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LARGE SCALE PRECISION

Ken Tapping, 21st October, 2014

It is hard not to be impressed when looking at a large optical or radio telescope. Even if you are an astronomer who has visited observatories all over the world, you still feel that awe. It comes from the combination of large-scale engineering and extreme precision that is an essential part of all large telescopes. We see it too in the instruments. The basic appearance of large telescopes has not really changed a lot in a hundred years or more. They still consist of large mirrors or dish-shaped radio antennas. However the instrumentation has become far more sensitive, sophisticated, and in the process, very complex. Imagine a small mirror flexing rapidly, taking out the distortions the atmosphere imposes on astronomical images.

One of the main problems is to take massive telescopes weighing hundreds or even thousands of tonnes and control them so they can be pointed extremely precisely and then track celestial objects across the sky just as accurately. Many elegant solutions have been invented to solve this problem. One of the most elegant was invented by Barnes Wallace, a British engineer whose most well-known for having invented a bouncing bomb, developed to destroy large dams, although his ingenuity extended into many other spheres. His elegant idea was applied to at least two major radio telescopes: one in Australia and the other in Canada. The Australian radio telescope was built at Parkes, and has a diameter of 210-ft (63m) and the Canadian one was built in the Algonquin Provincial Park, Ontario. It is a little smaller, with a diameter of 150ft (46m). Other than the difference in size, the only significant difference was the Canadian one had a shield to keep snow out of the drive machinery; the Australian didn't. The ingenious idea for the precision control of both these radio telescopes was that it is far easier to precisely drive a small thing than a big one.

Inside the tower supporting each of these big dishes is a slender column, extending down through the centre of the tower, deep into bedrock, making it highly stable. It is completely independent of the surrounding tower, touching it nowhere. On the top, on a thick, steel platform is an amazing device called the Master Equatorial. It is essentially an extremely high-precision telescope mount. However, instead of a telescope there is a special projector, which sends out a narrow, well-defined light beam. The radio telescope is equipped with detectors to sense this light beam, and to follow it. It does not matter if there are irregularities in the gears; the telescope just follows the light beam. In the days when computers were expensive, this system worked well without needing one. However, there was one area where a computer would have been helpful; helping the telescope to find the light beam.

Maintenance and other needs often result in the Master Equatorial pointing in one direction and the telescope pointing in another. To start making observations the telescope has to be slaved to the light beam. This was accomplished using a device known as the Coordinate Converter, or Co-Co. This unit, a strange mixture of motors, synchros, gears and other devices, converts the antenna position information into the same units as those used by the Master Equatorial. The Telescope Operator, sitting in the Control Room, can see displays of the telescope and Master Equatorial coordinates, and then drive the telescope until it "sees the light" and locks in.

Developing instruments for astronomy requires a mixture of civil and extreme precision engineering. Then add instruments capable of measuring amazingly weak emissions and sophisticated systems to process that data. Astronomy is a fascinating science, and branch of engineering.

Jupiter rises soon after midnight hours. Mars lies low in the sunset flow. Saturn is now lost in the glare. The Moon will be New on the 23rd.

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