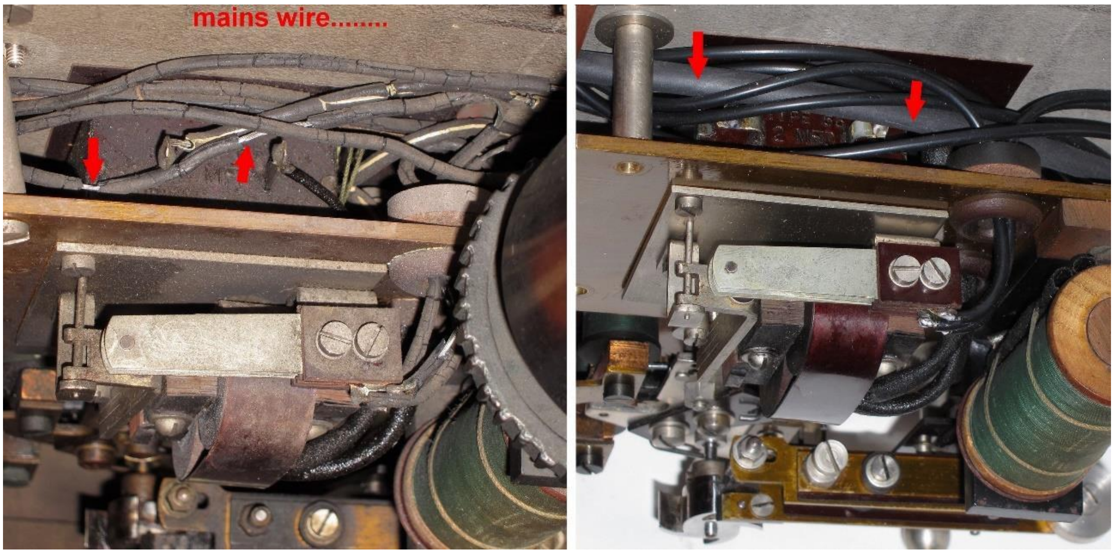

Fig. 29 dealing with unsafe mains wiring

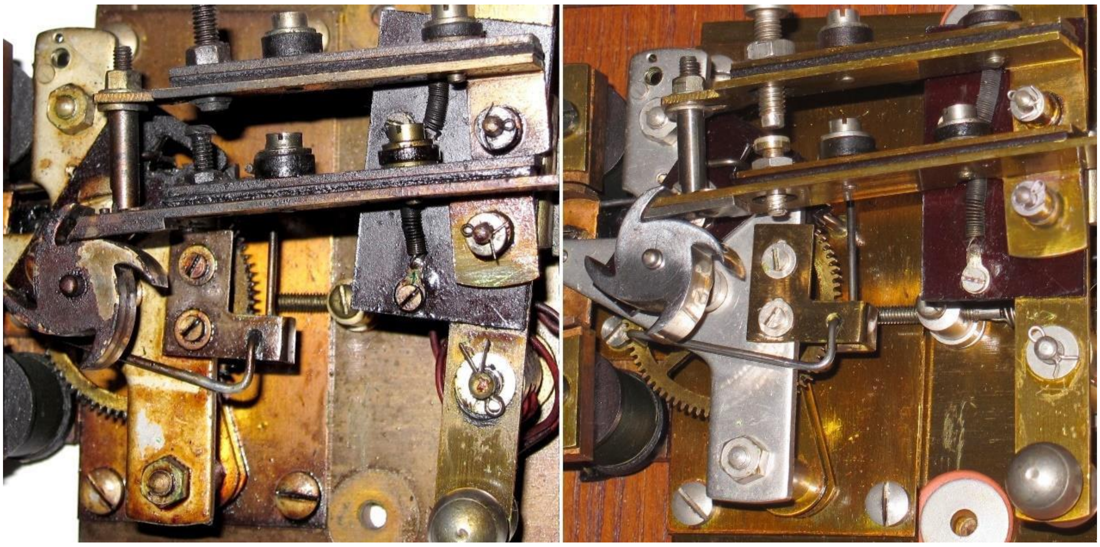

Fig. 30 The half-minute unit

Fig. 31 The AC contact unit

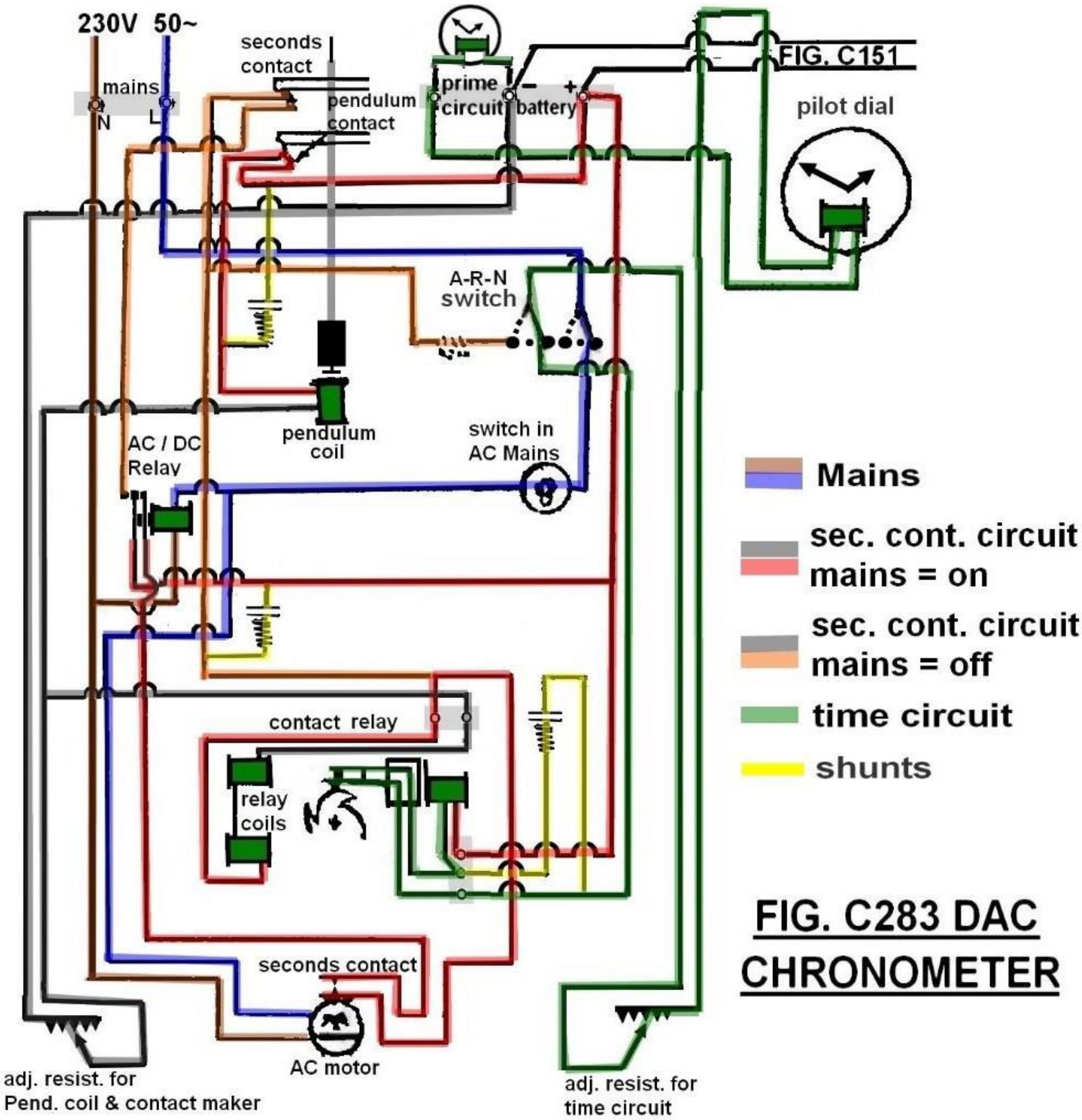

Fig. 32 DAC Chronometer with pendulum back-up, wiring diagram