

Project 150 - moving on, 6

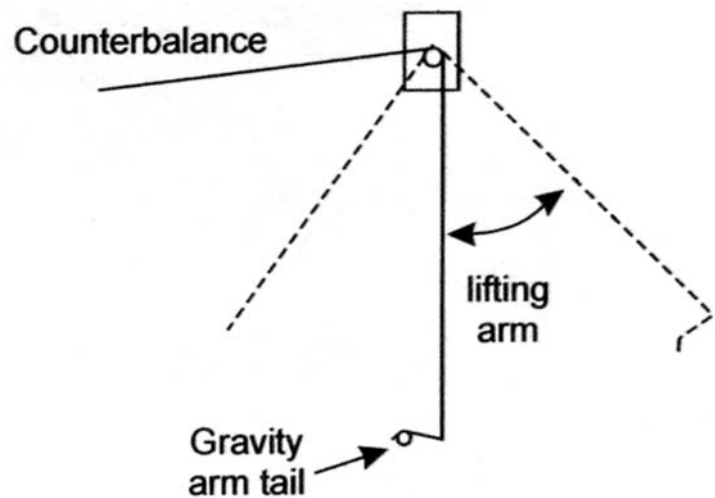
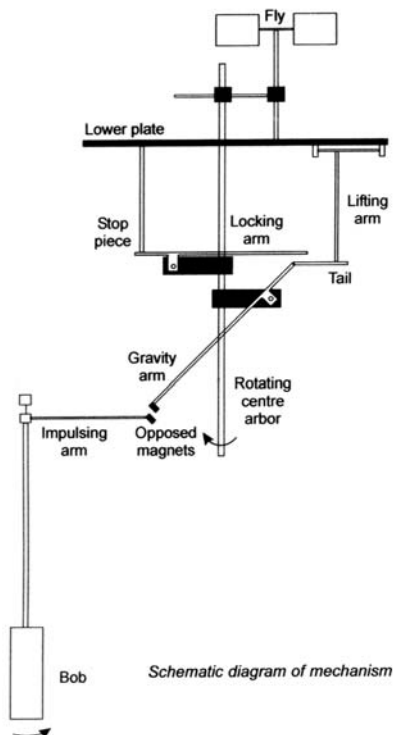
The unfinished, but working, clock received a lot of attention at the BHI Show and at Art in Action. Much discussion ensued and in general the comments were complimentary, but a number of people said they thought that we had made it more complicated than necessary, and that they found the articles about it in the Journal also too complicated.

Most seemed to have missed the fundamental reasons for having three pendulums, apart from the obvious original aims of having something 'different and spectacular'. The Hall floor is very springy, and a single pendulum system might rock itself to sleep; in addition, the clock could have poor time keeping because of the movement caused by people walking by. Three pendulums go a long way to prevent these problems. Then, having chosen three pendulums, one needs the triple escapement and so it starts to look complicated.

Understanding the mechanism

Let us stop here and remember how a weight driven, pendulum clock works. There is a weight trying to turn the hands around a dial and the action is controlled to give the correct time by the escapement, which allows a discrete movement only when triggered by the regular swing of the pendulum. The clock needs one more input - the pendulum must receive a tiny impulse to keep it going.

Concentrate now on one pendulum station in this clock and refer to the diagrams below, from Arnfield 2, *HJ August 2004*. On the rotating centre arbor (in the train between the weight and the hands) the gravity arm tail pushes the lifting arm to the side which in turn pushes the tail down. The little weight on the other end of the gravity arm is thus raised, call this lift 1, gaining more than enough energy to later impulse the pendulum. The rotation of the arbor is then arrested because the locking arm hits the stop piece. At this time, the impulsing arm on the pendulum is moving upwards and this lifts the weighted end of the gravity arm a little further, call this lift 2, and this also releases the arm from the lifting arm; (note that the magnets



Side view of the lifting arm



were replaced some time ago by a roller). Then the pendulum reverses and the weighted end of the gravity arm follows it down, giving back the energy it took from the pendulum on lift 2. Then the pendulum gets its impulse because the weighted gravity arm continues to drop, equivalent to some of lift 1. It then falls free and kicks the locking arm, corresponding to the rest of lift 1, releases it, and the centre arbor rotates again to the next pendulum position.

It is termed a 'gravity escapement' because the impulse energy is from the falling gravity arm, which is very constant. This leaves the term 'detached' to be explained. An escapement would be completely detached if it did not interact at all with the pendulum, leaving it to swing freely; but the pendulum would stop because of a lack of impulse and the train would not be controlled by the pendulum via the escapement. In this clock there is minimum interference, so it is 'detached'. The interaction with the pendulum starts after the train has been stopped, when the impulsing arm lifts the weighted gravity arm, but then almost the same energy is given back as the reversal starts so there is little interference (there is a tiny loss of energy due to friction associated with the roller and pivots and with the release from the lifting arm). Then comes the impulse during the continued drop of the gravity arm, which is absolutely necessary. The pendulum does not cause the release of the locked escapement as the gravity arm has parted company from the pendulum when that happens.

Compare this to say, the anchor escapement. In this case, the impulsing is from the escape wheel and the amount of push depends on the power from the train. Also, the train is stopped by contact with the anchor, which is fastened to the pendulum.



Energy is taken and given back to the pendulum, as with the 150 clock, but now with relatively very high friction losses, as the whole train is reversed and then returned to the forward direction. There is also a loss of energy associated with the relatively long paths of sliding contact between the escape wheel teeth and the pallets. This all matters to the time keeping; for example, as oil thickens in the train, more energy is lost from the pendulum and there is less impulsing resulting in a loss of amplitude and therefore a change in the clock rate. Thus it is far from 'detached'.

It is hoped the above helps in the understanding of 'the how and why', as well as emphasising the unique quality of this three-pendulum clock.

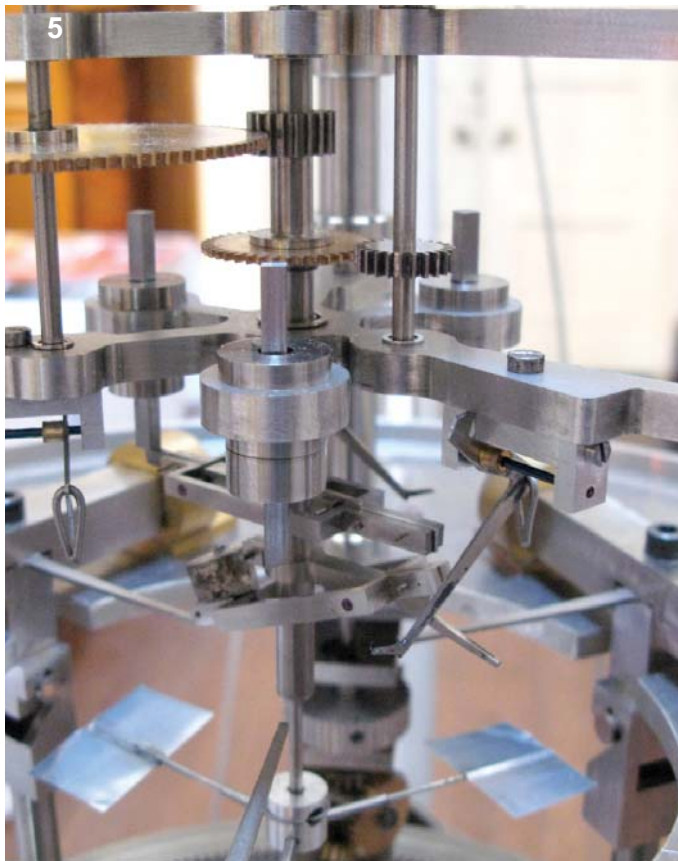
Progress

The clock is now beginning to take on its final form, **Figure 1**. The base is still a temporary wooden one and this has been useful in that it has prompted the idea of making it circular. The circular shape would allow the support cable fixings to be further from the edge and it has been pointed out that there are no matching hexagons in the clock. This is fair, but one must remember that the original shape was to be triangular to match components in the clock; this was abandoned in favour of the hexagon because the points stuck out a very long way.

We move now to the support rods, which have come to be known as javelins. These again are currently made of wood, painted silver. Once more the use of a trial setup has been useful in that it has been found that the top points currently are at eye-height for tall people, so the final metal ones will be much longer. These wooden javelins proved a problem for manufacture as the necessary long lathe was not available. **Figure 2** show Frank Schmidt making one with his solution of a home-made lathe. He has a builder's plank supported on a chimney pot and a Workmate, on which he has bolted a motor and a 'tailstock'. There is a 'steady' in the centre and he has a movable tool rest for his turning tool - an ingenious setup!

As you see from the picture of the whole clock, the glass dome has been purchased. We also have the glass cylinder which houses the pendulums and weight, and an experiment is in hand to check the adhesive which will glue the glass to the stainless steel rings. There remains in some of the team's minds the terrible vision of the cylinder parting company from the ring, with calamitous results. However, following extensive enquiries by the author, we have found a supplier who has assured us that Araldite 2011 is up to the job.

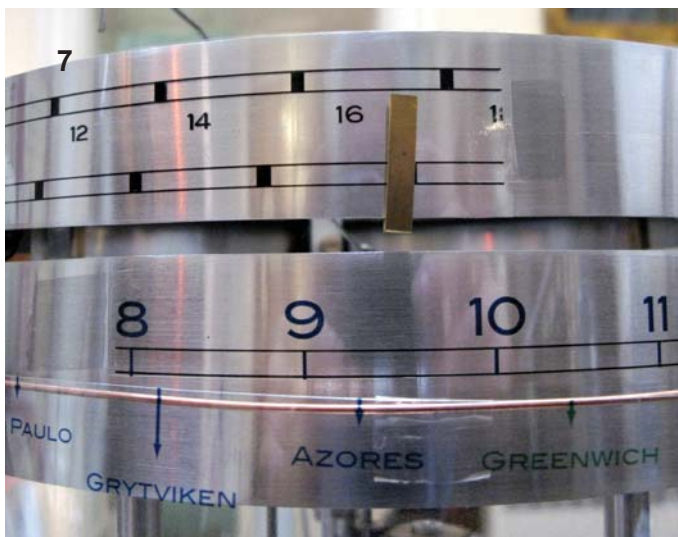
Previous reports have described the use of temporary aluminium plates whilst sorting out the details of the train layout. The thought of cutting out the final skeletonised stainless steel plates was, to say the least, daunting, but Bob Bray of Sinclair Harding (UK) Ltd. provided us with a better way



forward. He has cut all the plates for us by EDM (electrical discharge machining) using information derived from Bill Connor's drawings, saving very many hours of labour and producing very clean cuts which needed very little cleaning up. **Figure 3** shows Bob and his son, Dominic, handing over the plates to Colin Walsh and Bill Connor, and **Figure 4** shows the new top plate on the original, triangular, aluminium plate, which it replaces.

The main mechanism is much easier to view now that the plates are skeletonised, **Figure 5**, and here the latest shape for the lifting arms can be seen. This configuration is working very consistently, although the temporary weights in the form of pieces of solder on the arms are still being used.

In this Figure, the pendulums are still suspended on the ball bearings. These have proved to be very troublesome, with friction increasing over periods of just a few hours causing one or more pendulums to lose amplitude. Cleaning, oiling or just giving them a vigorous turning usually gave a few more hours of use, and although only intended for use whilst setting up,



they have been a bit of a nuisance. Just before this report, the final knife edge assemblies were fitted, **Figure 6**. These comprise grooved sapphire plates sitting on zirconia knife edges and the reduction of friction became apparent immediately, with pendulum amplitude picking up to the extent that the bobs were hitting each other. Although little time was available to run the clock with the knife edges, preliminary indications are that it runs well with the gravity arm weight removed and the driving weight reduced by a third.

A final decision is still to be made regarding the material for the wheels. At the time of the last report, we had changed from soft aluminium alloy to brass, then to a harder aluminium alloy, but were waiting for advice from a company using a process of anodising and PTFE impregnation, called Nituff (this would probably have necessitated remaking of the wheels from a different aluminium alloy). That company lost interest in us, so it was agreed to use brass after all, which would have been a safe solution. However, no one has come up with a satisfactory method of blackening them, whilst an aluminium wheel has been anodised and blackened satisfactorily. On the other hand, aluminium is not a tried and trusted material for clock wheels and some claim them to be abrasive in the anodised state; a final decision is becoming urgent.

Moving now to the top of the clock, **Figure 7**, the dial rings are in place, but with temporary hands, numbering and location display. This was set up to see how it would all look and particularly for the two shows in order to answer the very often asked question 'how do you tell the time'. For locations, it has now been decided to show a 'city' for each of the time zones and these will be on the inside surface of the dome, against the rotating hour ring. One extremely good talking point has been the choice of the place 'Grytviken', which is clearly between The Azores and Sao Paulo! The author has only come across one person who knew where it is, so for the record, it is a whaling station on South Georgia in the South Atlantic near the Falkland Islands. Although it is a U.K. territory, it was named by a Norwegian who established the settlement.

The motor for winding has still to be fitted and the device to allow separation of the clock mechanism from the bottom plate without releasing the weight is nearly ready. There remains the base, the javelins, the glass cylinder fitting, the bottom cylinder plate and numerous smaller alterations and finishing still to do, so although we report considerable progress, it is nowhere near the time to relax.