Homebrew rotator

Made from junkbox parts and powerful enough for small HF beams

INTRODUCTION. This article describes the construction of a homebrew rotator that has been in use for over 18 months and has survived a winter with temperatures below -30°C. It can be made using a drill press and hand tools, but access to a metalworking lathe was useful in one or two situations. The rotator is based on a worm gear sandwiched between two aluminium discs. Use of a worm gear provides the benefit of not requiring a braking system, which was the major source of problems in my previous efforts to build a rotator. It is not likely that it can be copied exactly, because many parts were obtained from local scrap metal and surplus dealers, but it is hoped that there are enough ideas in this project to lead others to try and make their own rotator. The pictures should show most of the necessary constructional information.

CHASSIS. The main chassis frame consists of two thick 8 inch diameter aluminium discs separated by six metal spacers arranged around the perimeter. **Photo 1** shows the general form of the construction. The main drive shaft rises up through the centre, passing through both discs. To achieve accurate alignment of the shaft holes and the spacer holes, the two discs were clamped together during the drilling process. The discs were marked in order to maintain alignment of all the holes during assembly. Other holes were drilled in the bottom disc, as needed, for other parts of the rotator.

DRIVE SYSTEM. With the exception of the worm gear on the output shaft, all parts of the drive system are mounted on the bottom disc, as shown in **Photo 2**. The drive train comprises a surplus 24V DC motor and gearhead that drives the worm via a series of spur gears. The spur gears were selected to give a convenient linkage between the motor and the worm and to provide a final rotation speed of about 1 RPM. A single start, single throated worm gear was used. Single start is important in order to gain maximum self braking, and single throated gives added strength. With 32 teeth, the worm gear gave a speed reduction of 32 to 1.

The worm was mounted between two L-shaped brackets, which needed careful placement to keep backlash low. It is also very important that these brackets are made as strong as possible to avoid movement and distortion from the high stresses imposed by movement of the beam.

The shaft for the worm was made from $^5/_8$ inch steel rod. The ends were turned down to $^1/_4$ inch, using a lathe, to fit the spur gear and to provide shoulders on the shaft. A small ball race was inserted between each shoulder and the L-brackets in order to reduce the friction from the lateral thrust. A slot for a key also had to be cut in this shaft.

The worm gear is mounted on the main drive shaft, which in this case was the front fork of an old bicycle. The worm gear is held in place with a one inch length of $^1/_4$ inch keystock and a set screw. The slot for the keystock was cut in the drive shaft using a cut-off wheel on a Dremel tool.

POSITION INDICATOR. A 10 turn 5kΩ potentiometer was coupled to the main drive shaft via two spur gears, which provided approximately 5 turns of the potentiometer for one full turn of the beam. The larger gear was screwed, with ¼ inch spacers, to the upper surface of the worm gear. The smaller gear was mounted on to the potentiometer shaft. This arrangement is shown in **Photo 3**, which also clearly shows the substantial worm gear. The potentiometer mounting bracket was made of thin steel to provide some flexibility. This spring action ensured constant meshing of the two gears. It also facilitates setting the potentiometer.

LIMIT SWITCH ASSEMBLY. The limit switches and associated cam are used to prevent over-rotation of the beam. The cam also serves as a spacer between the worm gear and the top disc. It is fastened to the main shaft with a set screw. In my prototype, the notch in the cam is positioned to stop the beam either side of due south. The limit switches were mounted on a plate screwed to the tops of the worm L-brackets. **Photo 4** shows the switches and cam in position, along with an upper bearing race. The control cable with connector can also be seen.

FINAL ASSEMBLY. The completed (but un-cased) assembly is shown in Photo 1. The U shaped shaft is a fork from an old bicycle. The flange at the bottom of the fork conceals a ball race, through which most of the vertical load is transferred to the upper aluminium disc.

Six long $^1/_4$ inch bolts hold the complete assembly together. The heads are covered with silicone sealant to help keep out moisture.

A cover for the rotator was cut from paper-

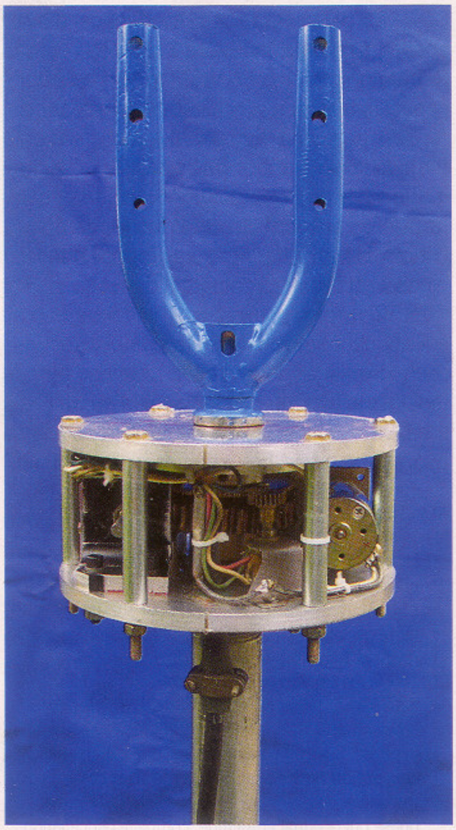

PHOTO 1: General view of the completed rotator, less covers.

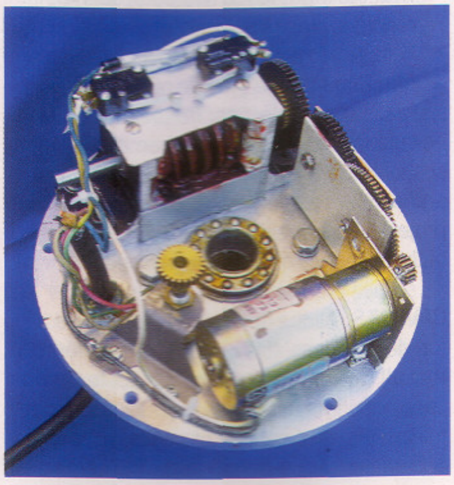

PHOTO 2: The base plate holds the motor, gear train and feedback pot.

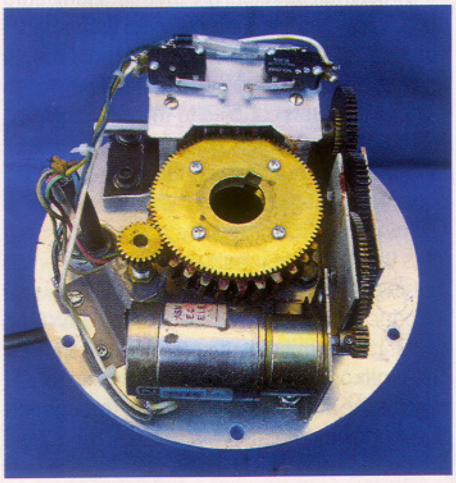

PHOTO 3: Adding the worm gear and feedback gear.

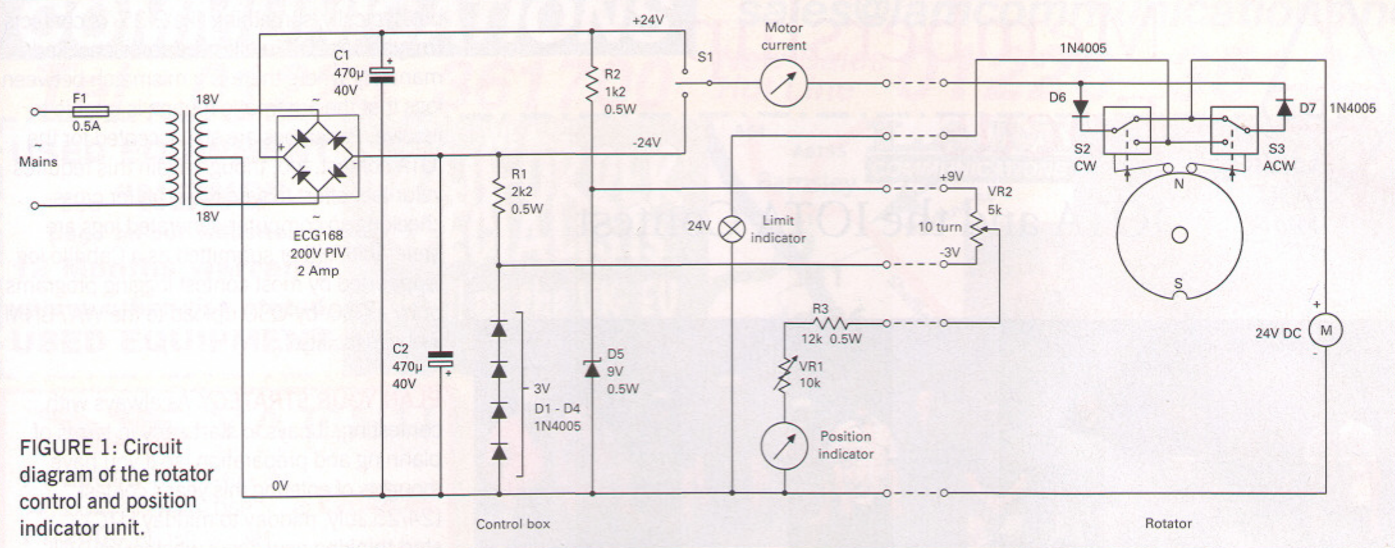

FIGURE 1: Circuit diagram of the rotator control and position indicator unit.

thin aluminium and wrapped around the assembly. Silicone sealant was used for waterproofing and the cover is held in place by two hose clamps. This arrangement can be seen in **Photo 5**.

ATTACHING THE ROTATOR TO THE MAST. A four inch pipe flange was bolted to the underside of the bottom disc. This was used to screw the rotator on to a threaded $1^1/_2$ inch aluminium pipe. The original arrangement used a set screw to discourage the pipe from unscrewing itself, but this was found to be inadequate so three struts, made from electrical conduit, were added. Photo 5 shows the details.

ROTATOR CONTROL BOX. A simple control circuit (**Figure 1**) was developed to operate the motor. The circuit produces an unregulated ±24 volt supply, which is used to drive the rotator motor via centre off, momentary, two position switch S1. Motor current is indicated by a centre-zero meter wired in series with the motor. The meter is shunted with a suitable length of nichrome resistance wire so that the normal motor operating current indicates about half scale.

Power to the motor is fed via steering diodes D6 and D7 and through the limit switches S2 and S3 to the motor. When a limit is reached in either direction, the voltage is fed back to the control box to light a 24 volt incandescent lamp. Both limit switches are in the depressed state except when the rotator reaches one of the limit points near due south.

To measure the position a 12V span was required, arranged as +9 and -3V. The +9V supply is derived from the +24V supply by R2 and Zener diode D5, while the -3V supply comes from the -24V rail via R1 and four forward-biased 1N4005 diodes. The 12V supply is fed to the position indicator pot, VR2, located in the rotator. As mentioned earlier, VR2 is a 10 turn potentiometer, geared so that there are five turns of VR2 for one revolution of the rotator shaft. It is best to have these five turns in the centre of the VR2 to avoid any risk of over running the ends of travel. The meter zero point is on the left hand side, so the -3 volts elevates the 0V point above the bottom end of VR2 by about $2^1/_2$ turns. Series resistors R3 and VR1 are chosen to suit the current rating of the meter used for position indicator. VR1 sets the span. The zero volts point of the potentiometer, relative to the main drive shaft, is set by pulling the two gears apart and turning the gear on VR2. These are bench adjustments made before the rotator is installed.

Photo 6 shows the prototype controller. This case also contains a control circuit to elevate the mast; the rotator controls and indicators are on the left. There are two meters associated with the rotator; the upper one shows direction and the lower one indicates motor current. A lamp indicates when the rotator has reached a limit.

FINAL REMARKS. The weight of the rotator worked out to about 7kg. The bronze worm gear is the heaviest component. It was surprising how the small elements added up in the final assembly.

A shaft collar was fitted below the bottom disc (located inside the $1^1/_2$ inch aluminium pipe) to help restrict vertical movement of the main drive shaft.

Set screws were treated with thread locking compound, and self-locking nuts were used whenever possible.

Ball bearings were not used in the aluminium discs, in order to simplify the machining. As previously mentioned, most of the vertical load is taken by the bicycle fork bearing. Considering the slow rotation speed and infrequent use, it was thought that the steel drive shaft against the well-greased bare aluminium plate would be OK. Keep an eye on the motor current; a rise in current indicates that all is not well and the internals of the rotator should be investigated.

I hope that this report shows what can be done with a little skill and some determination, and inspires you to have a go at making something mechanical yourself.

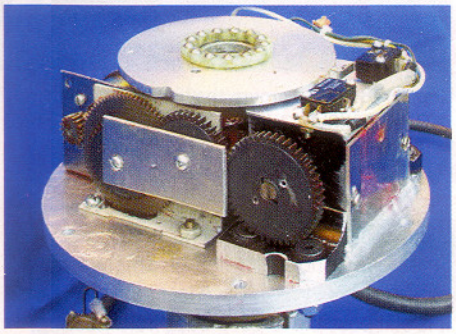

PHOTO 4: Detail of drive train and limit switches, including cam.

PHOTO 5: Looking up the mast, showing the foot plate and anti-rotation arms.

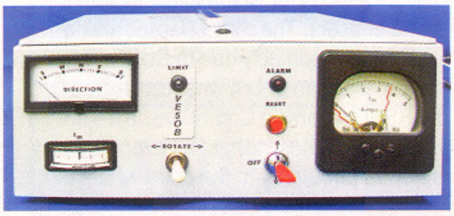

PHOTO 6: The control box. Rotator controls are on the left side.