

EMC modifications to the Lockyer 6¼" refracting telescope

By David Knight, G3YNH, July 2001



Fig. 1. Norman Lockyer Observatory as it was in 2001. The Mond Dome is in the foreground, close to the HF antenna tower.

Amateur Radio stations are normally regarded as sources of electromagnetic interference, but they are, more often than not, the victims rather than the perpetrators. The reason for this, is that Radio Amateurs are in the habit of talking to the world using only the power of an electric light-bulb, the light from which tends to become somewhat attenuated after travelling to the other side of the planet and bouncing at least once off of the ionosphere. The fact that long-distance communication is feasible at all is due to extreme receiver sensitivity, it being perfectly possible to understand speech signals of the order of one microvolt at the receiver antenna socket, provided that such signals can poke their heads above the noise. In an ever-increasingly filthy electromagnetic environment, a sub-microvolt noise level over a bandwidth wide enough to carry speech is something of a luxury for city dwellers; but it ought, by rights, to be possible at an observatory located, more or less, in the middle of nowhere. The problem at the NLO was that it wasn't, at least while the equatorial drive-motor of the Mond Dome Telescope was running.

The telescope in the Mond Dome is the historic Lockyer 6¼-inch refractor, which in its earliest incarnation was used by Sir Norman Lockyer to measure the temperature of the Sun. This same instrument, used in conjunction with a spectrometer, led to the discovery of the absorption spectrum of a previously unknown element, which he named 'Helium' (after 'Helios, the Sun'). The telescope was rebuilt in 1871 by Thomas Cooke, after Lockyer had achieved fame and sufficient fortune to have it engineered properly, and ultimately moved to its current location in the dome built by Sir Robert Mond in 1932. Modifications, since the efforts of Thomas Cooke have been few; save for

the addition of a not-quite-authentically-Victorian thyristor-controlled drive-motor of a somewhat electromagnetically unfriendly disposition.

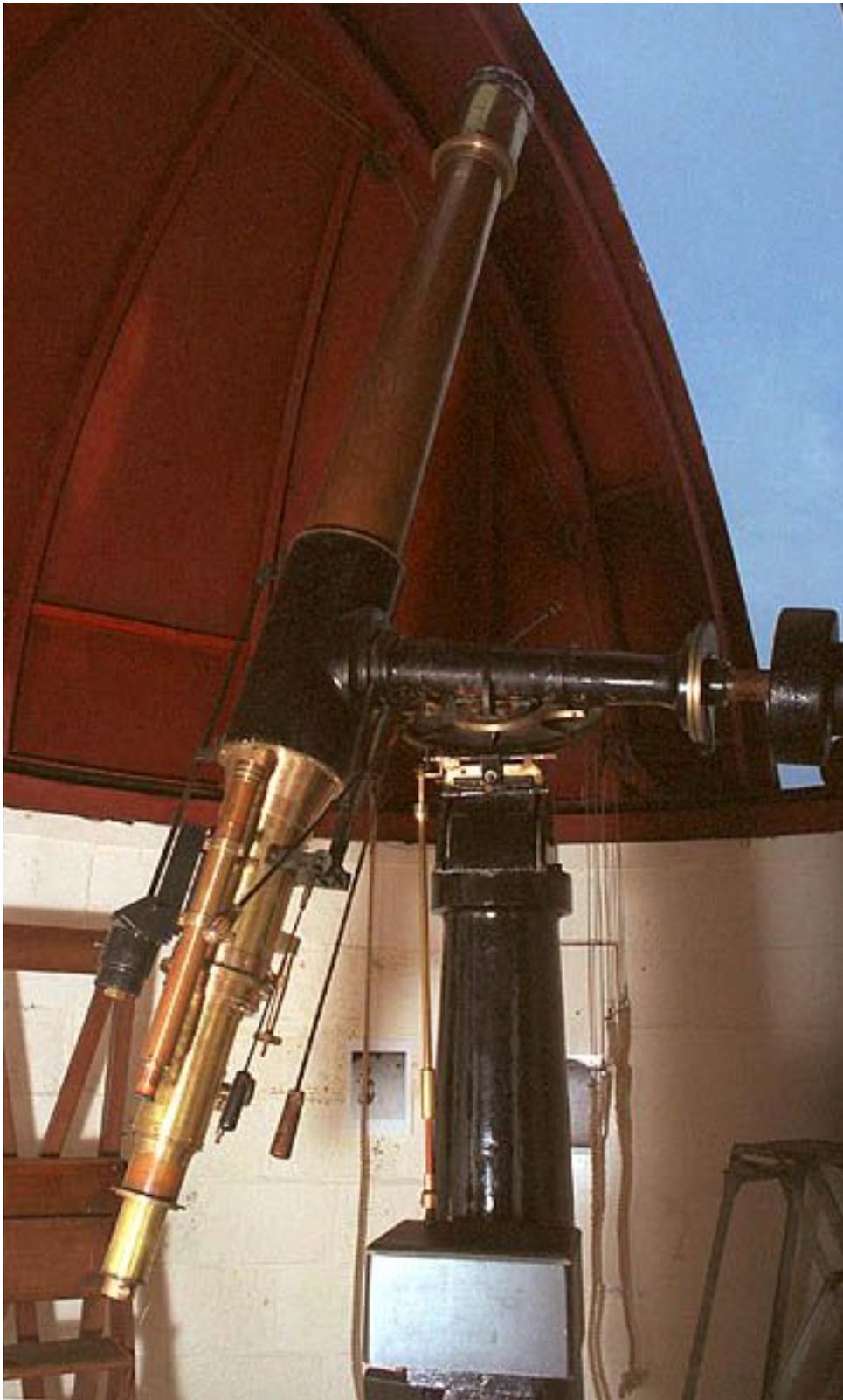


Fig. 2. The Lockyer 6¼" Refracting Telescope inside the Mond Dome

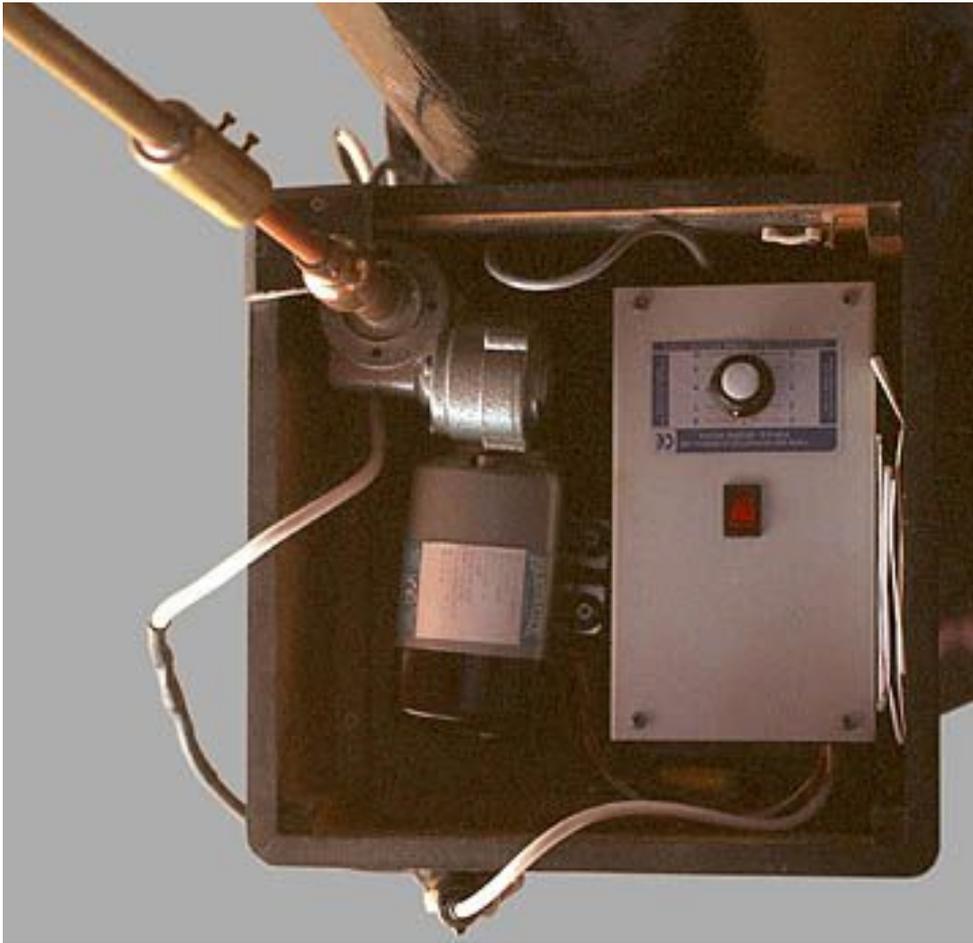


Fig. 3. Drive motor and speed control unit

The equatorial drive-motor sits inside a black-painted wooden box; mounted on the telescope pedestal, and sheltered by a lid from the gaze of those members of the public who might discern its slightly non-authentic appearance. Everything else about the telescope supposedly dated back at least to 1871, and it was considered desirable that things should stay that way. The problem was that the operation of the motor gave rise to a noise level of some $50 \mu\text{V}$ (in 3 kHz bandwidth) at the receiver input (S-9 in Amateur Radio parlance) over most of the short-wave radio spectrum, making it impossible for the GB2NLO HF equipment and the Lockyer 6¼" Refractor to be used simultaneously during public demonstrations.

The interference caused was in the form of pulses, evidently due to arcing at the brushes of the motor. On first appraisal, it appeared that the telescope pedestal, although not wired to the mains earth, was nevertheless firmly connected to the ground; and it seemed that the interference must be traveling via the mains. A mains filter was duly installed at the input to the speed controller, but made no practical difference. A temporary earth-lead was also taken from the motor supply to the telescope itself, but this made no difference either; at which point, the head-scratching began in earnest. The motor was obviously acting as a spark-transmitter, but did not appear to have an antenna. While this mystery prevailed, it was thought prudent to try to stop the motor brushes from sparking, and it was only in the process of dismantling the equipment to fit a spark suppressor, and subsequent testing, that the spurious antenna was revealed.



Fig. 4. Close-up of the equatorial drive system and coupling rod

A network consisting of a $0.1 \mu\text{F}$ capacitor in series with a 100Ω resistor was placed directly across the motor brushes. This network, as is usually the case, was more effective than a capacitor on its own, because a capacitor on its own is not effective at dissipating energy. The suppressor reduced the interference to about half its former level, but came nowhere near to the two orders of magnitude required. It was soon noticed however, that the interference virtually disappeared when the motor was run without the rod that connects it to the equatorial mount. It was then apparent that the entire telescope and its pedestal were acting as the antenna, the corroboration being that the strength of the interference tended to vary during each rotation of the rod, due to variations in the

electrical resistance of the connection between the telescope and the motor.

The coupling rod is equipped with metal cups at either end, which are designed to fit over ball-joints on the motor and the equatorial drive mechanism. Each of the ball joints is drilled and fitted with a steel cotter pin, and each of the cups has a slot cut across it to engage with the pin. In this way the drive is delivered via two simple universal joints, with rust and grease ensuring a somewhat variable electrical connection during the course of each rotation. To allow length adjustment, the middle section of the rod is telescopic, consisting of a bar sliding within a tube, with a brass boss soldered on to the end of the tube to provide a thickened section for locking screws. Both bar and tube were originally made of brass, and the problem was that of how to break the electrical connection without causing serious aesthetic damage.

Short of a supply of Ebonite, or tropical hardwood in handy machined sizes, the nearest available to an ancient engineering material was Whale Tufnol, otherwise known as 'Synthetic-Resin-Bonded Fabric' (SRBF). This phenolic composite material hails from the 1940s, but as it turned out, has a more ancient pedigree than one of the existing features of the rod; which was that it was fitted with two black-Japanned Allen-head 6BA locking screws, these items being unavailable prior to the late 1950s. It may be however, that someone simply changed the screws because the old-ones were damaged or worn, since the supposed age of the brass material was corroborated by its machining properties. Commonly available modern brasses have lead in the alloy, and are known as 'free-machining brasses'. Victorian brass, on the other hand, has no lead and is closest in composition to what we now call 'Naval brass', this having better corrosion resistance than leaded brass, but being hard and difficult to machine.

The chosen approach was to replace the $\frac{3}{8}$ " (9.525 mm) diameter inner sliding bar with Tufnol, but although $\frac{3}{8}$ " diameter Tufnol tube was available, the bulk strength of solid rod was to be preferred and rod was only available with a nominal diameter of 10 mm. Tufnol is a relatively flexible material, and it is therefore extremely difficult, if not impossible, to machine a long length of it to reduce its diameter by 0.5 mm. The practical solution therefore, was to ream the internal diameter of the boss to accept the standard metric rod size, but with the added complication that the brass tube was blind-ended by the soldered-on ball-joint cup, and it was therefore impossible to know its internal diameter. If followed, that if the inner diameter of the tube turned out to be less than 10 mm, the available adjustment range would be severely restricted by the limitation in drilling depth on reaming out the hole, whereas if the diameter was greater than 10 mm, Tufnol rod could be inserted for the full length of the tube, as was the case with the original $\frac{3}{8}$ " brass rod. Fortunately, it transpired that the tube internal diameter was greater than 10mm, and so it is probable that the chosen bore was $\frac{13}{32}$ " (10.319 mm) or greater.

The actual measured diameter of the Tufnol bar stock used was 9.9 mm, and so the boss was mounted in the lathe, centered, and drilled out to 10.0 mm. Cutting properties against an HSS tool indicated that the material was a Naval grade brass, and it was noted with some relief, that the tool ceased to cut on having been inserted for the full length of the boss. The tube assembly was then de-burred and cleared out with compressed air, and the Tufnol rod, after light polishing and lubrication with Dow-Corning Molycote 111 Silicone grease, could then be easily inserted as far as the ball-joint cup at the other end. Completing the job was then simply a matter of removing the ball-joint cup from the end of the original $\frac{3}{8}$ " diameter bar and re-fitting it to the same length of Tufnol. Fortunately, this cup was not soldered in place, but attached by means of a $\frac{1}{8}$ " (3.175 mm) diameter steel cotter pin, and it was possible to drive out the original pin and re-use it. The socket at the rear of the cup was drilled out to 9.9 mm, and the Tufnol rod was inserted with the aid of a soft mallet. The Tufnol was then drilled from either side, through the original cotter-pin holes, until the drillings met in the middle; using a 3 mm drill to start, and finally reaming out to 3.175 mm with care not to cut away any metal. This ball-joint cup incidentally, is different from the rest of the assembly, being made of an unusually light-coloured phosphor bronze.

The re-engineered coupling rod can be seen in figure 4, the visible part of the Tufnol rod being at

the bottom. As expected from earlier investigations, interference signals picked up by the HF beam antenna dropped to less than the general radio background noise (S-3, about 0.8 microvolts in 2.7 kHz), and the job was done.

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