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Work Carried Out at Narrabri in 2003 July

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Abstract
The main aims of this trip were to install the latest version of the Automatic Gain Control (AGC) circuit to try to improve the Narrabri Autoguider, to reconfigure the blind motor system and to install a "magnetic" Pockels cell. In the end, the latter was thwarted by an unexpected fault in the "velocity" Pockels cell driver. A few maintenance tasks were also achieved.

1 Introduction

In March of 2003 the blind motor failed. George visited in April and set the system to run with the blind fully closed, using the raising and lowering of the shutter to allow light onto the instrument. This shutter arrangement cannot go high enough for Summer running, and the standard system needed to be restored. At the same time it was decided to bring Narrabri into line with Las Campanas (BTR-190 and BTR-200) and Sutherland (BTR-212) by installing a second Pockels cell to allow measurement of magnetic field, and to modify the guider by installing an Automatic Gain Control (AGC) circuit (BTR-214).

Roger was on site from 21st to 30th July. George arrived on the 25th and left 1st August.

2 Diary (RN)

2003 July 21

Arrived at about 3 pm. Cloudy. System apparently fine as far as I could tell. Checked Rain Detector.

2003 July 22

Almost cloudless day. Ran to get "benchmark" data and made preliminary measurements for AGC installation. Oven temp is 107 °C, 4 degrees lower than I left it 4 years ago (BTR-99). Other temperatures are as before – and IF started about 1 degree low at the start of the day.

2003 July 23

Cloudy until after lunch. Worked on the AGC, completing installation (but not final adjustment) just before sunset.

2003 July 24

Broken cloud all day – very frustrating. Set AGC before dawn. Started to monitor and work on the temperature controller to try to fix poor control of IF in cold conditions. Goodies arrived from Birmingham. Installed and made first attempt to set the LDR in the cloud detector. Tried to prepare for installation of new blind motor and magnetic Pockels cell.

2003 July 25

Started clear (and cold – Narrabri had ice!), but then was partly cloudy. Checked LDR operation at dawn - fine. Installed magnetic Pockels cell; retained existing velocity cell. Problems with fitting new cells (height of HT-BNC's), and light beam may not be passing through well. Cleaned front red filter. Velocity Pockels driver has a periodic (mains?) problem – not sorted.

Tried to offer up the Parvalux motor with Mike. Will not fit without cut-out – size of which needs determining by further tests.

Spectrometer temperature was too low for the IF controller to work all day.

George arrived late pm.

2003 July 26

Clear early, broken cloud for the rest of the day. In the early sun I had a closer look at the new Pockels cell alignment – found the beam low in the cell, ie it needed to go lower, making HT connection easier. May be OK. Spent rest of day fighting the Pockels driver fault. Finally fixed (kluged?) it close to sunset.

2003 July 27

Cloudless day. Installed new Pockels cells – found problem with magnetic measurement cycle.

Worked on new Dayton motor. Found out how to mount and drive it.

2003 July 28

Another cloudless day after a frosty start. Tracked down magnetic measurement problem to poor waveform shape of Velocity Driver (ie the kluge of 26th was too klugy even for us). After diagnosing the fault we ran on velocity only using the Magnetic Driver and Velocity Gate.

Worked on blind motor, getting to the point of having wired it in and tested. Final mechanical mounting still required.

Investigated the possibility of a dual-cycle air-conditioner to warm the circulating water in winter. Warned off the idea – apparently the outsides ice-up when they run on heat-cycle in frosty conditions. Bought a fish-tank thermostatically controlled heater to go kluging with.

2003 July 29

Yet another cloudless day following frost. When has Narrabri last achieved three successive cloudless days?? Got the blind motor operating and reset the shutter calibration. System seemed to be working as normal. Walked Mike through this and the AGC, and left documentation on both.

George did a bit more trouble-shooting on the Velocity Pockels driver – still not able to find the source of the fault.

2003 July 30

Again, starts clear and frosty. Checked that system had opened up correctly and noted instrument and mount settings. Hit the road!

3 Installation of a Mark III AGC Circuit

The necessary detail to understand the operation of the Mark III AGC is contained in BTR-214.

3.1 Relevant measurements and settings

The sum of the Autoguider Test Points 1 and 4 (giving the light level on the quadrant detector) at noon is about six times that at dawn/dusk. The total output of the Summer stage at noon is 4.32 V. See Section 4.2 of BTR-214 for the significance of these values.

3.2 In operation

The AGC appeared to work well – providing more servo activity at the ends of the day. However, the mount behaviour in Narrabri appears similar to that in Sutherland, and is less prone to oscillation close to noon than is the system in Las Campanas. Without carrying out detailed analysis, I came away with the distinct impression that the Narrabri ratio traces showed the usual degree of "footprint", with or without the AGC.

3.3 Instructions emailed to Mike Hill

<u>Automatic Gain Control for the Autoguider in Narrabri (24/7/2003)</u>

1 The circuit is housed in the die-cast box to the right of the Autoguider, and is connected to the Autoguider via a D-connector.

2 The purpose of the circuit is to reduce the variations in the guiding servo's gain which occurs because the Autoguider's error outputs are proportional to the solar light level. The Automatic Gain Control (AGC) divides the Autoguider error signal by a voltage proportional to the light level. This allows a single electronic gain setting on the Autoguider to give good performance throughout the day.

3 The AGC has one channel each for RA (Channel 1) and Dec (Channel 2). Two switches at the back connect the two channels to the Autoguider. With the switch in the "OUT" position, the AGC is disconnected for that channel. When the switch is in "IN" the channel of the AGC is enabled. The gain switches on the front of the Autoguider need to be set differently when the AGC is enabled.

The following settings should be used (unless advised differently from Birmingham):-

Switch setting	Dec Autoguider Gain	RA Autoguider Gain
AUTO	2	2
NORMAL	5	5

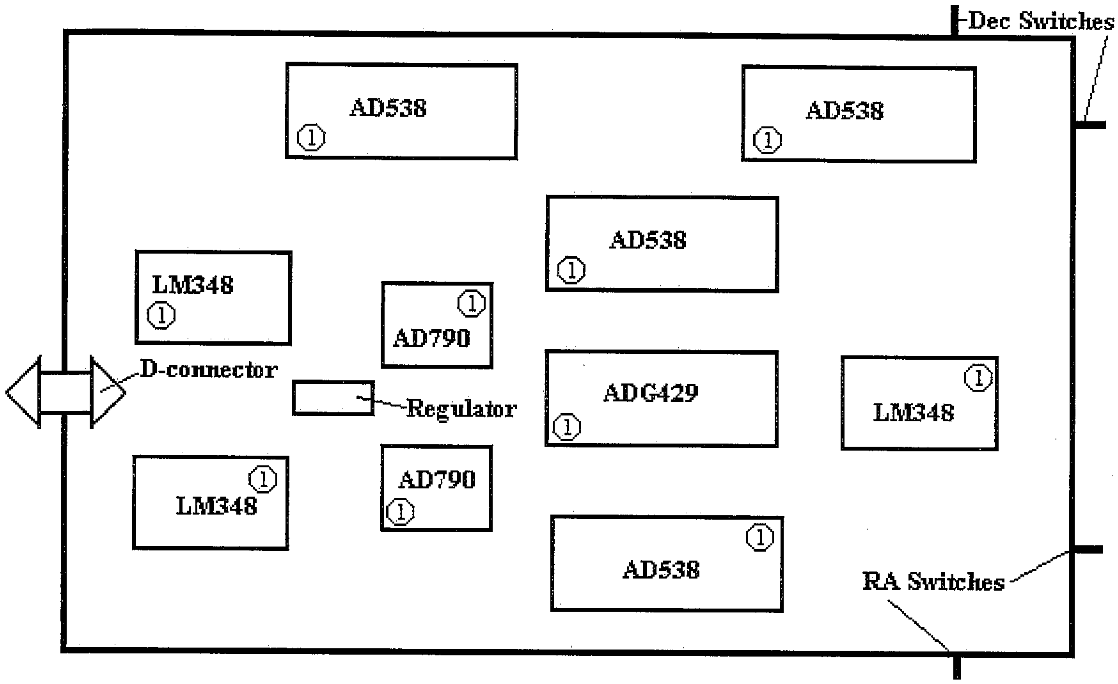
4 There are two switches on the sides of the AGC box. These allow an output filter to be switched in for each channel. Unless advised by Birmingham, the filters should be enabled.

5 Outline of the circuit operation (there is a copy of Figure 4 from Section 4.2 of BTR-214):-

i) The above shows one channel and "Sum" and "Gain" stages which are used by both.
ii) The aim is to divide the error signal by the light level (sum of TP1 and TP4 of the Autoguider). An offset is added to the divisor to prevent divide-by-zero conditions, and the whole is raised to a power of just over 1. This use of the power allows for a little more bias to be introduced at dawn/dusk compared with noon than purely necessary to cope with light-level change.
iii) The divider chip AD538 works best if its numerator is always positive. Of course the error signal is bipolar, so the magnitude and sign of the error signal are determined. The magnitude is divided, and the sign addresses the multiplexer to output a positive or negative signal as appropriate.
iv) The output can be low-pass filtered (S1) or completely bypassed (S2).
v) The Sum, Gain, -1 amp and active filters are achieved using 3 LM348 quad-op-amps. Each channel has its own AD 790 comparator and AD 538 Analog Computational Unit. The 5V level is provided by a 5V regulator.
vi) The Sum, Gain and –1 circuits are as follows (there is a copy of Figure 5 from Section 4.2 of BTR-214):-

vii) The active rectifier and output filter follow Figures 4.45 and 5.16 of Horowitz and Hill (in "Sutherland (continued)" ring binder).
viii) One 4-channel MUX (ADG429) is used to multiplex both channels.

6 The board layout is as shown below:-



7 Filed along with this brief description are:-

Data sheets:- AD538
AD790
ADG429

H+H extracts:- Active rectifier Fig 4.45
VCVS active filter Fig 5.16

PCB detailed layout

8 There are spare chips in a black plastic box in the "Electronics" tray.

4 Pockels cell work

4.1 Driver problems

The velocity driver had a fault which had a number of symptoms (collected together with hindsight):-

1) The gate light faded in and out with a period of about a second, instead of being steady, when the gate signal was connected, and pulsed on and off when no gate was connected.
2) With the driver gated, the monitor showed an unstable square wave – the appeared to be a rippling signal on top of it. With no gate there was a monitor output (there should not be!). This output had very strange features – a large positive "spike", lasting about 10 ms, followed by a few smaller sharp peaks spaced by 10 ms. This repeated with the first broad spike being negative. The overall period was about 1 Hz.

3) The power supply showed the effects of the loading during the signals described in 2) above. For example, the ± 15 V regulated lines showed 1 Hz signals.

George and I never really got an understanding of the problem. We confirmed that it had something to do with the feedback loop containing the transformer by finding that the power supply became well behaved with the loop broken (by desoldering one end of the 1 Ω resistor). We swapped all op-amps and the two low power transistors, to no effect. Expecting the problem was very likely related to one or more of the passive components, we homed in on the one long time-constant in the feedback loop – a 10 MΩ and a 2 μF capacitor combination. (We wondered if the capacitor, actually two 1 μF's in parallel, had developed a problem.) More by luck than judgement, we tried resistors and then capacitors in parallel with the 10 MΩ resistor. Resistors affected the magnitude of the output, capacitors modified the shape. We found that a 10 nF capacitor removed the spurious signals present for no gate input, and cured the problem with the monitor square-wave when a gate was connected. A 10 nF capacitor was soldered beneath the board in parallel with the 10 MΩ resistor. This removed the problem's symptoms. Neither of us was convinced that it has cured the fault, and expected that it may well return…

…but not so soon as the next day!!! In fact the waveform remained as "good" as we'd obtained the day before, but when we actually installed both Pockels cells and tried to acquire data we found that the four displayed ratios were giving very odd results. The main symptom was that both Starboard and Port detectors showed a very large difference (equivalent to about 500 m s^{-1} or 150 Gauss) between the ratios obtained in left- and right-circular polarisation. In April George had a scaler read out problem. To confirm that this was not the case here, we read the scalers manually and worked out the ratios by hand to confirm that the displayed results really reflected the scaler counts – they did.

Looking at both Velocity (kluged) and Magnetic (un-kluged) Driver Monitors it was clear that the rise/fall time of the Velocity signal was much slower than for the Magnetic and that the velocity trace only reached its plateau after one-half cycle of the Magnetic sequence. To confirm that this was the cause of our problem we increased the start delay of the EOLM module. We expected that the ratio in the state of circular polarisation which was activated second in the sequence would give a "good" result (close to the value obtained when running velocity) and the other would be lousy – this was confirmed (see Table 1).

EOLM Mode	Circ-pol state 1	Circ-pol state 2	Start Delay
Single (velocity)	7.53*	7.53*	9
Double (magnetic)	7.39	7.48	9
Double (magnetic)	6.15	7.60	5

Table 1 The effect of start delay on magnetic measurements. The ratios generated by the two states of circular polarisation are expected to be very similar. In the "Single" mode, no magnetic gating occurs, and the two ratios must be the same. These results are marked *. In "Double" mode the magnetic gating is enabled. As the start delay is decreased the results of one polarisation state (the first accessed in the gating sequence) becomes

severely affected. The other is less badly altered, but still to an extent equivalent to 2 Gauss.

Finally, accepting that our kluge was no good, we ran purely in velocity and varied the EOLM start delay. We found that using the Velocity Driver the settings on the delay ran out before we reached a plateau in ratio, but that using the Magnetic Driver, gated with the Velocity Gate, did peak out as shown in Table 2.

Start Delay	Ratio ("Vel" driver)	Ratio ("Mag" driver)	Sum ("Mag" driver)
3	6.14	7.36	294 k
4	6.44	7.70	284 k
5	6.85	7.92	274 k
6	7.15	8.03	264 k
7	7.34	8.10	254 k
8	7.47	8.13	244 k
9	7.55	8.15	233 k

Table 2 The effect of start delay on velocity measurements using the two Driver units. The "Velocity" unit has clearly a poorer behaviour. The Sum data for the "Magnetic" Driver show that the drop in sensitivity as the delay decreases is just about compensated for by a rise in counts. We ended up running with setting 3. A fag packet calculation indicated that the delay setting differ by about 30 μs. The data were taken in the mid-morning when the ratio was rising rapidly.

We ended up back with one Pockels cell (L7) driven by the "Magnetic" Driver, using the "Velocity" Gate with the start delay on setting 3.

4.2 Installation of the new cells

I adjusted the height of the cells (L7 and L12) by putting them one at a time on the optical bench in the spectrometer with a beam of sunlight passing through. I'd removed the IF so that the beam was easily visible. For some reason they align well with the beam with their cylindrical bodies somewhat below a concentric arrangement with the rear lens – which also seem well aligned! In this state, one of the HT cables of each cell is in contact with the spectrometer lid, which needs to be put on and taken off very carefully so as not to twist the cells.

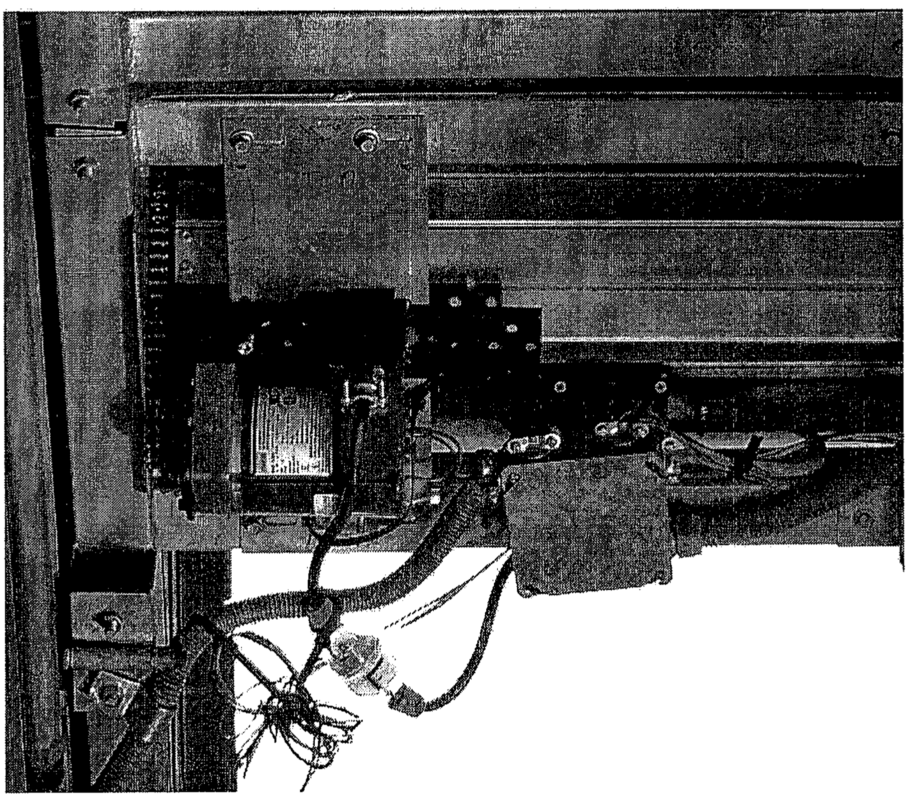
I removed the red front filter and tried to see Heidinger brushes (BTR-105) with each cell between crossed polaroids (the Polaroid in the main beam and that in the transmission monitor. L7 showed a clear, well-centred brush pattern. L12 gave some diagonal lines that I never got looking as good as L7 – I tried the only adjustments, height and rotation about the vertical pin. I decided to use L7 for velocity and L12 for magnetic. I then optimised both cells for ¼ wave action. I put each cell in turn in the "velocity" position and adjusted the applied voltage until I saw maximum ratio. For each cell I used its own driver, but gated with the velocity gate signal. There were two slightly unexpected outcomes. Firstly L12 gave about 15% lower ratio maximum than L7. This may be related to its "Heidinger" behaviour, or it might be some degrees' relative misalignment of the two cells' fast axes – by the time we'd got this far, the Sun's angle made it difficult to get the spectrometer lid off quickly enough to check the best polariser angle for L12. The second puzzle was that the Pockels Driver amplitude and monitor settings differ by a factor of two for ¼ wave behaviour. This could well mean that the Drivers are not identical - we did not have time to check inside the Magnetic Driver.

5 Blind Motor Replacement (The blind fixing the Blind)

5.1 Motor choice

We had the choice of two motors: a large unit from Parvalux which George had decided against installing in April and a smaller systems from Dayton which arrived during our stay. The blind assemblies in the different domes seem to have different mechanical configurations – Richard, Brek and Barry have tested both motors in Birmingham, finding that the Parvalux needed an acceptable cut-away in one of the beams at the top of the shutter mechanism and that the Dayton fitted comfortably. Here, George in April and Mike, George and Roger in July all found that the Paravlux was unlikely to fit without cutting right through the beam, and that the smaller Dayton motor still needed a cut-away similar to that used by Brek and Richard for the Parvalux in Birmingham. Although we were worried by experience that Brek and Barry had in Birmingham with the Dayton skipping teeth in the drive chain, we decided that we either <u>had</u> to use the Dayton, or had to consider rigging the Shutter limit to cut in early and prevent the motor reaching the offending beam. In the end we decided to try the Dayton.

5.2 Mechanical mounting



<u>Figure 1 The Dayton motor after installation</u>

Figure 1 shows the Dayton motor in situ. We adapted the plate originally sent from Birmingham as part of the "Parvalux kit", mounting the Dayton using two bolts through the integral bracket. This bracket has an inconvenient flange which prevents the motor sitting flush to flat surface. We used two of the spare shims sent for the dome levelling exercise to fill the "gap" created by the flange.

The original Ash chain was a few links too short. We cut a few links from the end of a new chain sent by Brek, using a thing for getting stones out of horses hooves and forcing links out of chains (yes it does work), intending to add these extra links to the Ash chain using some split-links. Ha! While the two chains had as far as we could tell indentical spacing from one link to another, the widths across the chains were slightly different (the Ash chain being a touch wider). This slight difference in width meant that while the split link pins were fine for use with the new chain, they were just too short to use with the Ash chain. So we cut an appropriate length of the new chain and fitted it.

The junction box and a few cables and umbilicals had to be shifted slightly to accommodate the new set-up.

To allow the motor to pass the beam at the top of the Shutter mechanism, the circular section slot already made by Ash for the Narrabri system had to be extended as shown in Figures 2 and 3.

Figure 2 Once a jolly file-man....

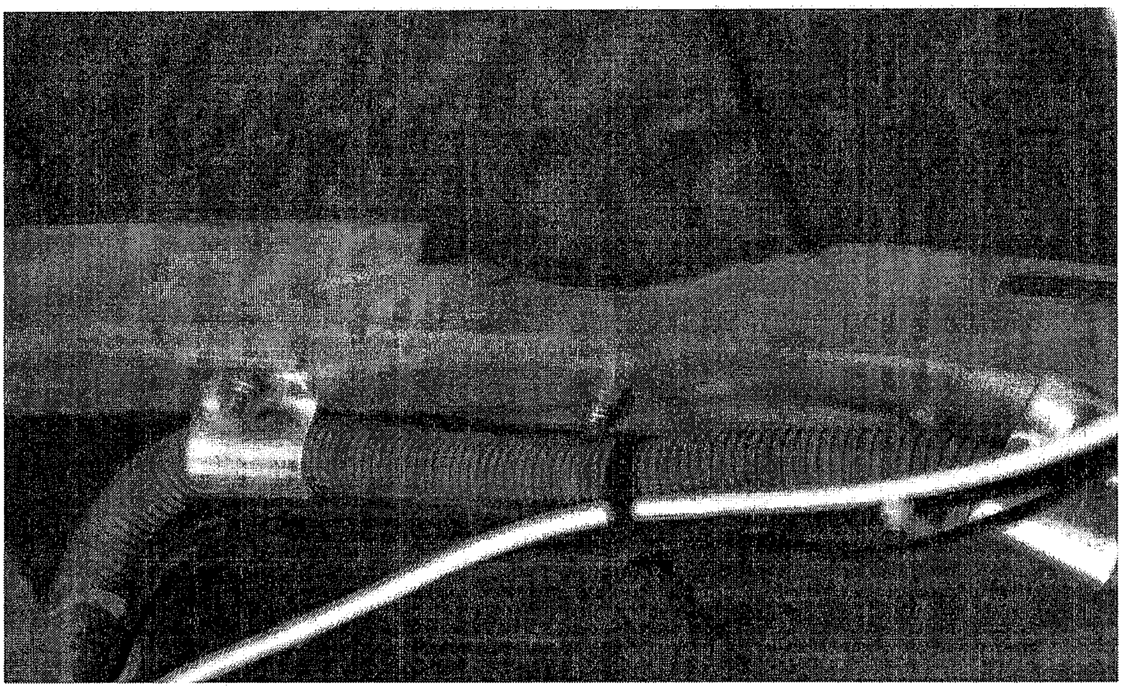


Figure 3 The cut-out finally used

5.3 Electrical connection

We followed guidelines emailed by Brek, with a couple of additions to account for the use of the capacitor by this motor and to wire in the Shutter Down switch properly. From Dayton's and Brek's information, we decided the motor needed to be connected as shown in Figure 4.

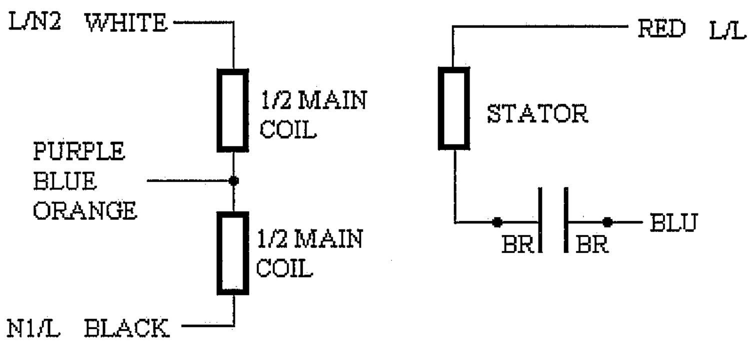


Figure 4 The connections needed by the Dayton motor

We used an Aussie three-pin plug and socket to supply power from the junction box to the motor to allow easier exchange. The wiring scheme we used and that which we replaced is shown in Figure 5 (cf Figure 5 of BTR-139).

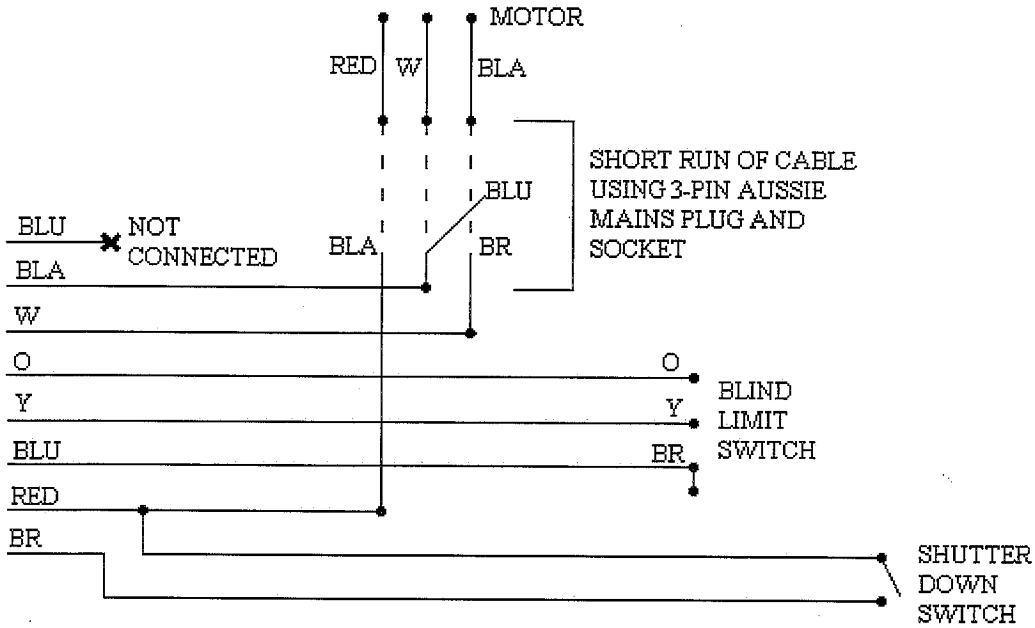


Figure 5 How the Dayton motor was connected

We drew the changes made onto Figure 5 of BTR-139 and left it in the Relay Box section of the green "Circuits" folder in the dome.

6 Settings as I left them

Mount

	Micrometer	AGC	Gain
RA	9.7 (I think!)	Yes	7
Dec	4.94	Yes	7

Spectrometer G

	Reading	Pot.setting
Interference Filter	28.9	
Oven Bottom	N/A	
Oven Top	114.2	5.7
Starboard Detector	20.3	8.0
Port Detector	20.2	8.0
Pockels Driver 1		3.8 (I think!)
Pockels Driver 2		3.8

Autoguider gain resistances (in kΩ)**

Setting	1	2	3	4	5	6	7	8	9
RA	150	100	68	47	33	27	22	13	10
Dec	150	100	68	47	33	27	22	13	10

** Not checked. These are the expected values.

7 Conclusions and recommendations

7.1 AGC

Installing this AGC went very smoothly – practice makes perfect. While I continue to think that AGC's, or some digital equivalent in any new microcontroller-based system, should be installed as standard, it is clear that they will have more effect at sights with slower "waves" (such as Las Campanas, Mt Wilson and Tenerife) and have limited effect in Sutherland and Narrabri.

7.2 Pockels cell lessons

a) The "velocity" driver has developed a fault and needs replacement. This may be indicative of an ageing of our drivers in general. Until the unit is replaced and/or fixed it will not be possible to collect magnetic field data at Narrabri.

b) The results in Tables 1 and 2 indicate that our instrument behaviour would be better if it were possible to run the Pockels cells a little slower. It may be worth checking their reliability down to 25 Hz. Simulations of results – especially magnetic data – should now try to examine the consequences of the slow rise time of the driver wave-form.

c) New cells should be mounted with their BNC's pointing upwards (for ease of access), but symmetrically about a perpendicular drawn from the base of the spectrometer. This give maximum clearance for the lid. The current arrangement <u>will</u> lead to misalignment of the cell as the lid slides to and fro over the cables.

7.3 Blind motor lessons

Ash don't seem to use the same design for each Dome. Sadly, a system which works at one site is not necessarily going to fit properly at another. In Narrabri, the Dayton system is positively the largest which can ever fit.

7.4 Temperature control

The controller for the interference filter is definitely unable to provide enough power in the Narrabri winter. I am not convinced that a similar, but smaller-scale, problem is not also shown by the oven heater. I tried insulating the IF mount from the x-bench better, to reduce conduction to the cold spectrometer, but with no real success. If the spectrometer temperature is below about 18.5 °C, the IF controller cannot cope. I bought a fish-tank heater specified as being able to cope with a tank volume similar to that of our reservoir, but never had chance to try it out. A proper solution needs working out before next winter.

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