INT Telescope Control System Manual

R.A. Laing,
Royal Greenwich Observatory,
Madingley Road,
Cambridge CB3 0EZ.

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This section contains a summary of the commands available at the user interface of the telescope control system, classified into functional groups. Details of individual commands are given in the alphabetical list of Section 3. Commands which require the telescope or one of its mechanisms to be moved are forbidden in engineering mode.

2.1 General TCS commands

All allowed in engineering mode.

- `ACKNOWLEDGE` Turn off a limit or engineering mode alarm.
- `HANDSET` Select handset mode.
- `HELP` Get help on a command.
- `RECALL` Recall a previous command.
- `TCSEXIT` Close down the control system.

2.2 Source data entry

All allowed in engineering mode.

- `DEC` Enter declination of edit source.
- `DIFF_RATES` Enter non-sidereal tracking rates for the edit source.
- `EPOCH` Enter epoch of position for edit source.
- `EQUINOX` Enter equinox for edit source.
- `PARALLAX` Enter parallax of edit source.
- `PM` Synonym for `PROPER_MOTION` (*q.v.*).
- `PROPER_MOTION` Enter proper motions of edit source.
- `RA` Enter right ascension of edit source.
- `RADIAL_VEL` Enter radial velocity of edit source.
- `RV` Synonym for `RADIAL_VEL` (*q.v.*).
- `SOURCE` Enter name, right ascension, declination and equinox for edit source.

2.3 Catalogue handling

All allowed in engineering mode.

- `ADD` Add the contents of the edit source data block to the catalogue as a named entry.
- `ERASE` Clear the user catalogue.
- `FIND` Get a named catalogue entry and put it in the edit source block.
- `INCLUDE` Append a text catalogue to the current user catalogue.
- `MARK` Store the current telescope position as a named catalogue entry.
- `OUTPUT` Output the current catalogue to an ASCII file, terminal or line printer.
- `REMOVE` Delete a catalogue entry.

2.4 Source change

None allowed in engineering mode.

- `BLIND_OFFSET` New source (from catalogue) with local corrections to the pointing model.
- `GOCAT` New source (from catalogue; specified by name only).
- `GOTO` New source (direct input of name, right ascension, declination and equinox).
- `NEXT` New source (using data in edit source block).

2.5 Positional and Aperture offsets

`ENTER` is allowed in engineering mode; the remainder are not.

- `APERTURE` Execute a preset (numbered) aperture offset.
- `BEAMSWITCH` Execute an aperture offset with direct input of x and y.
- `ENTER` Input data for numbered aperture or positional offsets.
- `OFFSET` Execute a positional offset with direct input of $\Delta\alpha$, $\Delta\delta$ or ξ, η.
- `POSITION` Execute a preset (numbered) positional (ξ, η) or ($\Delta\alpha$, $\Delta\delta$) offset.
- `STORE` Store aperture or positional offsets set up using the handset.
- `TWEAK` Apply a given (x_A, y_A, ρ_A) aperture offset.

2.6 Autoguiding

`AGSELECT` and `PROBE` are allowed in engineering mode; `AGVIEW` and `AUTOGUIDE` are not.

- `AGSELECT` Identify the autoguider currently in use.
- `AGVIEW` Aperture offset to move image to autoguider field.
- `AUTOGUIDE` Lock or unlock the autoguider loop.
- `PROBE` Input coordinates of guide probe.

2.7 Calibration procedures

The keywords for this command which require the telescope to be moved are not allowed in engineering mode.

- `CALIBRATE` Determine encoder zero-points and collimation errors.

2.8 Mechanism control

None allowed in engineering mode.

- `DOME` Move the dome to a given azimuth and stop it.
- `DFOCUS` Change the focus by a specified amount.
- `FOCUS` Move the focus to a specified position.
- `PARK` Move the telescope to a defined position.
- `ROTATOR` Move the rotator to a given sky PA.
- `STOP` Stop a mechanism or combination of mechanisms.

2.9 Mechanism configuration

`ENCODER` and `ZEROSET` are allowed in engineering mode; `TRACK` is not.

- `ENCODER` Set the combination of encoders used for pointing.
- `TRACK` Turn focus, dome, rotator or telescope tracking on or off.
- `ZEROSET` Determine incremental encoder zero-points.

2.10 Change of focal station and instrument

Note that "Select" in this context means "set up software and drive the correct rotator". Both allowed in engineering mode.

- `STATION` Select focal station.
- `INSTRUMENT` Tell the TCS which instrument is in use.

2.11 Display functions

All allowed in engineering mode.

- `DISPLAY` Change the coordinate system of the displayed telescope position.
- `MOON` Give the current right ascension and declination of the Moon.
- `PAGE` Switch to another information display page.
- `SHOW` Display information about the system state.

2.12 Logging of test data

All allowed in engineering mode.

- `LOG` Log tracking errors and associated data.
- `POINT` Write encoder coordinates to a data file.
- `RMS` Calculate and display mean and rms servo errors.
- `SNAPSHOT` Record the current information display page.

2.13 Meteorological and Earth-rotation data

All allowed in engineering mode.

- `HUMIDITY` Input relative humidity used in refraction calculation.
- `POLE` Input values of polar motion.
- `PRESSURE` Input barometric pressure used in refraction calculation.
- `TEMPERATURE` Input temperature used in refraction calculation.
- `UT1UTC` Input UT1 − UTC.
- `WAVELENGTH` Input wavelength used in refraction calculation.

3 TCS user interface commands: an alphabetical glossary

The following section gives a brief summary of the operation of each command together with examples and defaults. It refers to the TCS local interface.

Notation:

- Examples of commands entered at the terminal are in typewriter font: `DEC 12 34 56.78`;
- Angle brackets denote parameter values or keywords: <`angle`>;
- Square brackets denote optional parameter values or keywords: `[x,y]`; all other parameters and keywords are obligatory;
- Keywords (parameters which must take one of a number of preset values) are indicated by bold type: **CASSEGRAIN**.

3.1 ACKNOWLEDGE

Turn off the engineering mode and/or software limit alarms.

Format: `ACKNOWLEGDE <alarm_type>`
Defaults: `ACKNOWLEDGE ALL`
Parameters: None.
Keywords:

LIMIT	turn off an alarm caused by a main drive software limit;
ENGINEERING	turn off an alarm caused by an unexpected switch into engineering mode;
ALL	turn off any alarm.

Example: `ACKNOWLEDGE`
Comments: An alarm (continuous bleeping) is triggered if the telescope or rotator encounters a software limit whilst tracking or when requested to slew to an object below the horizon or if a switch from computer to engineering mode occurs unexpectedly (i.e. not as a result of a `TCSEXIT` command).

3.2 ADD

Write the current contents of the edit source data area as a new entry in the user catalogue.

Format: `ADD`
Defaults: None.
Parameters: None.
Keywords: None.

3.3 AGSELECT

Select which autoguider to use.

Format: `AGSELECT <autoguider_name>`
Defaults: None. The Cassegrain autoguider is selected on startup.
Parameters: None.
Keywords: Valid autoguider names are:

CASSEGRAIN	the Cassegrain off-axis autoguider;
PRIME	the prime-focus (Wide-Field Camera) autoguider.

Examples: `AGSELECT CASS`

Comments: The TCS needs to be told which autoguider is currently in use in order to perform the conversion between guide star pixel position and drive corrections.

3.4 AGVIEW

Perform an aperture offset to move an image onto the autoguider CCD.

Format: `AGVIEW`
Defaults: None.
Parameters: None.
Keywords: None.
Comments: This command allows a field to be viewed using the autoguider. An offset is applied to move the image from the nominal aperture (usually the rotator centre) to the centre of the autoguider field. It is essential to tell the TCS which autoguider is in use and to define its position in the focal plane (use the `AGSELECT` and `PROBE` commands as necessary).

3.5 APERTURE

Offset the telescope so that an object moves by a vector fixed in the focal plane.

Format: `APERTURE <aperture_number>`
Defaults: None. The reference position (aperture 0) is selected on startup. This is usually also the rotator centre, (0,0).
Parameters: The aperture number is in the range 0–10. The corresponding (x_A, y_A) displacement must have been set up previously in the initialisation file, or by using the `ENTER` or `STORE` commands. `APERTURE 0` is the reference position (see below).
Keywords: None.
Examples: `APERTURE 2`
Comments: An (x_A, y_A) shift in the focal plane is divided into two parts: the reference position, which is unaltered on source change and an aperture offset which is reset to zero on source change. The `APERTURE` command provides a means of switching between the reference position and previously-defined aperture offsets.

3.6 AUTOGUIDE

Lock or unlock the CCD autoguider loop.

Format: `AUTOGUIDE <state> [x y]`
Defaults: None.
Parameters: The optional parameters `x` and `y` are the desired pixel coordinates for the guide star and are used with the **ON** keyword. If they are not specified, the system will adopt the current position of the guide star.
Keywords: Valid autoguider states are:

ON	specifying that the telescope should be guided in response to guiding errors from the CCD autoguider.
OFF	specifying that autoguiding should be switched off, *i.e.* that any guiding errors from the CCD autoguider should be ignored.
SUSPEND	Put the TCS in a state where pixel coordinates are read from the autoguider and the current reference position is maintained, but guiding errors are not applied.
RESUME	Restart guiding if the loop has been suspended.

Limits: The limits used in validating the pixel coordinates for `AUTOGUIDE ON x y` are:

	Cassegrain	$32 \le$ x ≤ 374; $20 \le$ y ≤ 267.
	WFC	$29 \le$ x ≤ 87; $176 \le$ y ≤ 240.

Examples: `AUTOGUIDE ON`
`AUTOGUIDE ON 122.5 63.2`

Comments: The autoguider sends xy pixel coordinates of a guide star to the telescope control computer. The TCS then adjusts the telescope drives to keep the star at a given location on the autoguider CCD. If the intention is to maintain the current positioning of a field (*e.g.* if acquisition onto a spectrograph slit has been verified), then the command `AUTOGUIDE ON` should be used. This takes the first position received from the autoguider after the command is issued, and keeps the guide star there. On the other hand, if the autoguider coordinates are already known, then the appropriate command is `AUTOGUIDE ON x y`. This is likely to be useful when an observation is to be repeated and the field is to be positioned at the same place on the detector. The guide probe and pixel positions should be repeated. The TCS must be told the autoguider in use (see `AGSELECT`), otherwise the telescope corrections will be in the wrong direction. The function key $\boxed{\text{F17}}$ on the TCS keyboard is equivalent to the `AUTOGUIDE OFF` command. The function key $\boxed{\text{F18}}$ on the TCS keyboard is equivalent to the `AUTOGUIDE ON` command.

3.7 BEAMSWITCH

Offset the telescope so that an image moves by a vector fixed in the focal plane.

Format: `BEAMSWITCH <offset_x> <offset_y>`

Defaults: None. On source change (*e.g.* `GOTO`), offsets are reset to to the nominal values (this can also be done with the `BEAMSWITCH 0 0` or `APERTURE 0` commands: see `APERTURE`).

Parameters: The aperture (x_A, y_A) positions in arcseconds.

Keywords: None.

Examples: `BEAMSWITCH 20.2 -100`

3.8 BLIND_OFFSET

Offset between a reference object which is centred on the acquisition TV and a faint target object.

Format: `BLIND_OFFSET <source_name>`

Defaults: None.

Parameters: The name of the faint target object.

Keywords: None.

Examples: `BLIND 0512+22E`

Comments: This is the standard method for locating very faint objects, which are difficult or impossible to see on the acquisition TV. Accurate positions for a brightish star and the faint target object must be entered in the catalogue. Slew to the bright star using `GOCAT` and centre it on the reference position with the handset keys. Then type `BLIND <source_name>` for the faint object. This offsets the telescope so that the faint object is accurately aligned with the reference position. It can then be moved around the detector using the `BEAMSWITCH` or `APERTURE` commands. `BLIND_OFFSET` performs a local correction to the pointing model, assuming that the position of the reference object is accurate. Subsequent executions of `BLIND_OFFSET` all use this correction, so several faint objects can be observed using the same reference star. The `NEXT`, `GOTO` and `GOCAT` commands revert to the default global pointing solution.

3.9 CALIBRATE

Update pointing coefficients at the start of an observing session.

Format: `CALIBRATE <solution>`

Defaults: `CALIBRATE NEW`

Parameters: None.

Keywords: Valid calibrate solutions are:

LAST	recalls the last pointing solution. This may be useful if the running of the control program has been interrupted, but does not ensure very accurate pointing because the encoder zero-points may have changed.
DEFAULT	reverts to the default pointing solution in the initialisation file. This is a suitable course of action if the `CALIBRATE` command fails (*e.g.* gives very large rms errors).
NEW	packages a sequence of commands to do a short pointing calibration using bright (FK5) stars.
FAINT	does the same as **NEW** but with a grid of fainter ($V \approx 9$) stars.

Examples:
```
CALIBRATE
CALIBRATE LAST
```

Comments: The `CALIBRATE NEW` command initiates an automatic sequence which does a restricted pointing measurement on 7 stars from the pointing grid in order to update the values for the encoder zero-points in hour angle and declination and the collimation error in hour angle. Stars are selected to be close to the meridian and either North or South of the zenith, depending on the initial azimuth. A range of declinations must be covered. The telescope is driven to the first star and the handset mode is selected. When the telescope is tracking, the star should be moved on to the reference position using the handset keys. Once you are satisfied, press the HANDSET key. This logs the position and drives to the next star. Repeat these operations until all 7 positions have been logged. You will then be asked whether all of the stars were centred correctly. If you do not answer `Y` to this question, then the procedure will be aborted. The derived and previous values will be displayed, together with their r.m.s. errors, and you will be asked whether the solution is reasonable. The errors should be in the range 0.5–1.0 arcsec for ID, 1.0–2.0 arcsec for CH and 1.0–3.0 arcsec for IH. If the errors are much larger than these values, then the solution should be rejected. Unless there has been a major change of configuration, the coefficients should not alter by more than a few arcseconds from night to night. Gross differences may indicate a problem. CTRL–Z may be used to abort the procedure at any time, but all of the measurements will be lost.

3.10 DEC

Enter a declination in the edit source data area.

Format: `DEC <dec_degrees> <dec_minutes> <dec_seconds>`

Defaults: Value of declination: None,
Sign of declination: '+'.

Parameters: The declination in degrees, minutes and seconds or arc. The value is rejected if any of the components lie outside the following ranges:

`dec_degrees`	0–89 inclusive
`dec_minutes`	0–59 inclusive

	`dec_seconds`	0.0–59.99... inclusive

Keywords: None.
Examples: `DEC -12 34 56.78`

3.11 DFOCUS

Offset the focus to compensate for additional optical elements.

Format: `DFOCUS <focus_offset>`
Defaults: None.
Parameters: Focus offset, in mm.
Keywords: None.
Limits: −10 – 10 mm.
Examples: `DFOCUS 0.3`
Comments: This command is intended to be used when the telescope focus has to be changed to compensate for the additional optical thickness of a filter. The virtual focus reading is unchanged, and the focus offset in use is displayed in the DF field on the bottom line of the Information Display.

3.12 DIFF_RATES

Enter differential tracking rate in right ascension and declination.

Format: `DIFF_RATES <diff_rate_in_ra> <diff_rate_in_dec>`
Defaults: None. Unspecified differential rates are assumed to be zero.
Parameters: Right ascension and declination differential tracking rates in seconds/second and arcseconds/second, respectively.
Keywords: None.
Limits: −100 – 100 s/s in RA and −100 – 100 arcsec/s in declination.
Examples: `DIFF_RATES 0.01 -0.3`
Comments: The differential (non-sidereal) tracking rates are added to the edit source data block. They must be actioned using the `NEXT` command. Note that differential rates are not included in a catalogue entry.

3.13 DISPLAY

Change the coordinate system of the information display.

Format: `DISPLAY <coordinate_system>`
Defaults: None. The default coordinate system on startup is **INPUT**.
Parameters: None.
Keywords: The allowed coordinate systems are:

INPUT	α and δ in the system used to input the source position;
APPARENT	α and δ in geocentric apparent coordinates;
J2000	α and δ in J2000 mean coordinates;
B1950	α and δ in B1950 mean coordinates;
HA_DEC	Topocentric hour angle and declination.

Examples: `DISPLAY J2000`
Comments: For technical reasons, there are restrictions on the permitted combinations of input and display coordinates, as follows:

INPUT	always allowed;
APPARENT	always allowed;

J2000	not allowed for input in apparent coordinates;
B1950	not allowed for input in apparent or FK5 (J) coordinates;
HA_DEC	always allowed.

3.14 DOME

Move the dome to the specified azimuth and stop.

Format: `DOME <angle>`
Defaults: None.
Parameters: The angle in degrees.
Limits: The angle must be in the range 0 – 360°, even though the dome has no mechanical limits.
Keywords: None.
Examples: `DOME 275.34`

3.15 ENCODER

Set the combination of incremental encoders used for pointing.

Format: `ENCODER <state> <axis> <encoder_name>`
Defaults: None. The default combination on startup is set in the startup file.
Keywords: Valid states are:

ON	add an encoder to the tracking combination.
OFF	remove an encoder from the tracking combination.

Valid axes are:

HA	hour angle
DEC	declination

Valid encoder names are:

FERR1	HA Ferranti head 1
FERR2	HA Ferranti head 2
FERR3	HA Ferranti head 3
HH1	Dec Heidenhain head 1
HH2	Dec Heidenhain head 1
BALDWIN	HA or Dec Baldwin

Examples: `ENCODER OFF HA FERR1`
Comments: There are three Ferranti encoder heads on the HA axis and two Heidenhain heads on the Dec axis: these are read in quick and slow motion. In addition, the high-resolution Baldwin encoders are used only in slow motion. The usual combination for HA is the mean of all three Ferranti heads in quick motion and the Baldwin in slow motion. For Dec, the mean of the two Heidenhain heads is normally used in both quick and slow motion.

3.16 ENTER

Set up aperture and positional offsets for repeated use.

Format:
```
ENTER APERTURE <aperture_number> <x_offset> <y_offset>
ENTER ARC_POSITION <position_number> <ra_offset> <dec_offset>
ENTER TIME_POSITION <position_number> <ra_offset> <dec_offset>
```
Defaults: None.
Parameters: `<aperture_number>` is an integer in the range 0–10, 0 being the reference position (the default on source change).

`<position_number>` is an integer in the range 1–10. Position 0 is a zero offset and may not be redefined.
`<x_offset>`, `<y_offset>` and `<dec_offset>` are in arcseconds.
`<ra_offset>` is in seconds of time if the **TIME_POSITION** keyword is specified, or arcseconds if the **ARC_POSITION** keyword is specified.

Keywords: Valid offset modes are: **APERTURE**, **ARC_POSITION**, **TIME_POSITION**.

Examples:
```
ENTER APERTURE 3 1.5 20.3
ENTER ARC_POSITION 3 -3.0 12.0
ENTER TIME_POSITION 1 -0.33 -11
```

Comments: `ENTER APERTURE` sets up an aperture offset which can be applied using the `APERTURE` command. `ENTER ARC_POSITION` and `ENTER TIME_POSITION` set up a positional offset which can be added to the telescope demand position using the `POSITION` command.

3.17 EPOCH

Enter a value for the epoch of the position into the edit source data block.

Format: `EPOCH <date>`
Defaults: None.
Parameters: The epoch in years.
Keywords: None.
Limits: The year must be in the range 1800.0 to 2100.0.
Examples: `EPOCH 1967.35`
Comments: The epoch is used in conjunction with the proper motions to compute the position of date.

3.18 EQUINOX

Enter a value for the equinox of the position into the edit source data block.

Format: `EQUINOX <equinox>`
Defaults: None.
Parameters: A code for the coordinate system, followed (for mean coordinates) by the equinox, in years. The allowed systems are:

APPARENT	Geocentric apparent coordinates;
J<year>	Mean coordinates (FK5 system);
B<year>	Mean coordinates (FK4 system).

Keywords: None.
Limits: The year must be in the range 1800.0 to 2100.0.
Examples:
```
EQUINOX B1950
EQUINOX J1992.5
EQUINOX APP
```

3.19 ERASE

Erase all entries from the current user catalogue.

Format: `ERASE`
Defaults: None.
Parameters: None.
Keywords: None.

3.20 FIND

Retrieve data for the named source from the user or system catalogues and place them in the edit source data block.

Format:	`FIND <source_name>`
Defaults:	None.
Parameters:	The name of the the source to be retrieved. It can be a string of up to 20 characters; extra characters are lost. To include spaces the whole string should be enclosed within double quotes.
Keywords:	None.

Examples:	`FIND HD123456`
	`FIND NGC_4151`
	`FIND "Supernova in LMC"`

Comments:	The user catalogue is searched first, followed by the system catalogue.

3.21 FOCUS

Drive the focus to a specified setting and stop it.

Format:	`FOCUS <setting>`
Defaults:	None.
Parameters:	The focus in mm (0 – 50.0 mm).
Keywords:	None.
Examples:	`FOCUS 29.1`
Comments:	If focus tracking is enabled (the default state), then the focus is a virtual one and the temperature compensation is concealed. If not, the raw encoder reading is displayed.

3.22 GOCAT

Retrieve the entry for the named source from the user catalogue and then send the telescope to track that source.

Format:	`GOCAT <source_name>`
Defaults:	None.
Parameters:	The name of the target object.
Keywords:	None.
Comments:	The user catalogue is searched first, followed by the system catalogue.

3.23 GOTO

Move the telescope to a new source and track it.

Format: `GOTO <source_name> <right_ascension> <declination> <equinox>`

Defaults: None.

Parameters: <source_name> The name of the new source. It must be a string of up to 20 characters; extra characters are lost. To include spaces the whole string should be enclosed within double quotes.

<right_ascension> Specifies the right ascension of the new source in three fields separated by spaces. Format: <ra_hours> <ra_minutes> <ra_seconds>. The right ascension is rejected if any of the components lie outside the following ranges:

<ra_hours>	0–23 inclusive
<ra_minutes>	0–59 inclusive

`<ra_seconds>`	0.0–59.99... inclusive

`<declination>` Specifies the declination of the new source in three fields separated by spaces. The <dec_degrees> field may be signed. If not signed, the default is '+'. Format: `<dec_degrees>` `<dec_minutes>` `<dec_seconds>`. The declination is rejected if the any of the components lie outside the following ranges:

`<dec_degrees>`	0–89 inclusive
`<dec_minutes>`	0–59 inclusive
`<dec_seconds>`	0.0–59.99... inclusive

`<equinox>` Specifies the equinox of the source coordinates. A valid equinox must have two components: a leading letter indicating the system of the coordinates; and a number indicating the epoch of the mean equator and equinox of that system. Format: `<letter-year>`, *e.g.* `B1950`, `J2000` or `APPARENT` (for which no number is required). Note that only `B`, `J` or `A` are acceptable as leading letters. The year must lie in the range 1800.0 to 2100.0.

Keywords: None.
Examples: `GOTO HD123456 12 34 56.78 76 54 32.10 J2000`

3.24 HANDSET

Place the TCS user interface in handset mode.
Format: `HANDSET`
Defaults: None.
Parameters: None.
Keywords: None.
Comments: In handset mode, the keypad may be used to guide the telescope, set up offsets or apertures, change the focus or move the rotator. See Section 4 for a more detailed description. This command is bound to the DO key on a standard Digital keyboard. To exit from the handset mode press the DO key and control will return to the `USER`> prompt.

3.25 HELP

Provide information about the commands available from the TCS user interface.
Format: `HELP [topic [subtopic]...]`
Defaults: Lists all available commands.
Parameters: The command you wish to receive help on.
Keywords: None.
Examples: `HELP GOTO EQUINOX`
Comments: Invoking the `HELP` command initiates an interactive dialogue with the user interface HELP library, a normal VMS HELP library. In response to a Topic? or subtopic prompt you may:

- Type the name of the command/topic for which you need help;
- Type a question mark (?) to redisplay recently requested text;
- Press the RETURN key one or more times to exit from HELP;
- Press CTRL–Z once to exit from HELP;

- Abbreviate any topic name, but note that ambiguous abbreviations result in *all* matches being displayed.

3.26 HUMIDITY

Enter the value of the relative humidity used in the calculation of refraction.

Format:	`HUMIDITY <relative_humidity>`
Defaults:	None. The value assumed on startup is 0.5.
Parameters:	The fractional humidity.
Limits:	0 – 1.
Keywords:	None.
Examples:	`HUMID 0.5`

3.27 INCLUDE

Read in a text format source catalogue.

Format:	`INCLUDE [directory]<catalogue_name>`
Defaults:	Extension: `.CAT`. Directory: default user catalogue area.
Parameters:	The name of the input catalogue.
Keywords:	None.
Examples:	`IN USER_CAT:SPECPHOT.CAT` or `IN SPECPHOT` to input a file called SPECPHOT.CAT in the default directory. `INCLUDE ing:[etc]test.cat` to input a file prepared on on the ICS and placed in /ing/etc.

3.28 INSTRUMENT

Tell the TCS which instrument is in use.

Format:	`INSTRUMENT <instrument_name>`
Defaults:	None. The parameters for the IDS are set on startup.
Parameters:	None.
Keywords:	Valid instrument names are: **IDS** Intermediate Dispersion Spectrograph and FOS-1. **WFC** Prime focus wide-field camera.
Examples:	`INSTRUMENT IDS`
Comments:	This command sets the origin of position angle used for a specific instrument and the scale and orientation for the `TWEAK` command (*q.v.*). Position angle on the sky is normally defined to be along the slit in a spectrograph and aligned with one of the detector axes for an imaging instrument. The scale and orientation parameters are currently set to match the standard TCS xy coordinate system.

3.29 LOG

Log tracking errors and associated data from autoguider and telescope encoders.

Format:	`LOG <system> <state> [<period>]`
Defaults:	The period parameter defaults to 20 cycles (1 second).
Parameters:	The period, in integer cycles of the synchronous loop (0.05 s). This parameter is only used with the **ENCODER** keyword.
Keywords:	`<system>` – valid keywords are:

AUTOGUIDER	pixel coordinates produced by one of the CCD autoguiders,
ENCODERS	encoder readings, servo errors and drive demands for the main drives.
TV	pixel coordinates produced by a TV system (not normally connected; does not work with the Grinnell, but retained for test purposes).

`<state>` – valid keywords are: **ON** or **OFF**.

Limits The period for `LOG ENCODERS ON` must be an integer in the range 1 – 20000.

Examples:
```
LOG AUTO ON
LOG ENC ON 5
```

Comments: If logging is turned on when it is already enabled for the keyword in question, the log file is closed and a new one is opened. Any of the logging functions may be run simultaneously. Beware of running out of disk space if very rapid encoder logging is used.

3.30 MARK

Store the current position of the telescope as a named catalogue entry.

Format: `MARK <source_name>`
Defaults: None.
Parameters: The name of the source.
Keywords: None.
Examples : `MARK SUPERNOVA`
Comments: This command stores the current position to allow return to an object at a later date. The position is stored in the current input coordinate system.

3.31 MOON

Display the geocentric and topocentric apparent right ascension and declination of the Moon.

Format: `MOON`
Defaults: None.
Parameters: None.
Keywords: None.

3.32 NEXT

Send the telescope to track the source whose data are in the edit source block.

Format: `NEXT`
Defaults: None.
Parameters: None.
Keywords: None.
Comments: The user catalogue is searched first, followed by the system catalogue.

3.33 OFFSET

Offset the telescope by a given amount in right ascension and declination.

Format: `OFFSET <offset_system> <offset_ra> <offset_dec>`
Defaults: None.

Parameters: If the **ARC** keyword is specified (see below), the offsets in right ascension and declination must be in arcseconds. If the **TIME** keyword is specified (see below), the offset in right ascension must be entered in seconds of time and offset in declination must be entered in arcseconds.

Keywords: The valid offset systems are:

ARC offsets the telescope by given amounts parallel to right ascension and declination in the tangent plane. Positive offsets imply that the right ascension and declination of the telescope both increase. The magnitude of the offset is independent of position.

TIME offsets the telescope by given amounts in right ascension and declination. The magnitude of the offset depends on declination. $\Delta\alpha$ and $\Delta\delta$ are assumed to be in the input coordinate system.

Examples:
```
OFFSET ARC 12.6 -18.8
OFFSET TIME 0.32 -13.4
```

3.34 OUTPUT

Write out the current user catalogue in text format to the printer, TCS user interface or to a disk file.

Format: `OUTPUT <output_device>`, or
`OUTPUT <file>[.<extension>]`

Defaults: There is no default output device. The default extension for the catalogue name is `.CAT`.

Keywords: Valid output devices are: **PRINTER**, **TERMINAL**, **FILE**.

Examples:
```
OUTPUT PRINTER
OUTPUT TERMINAL
OUTPUT FILE TABBY.CAT
```

Comments: The catalogue may be saved in the default catalogue area on the telescope computer, whence it may be recovered on a subsequent night. It will, however, be deleted when you leave the site. Files which are to be backed up should be transferred elsewhere using FTP. **How??** To print the catalogue on the local line printer, type `OUTPUT PRINTER` and to list it at the user interface terminal, type `OUTPUT TERMINAL`.

3.35 PAGE

Display the next page in the cycle of information and status displays.

Format: `PAGE <display_screen>`

Defaults: `PAGE NEXT` – the next display screen in the cycle. The information display appears on startup.

Parameters: None.

Keywords: The various displays in the cycle are, in order:

INFO Top-level information display (appears on startup);
ENCODERS Encoder readings;
LIMITS Limit indicators;
ALARMS Alarm indicators. **This is a silly name and should be changed.**

Examples:
```
PAGE ENC
PAGE
```

3.36 PARALLAX

Enter a parallax into the edit source data area.

Format:	`PARALLAX <parallax_arcsecs>`
Defaults:	None. Unspecified parallaxes are assumed to be zero.
Parameters:	The parallax in arcseconds.
Keywords:	None.
Limits:	The parallax is rejected if it lies outside the range 0.0 to 10.0 arcseconds.
Examples:	`PARALLAX 0.023`

3.37 PARK

Move the telescope to a defined park position and stop it.

Format:	`PARK <park_position>`
Defaults:	None.
Keywords:	The valid park positions are:

ZENITH	The zenith park position (HA = 0; declination = latitude).
AP1	Access Park 1 (HA = 0; declination = 98.75°).

Examples:	`PARK ZEN`

3.38 PM

Synonym for `PROPER_MOTION` (*q.v.*).

3.39 POINT

Log, in TPOINT format, the present position of the telescope as read on the encoders.

Format:	`POINT <file_status>`
Defaults:	`POINT OLD`
Parameters:	None.
Keywords:	The log file may be either an old file (specified by the **OLD** keyword) or a new file (specified by the **NEW** keyword).
Examples:	`POINT` `POINT NEW`
Comments:	The data are logged to a pointing data file in a format suitable for input to the TPOINT analysis package. `POINT NEW` always creates a new pointing file. `POINT` or `POINT OLD` uses the latest file created that night or creates a new one if none has been created that night. The function key $\boxed{\text{F20}}$ is equivalent to the `POINT` command.

3.40 POLE

Input values of polar motion.

Format:	`POLE <x_position> <y_position>`
Defaults:	None. See comments below.
Parameters:	The polar motion xy corrections in arcseconds.
Keywords:	None.
Examples:	`POLE 0.10 -0.23`
Limits:	-1 – 1 arcsec.

Comments: This command overrides the initial values for polar motion, which are derived from an interpolation formula supplied by the Earth Rotation Prediction Service. It makes a very small difference to the pointing of the telescope and is too esoteric for normal use.

3.41 POSITION

Move the telescope by a previously-stored (ξ, η) or $(\Delta\alpha, \Delta\delta)$ offset.

Format: `POSITION <position_number>`

Defaults: None. `POSITION 0` (zero offset) is automatically selected on startup or change of source.

Parameters: The position number is an integer in the range 0-10. The offset values for a given position number must have been set up using the `ENTER` or `STORE` commands. `POSITION 0` corresponds to a zero offset and returns the telescope to the reference position.

Keywords: None.

Examples: `POSITION 2`

3.42 PRESSURE

Enter the value of the barometric pressure used in the calculation of refraction.

Format: `PRESSURE <pressure>`

Defaults: None. The pressure assumed on startup is 779 millibar.

Parameters: The barometric pressure in millibars.

Keywords: None.

Limits: 750 – 800 mbar.

Examples: `PRESSURE 779.5`

Comments: The refraction correction is proportional to the pressure. An error of 5 millibar is just about noticeable (it corresponds to a pointing deviation of 1 arcsecond at a zenith distance of 75°).

3.43 PROBE

Enter current position of the autoguider probe (or, equivalently, the location of a defined reference point on the WFC autoguider chip).

Format: `PROBE <x> <y>`

Defaults: None.

Parameters: The coordinates in μm (Cassegrain) or (?) pixels (Wide-Field Camera).

Keywords: None.

Limits: 405000 < x < 595000 and 405000 < y < 595000 (Cassegrain). **Not set up for WFC.**

Examples: `PROBE 500000 500000`

Comments: This command is needed for the `AGVIEW` command to work, but does not affect guiding with the current INT autoguiders.

3.44 PROPER_MOTION

Enter proper motions into the edit source data area.

Format: `PROPER_MOTION <pm_in_ra> <pm_in_dec>`

Defaults: Unspecified proper motions are assumed to be 0.

Parameters: The proper motion in right ascension and declination in units of seconds/year and arcseconds/year, respectively.

Keywords: None.

Limits: -20 – 20 s/year in RA; -100 – 100 arcsec/year in declination.

Examples: PROPER_MOTION -1.54 0.675
Comments: The synonym PM can also be used.

3.45 RA

Enter a right ascension in the edit source data area.
Format: RA <ra_hours> <ra_minutes> <ra_seconds>
Defaults: None.
Parameters: The right ascension in hours, minutes and seconds of time. The right ascension is rejected if the any of the components lie outside the following ranges:

ra_hours	0–23 inclusive
ra_minutes	0–59 inclusive
ra_seconds	0.0–59.99... inclusive

Keywords: None.
Examples: RA 12 34 56.789

3.46 RADIAL_VEL

Enter a radial velocity in the edit source data area.
Format: RADIAL_VEL <radial_velocity>
Defaults: Unspecified radial velocities are assumed to be 0.
Parameters: The radial velocity in km/sec. A positive velocity implies a receding source.
Keywords: None.
Examples: RADIAL_VEL -98
Comments: The synonym RV can also be used.

3.47 RECALL

Recall a previous command.
Format: RECALL <n>, RECALL string or RECALL/ALL
Parameters: <n> refers to the n-th last command.
string is a character string forming the first part of a command to be recalled.
Qualifiers: /ALL causes the entire command buffer to be listed.
Defaults: Last command.
Examples: RECALL 2
RECALL SOURCE
RECALL /ALL
Comments: This command is essentially identical to its namesake in DCL. RECALL <n> recalls the nth last command within a 50-line buffer and RECALL string recalls the last command beginning with string. RECALL / ALL lists the command buffer. If no argument is given, the last command is recalled, but this is more conveniently done with the ↑ cursor key.

3.48 REMOVE

Remove the entry for the named source from the user catalogue.
Format: REMOVE <source_name>
Defaults: None.

Parameters: The name of the source to be deleted. The name may be a string of up to 20 characters; extra characters are lost. To include spaces, the whole string should be enclosed within double quotes.

Keywords: None.

Examples: `REMOVE NGC_4151`
`REMOVE "Supernova in LMC"`

3.49 RMS

Turn calculation of mean and rms servo or guiding errors on or off, and display the results.

Format: `RMS <error> <state>`

Defaults: None.

Keywords: `<error>` is the source of errors:

SERVO	Main drive position errors.
AUTOGUIDER	Autoguider guiding errors.
TV	TV system guide errors (not normally connected for the INT).

`<state>` is either:

ON	Begin calculation of errors.
OFF	End calculation of errors and display results.

Examples: `RMS SERVO ON`

Comments: This command is used to check the performance of the main drives. To start accumulating data, type `RMS SERVO ON` or `RMS AUTO ON`. Wait for about 1 minute for `SERVO` (sampling is at 20 Hz) or for >50 autoguider samples (`AUTO`)and then type `RMS SERVO OFF` or `RMS AUTO OFF`, as appropriate. The results of `RMS SERVO` should be rms errors of <0.05 arcsec in HA and Dec and means whose absolute values are <0.001 arcsec. The rotator values are not normally useful for the INT.

3.50 ROTATOR

Move the rotator to the specified position angle and stop it.

Format: `ROTATOR mode <position_angle>`

Defaults: None.

Keywords: `mode` is one of:

SKY	The position angle is in the input coordinate system (e.g. J2000) at the epoch of observation.
MOUNT	The position angle is in the telescope mount coordinate system.

Parameters: `<position_angle>` – position angle in degrees, measured anticlockwise from North.

Limits: The position angle must be in the range 0 – 360° (values outside this range are not converted). The Prime focus rotator has no mechanical limits; the Cassegrain rotator is restricted to 360° pf travel.

Examples: `ROTATOR SKY 275`
`ROT MOU 275`

Comments: At present, mount and sky position angle are regarded as identical. This is not quite correct (because of the effects of precession and pointing errors), but is the conventional approximation for equatorial telescopes. Mount position angle is used.

3.51 RV

Synonym for `RADIAL_VELOCITY` (*q.v.*).

3.52 SHOW

Display data on the topic indicated by the keyword.

Format: `SHOW` <`show_topic`>

Defaults: None.

Parameters: None.

Keywords: <`show_topic`> – The following keywords are valid show topics:

APERTURES	Displays the x_A and y_A coordinates of apertures 0 – 10 and the currently-selected aperture. See `APERTURE`, `BEAMSWITCH`, `ENTER` and `STORE`.
ASTROMETRY	Displays the user-modifiable astrometric parameters: wavelength, pressure, temperature, relative humidity (all used to calculate refraction); UT1-UTC, and polar motion. TDT-UTC is also shown as a check on the insertion of leap seconds. TDT−TAI = 32.184 s; TAI−UTC is an integral number of seconds (compare with the IERS Bulletins). See `WAVELENGTH`, `PRESSURE`, `TEMPERATURE`, `HUMIDITY`, `UT1UTC` and `POLE`.
AUTOGUIDER	gives the autoguider currently selected by the TCS (see `AGSELECT`), the associated probe position (see `PROBE`), the guiding pixel coordinates and the state of the guiding loop (unlocked, locked or suspended: see `AUTOGUIDE`).
CALIBRATE	displays the values of declination index error, HA index error and HA collimation, together with their rms errors and the sky sigma for the last `CALIBRATE` at the current focal station. The corresponding parameters for the default pointing model are also given.
CATALOGUES	gives a directory of user catalogues.
EDIT	displays the parameters of the edit source, which will be selected by the `NEXT` command.
ENCODERS	lists the encoders currently being used by the TCS to control the telescope. See `ENCODER` for information on how to change the configuration.
FOCAL_STATION	gives the current software selection of focal station. This option is intended to allow the user to check that the combination of TCS selection of focal-station, autoguider and instrument is self-consistent. See `STATION`, `INSTRUMENT` and `AGSELECT`.
LIMITS	lists the software position limits for the main drives, rotation (both focal stations), focus, shutter and widshield.
LOGGING	shows the current status of data logging (see `LOG`).
MECHANISMS	displays the status of all of the main mechanisms. The main drives are said to be "following" during a sidereal track. For the dome, "following" means that it is tracking the telescope and for the focus, that it is being adjusted to compensate for temperature changes (see `TRACK`). The

	software and hardware limit status for the mechanism is shown next. The mechanism is "moving" if it is being driven under computer control, otherwise "stopped". The next field reads "in position" if the mechanism is either tracking or stopped within a defined position error, depending on its requested state. The final field shows whether the mechanism can be driven under computer control (if not, the status shown is "Manual override" or "Engineering mode".
POSITIONS	Lists the RA-Dec offsets (1 – 10) currently defined and any offset in use. See `OFFSET`, `POSITION`, `ENTER` and `STORE`.
TV	gives the TV camera currently selected by the TCS. This option is only useful under special circumstances for the INT; a suitable TV system is not normally connected to the TCS.
VERSION	Displays the current version of TCS software in use.

3.53 SNAPSHOT

Dump a copy of the information display screen to a file.

Format: `SNAPSHOT <filename>`

Parameters: `<filename>` is the name of the snapshot file, which is written in a standard directory.

Defaults: The file extension is set to .SNAP if it is not specified explicitly.

Examples:
```
SNAPSHOT ARCHIVE
SNAP NGC1234.DAT
```

Comments: This command may be used to record information relevant to an observation or to provide evidence of problems. Please include the name of the snapshot file as output by the TCS in any defect report.

3.54 SOURCE

Enter new source data into the edit source data area.

Format: `SOURCE <source_name> <right_ascension> <declination> <equinox>`

Defaults: Name, right ascension, declination, equinox: None.
All other source values: User defaults.

Parameters: `<source_name>` The name of the new source. It must be a string of up to 20 characters; extra characters are lost. To include spaces the whole string should be enclosed within double quotes.

`<right_ascension>` Specifies the right ascension of the new source in three fields separated by spaces. Format: `<ra_hours>` `<ra_minutes>` `<ra_seconds>`. The right ascension is rejected if any of the components lie outside the following ranges:

`<ra_hours>`	0–23 inclusive
`<ra_minutes>`	0–59 inclusive
`<ra_seconds>`	0.0–59.99... inclusive

`<declination>` Specifies the declination of the new source in three fields separated by spaces. The `<dec_degrees>` field may be signed. If not signed, the default is

'+'. Format: <dec_degrees> <dec_minutes> <dec_seconds>. The declination is rejected if the any of the components lie outside the following ranges:

<dec_degrees>	0–89 inclusive
<dec_minutes>	0–59 inclusive
<dec_seconds>	0.0–59.99... inclusive

<equinox> Specifies the equinox of the source coordinates. A valid equinox must have two components: a leading letter indicating the system of the coordinates; and a number indicating the epoch of the mean equator and equinox of that system. Format: <letter-year>, *e.g.* `B1950`, `J2000` or `APPARENT` (for which no number is required). Note that only `B`, `J` or `A` are acceptable as leading letters. The year must lie in the range 1800.0 to 2100.0.

Keywords: None.

Examples: `SOURCE HD123456 12 34 56.789 11 22 33.44 B1900`

Comments: `SOURCE` copies the user default values for all source values into the edit source entry and then takes the command line or prompted input for source name, right ascension, declination and equinox.

3.55 STATION

Select a focal station.

Format: `STATION <focal_station>`

Defaults: None.

Keywords: Valid focal-station names are:

CASSEGRAIN
PRIME

Comments: Applies the appropriate pointing model and configures the rotator.

3.56 STOP

Stop the named mechanism by ramping the velocity to zero.

Format: `STOP <mechanism>`

Defaults: `STOP ALL`

Parameters: None.

Keywords: Valid mechanism names are: **ALL**, **HA**, **DEC**, **DOME**, **FOCUS**, **ROTATOR**, **CASS**, **PRIME**.

Examples: `STOP ROT`
`STOP`

Comments: The `STOP ALL` or `STOP` commands stop all mechanisms.

3.57 STORE

Store aperture and positional offsets.

Format: `STORE <offset_type> <offset_number>`

Defaults: None.

Parameters: <offset_number> is the aperture number if the **APERTURE** keyword is specified (see below). It must be an integer in the range 0–10. `APERTURE 0` is the reference position and is not reset on source change.
<offset_number> is the position number if the **POSITION** keyword is specified (see

below). It must be an integer in the range 1–10 (position 0 corresponds to a zero offset and cannot be overwritten).

Keywords: Valid offset types are:

POSITION	sets up a (ξ, η) or $(\Delta\alpha, \Delta\delta)$ positional offset which can be added to the telescope reference position using the `POSITION` command.
APERTURE	sets up a beamswitch position which can be applied to the telescope using the `APERTURE` command.

Examples: `STORE APERTURE 3`

Comments: The command may be used to store positional or aperture offsets which have been found using the APOFF or OFFSET handset modes or input using the `BEAMSWITCH` or `OFFSET` commands. They may then be recalled for future use with the `APERTURE` or `POSITION` commands. When `STORE` is executed, the aperture or offset stored becomes the current one and the Information Display is updated. Note that offsets stored after using the handset OFFSET mode or `OFFSET ARC` are stored as (ξ, η) whereas those from `OFFSET TIME` are stored as $(\Delta\alpha, \Delta\delta)$

3.58 TCSEXIT

Initiate an orderly shutdown of the telescope control system.

Format: `TCSEXIT`

Defaults: None.

Parameters: None.

Keywords: None.

Comments: This command stops the telescope before shutting down the control system.

3.59 TEMPERATURE

Enter the value of the outside air temperature used in the calculation of refraction.

Format: `TEMPERATURE <temperature>`

Defaults: None. A temperature of 5° C is assumed on startup.

Parameters: The outside air temperature in degrees Centigrade.

Keywords: None.

Examples: `TEMPERATURE 7.5`

Limits: −10 – 30 C.

Comments: An error of 10°C gives a pointing error of 1.7 arcseconds at an elevation of 45°.

3.60 TRACK

Turn the focus, dome or telescope tracking on or off.

Format: `TRACK <track_system> <track_state>`

Defaults: None.

Parameters: None.

Keywords: The `<track_system>` keyword selects the mechanism which is to have its tracking state changed. The allowed mechanisms are: **DOME**, **FOCUS**, **TELESCOPE**. The `<track_state>` keyword sets the tracking either **ON** or **OFF**.

Examples: `TRACK FOCUS OFF`

3.61 TWEAK

Apply a given (x_A, y_A, ρ_A) aperture offset to align a field on an instrument.

Format: `TWEAK <x_offset> <y_offset> <rotation>`

Defaults: `<rotation>` defaults to 0.

Parameters: `<x_offset>` `<y_offset>` are displacements in x_A and y_A, in arcsec.
`<rotation>` is the rotation of the field in degrees.

Keywords: None.

Examples: `TWEAK 0.5 -0.6 0.1`

Comments: This command is used to position a field precisely on an instrument. It can be used whether or not the telescope is being autoguided and is useful for long-slit spectroscopy, especially when two objects are to be placed on the slit simultaneously. It is not advisable to use displacements of more than 1 arcsec or rotations of more than 0.1° when autoguiding, since the guide star may be lost. Larger offsets can be split into successive smaller ones, or autoguiding may be suspended whilst the CCD window is moved. The TCS focal plane (aperture) coordinate system is used, with position angle measured anticlockwise.

3.62 UT1UTC

Enter the value of the correction to Universal Time (UT1–UTC) used in the control system.

Format: `UT1UTC <correction>`

Defaults: None. This command overrides the startup value of UT1 $-$ UTC, which is determined from an interpolation formula supplied by the Earth Rotation Prediction Service.

Parameters: The correction in seconds.

Keywords: None.

Limits: -1 – 1 s.

Examples: `UT1UTC -0.0222`

Comments: The IERS bulletin is pinned up on a noticeboard in the control room or can be found on the Web. The correction UT1–UTC for each night is listed in a table which starts on page 3 of the bulletin.

3.63 WAVELENGTH

Enter the value of the effective wavelength of light used in the calculation of the refraction correction.

Format: `WAVELENGTH <wavelength>`

Defaults: None. The startup value is 0.4 μm.

Parameters: The wavelength in microns.

Keywords: None.

Limits: 0.3 – 35 μm.

Examples: `WAVELENGTH 0.55`

3.64 ZEROSET

Set the zero-points of incremental encoders by a variety of methods.

Format: `ZEROSET <mechanism> <method> [<position>]`

Defaults: None.

Keywords: `<mechanism>` – The following mechanisms may be zeroset:

HA
DEC

<method> – Several different methods are provided to set the zero-points of the incremental encoders, in order to reduce the dependence on individual bits of electronics. These are:

TARGET	This method is, in principle, capable of the highest accuracy. A mechanical target is used to provide a fixed reference point. The targets are located at HA 0 and declination 28° 45′, respectively. The mechanism is driven slowly through the standard position in engineering mode and the encoder is reset when the target is detected electronically, in which case the user terminal will bleep and output a suitable message. HA and Dec target zerosets may be active simultaneously.
CANCEL	This is used to cancel a target zeroset request if, for some reason, it fails.
TO	Allows the current position of the mechanism to be input. This would normally be derived from the engineering-desk synchros and is corrected for known zero-point errors. This method provides a backup in case of failure of the target electronics.
PARK	This is used to set the zero-points in HA and/or declination assuming that the telescope is at one of its two park positions.This is a useful backup option when there is a problem with a target zeroset since the telescope can be moved to a reproducible position independently of the encoders.

Parameters: The **PARK** and **TO** keywords both require additional parameters.

TO	requires the position to be entered in the format: `<hours>` `<minutes>` `<seconds>` in HA or `<degrees>` `<minutes>` `<seconds>` in declination.
PARK	requires <position> to be one of `ZENITH` (the zenith park position at HA 0 and Dec 28° 45′, at which the yellow light will be lit on the synchro dials) or `AP1` (the access park 1 position at HA 0; Dec 98.75°.

Examples:

```
ZERO HA TARGET
ZERO DEC PARK ZENITH
ZERO HA TO 02 00 00
ZERO HA CANCEL
```

Figure 1: An example of the handset display. This example applies to change of the reference position in x, y coordinates and is the default on startup.

4 The TCS Handset

4.1 General

The handset provides an interactive way of incrementing the position of the telescope in various coordinate systems, setting apertures and offsets and altering the focus and rotator position angle. The handset is selected by pressing the HANDSET key or typing HANDSET at the user interface. Pre-defined and user-selectable increments may be used and the arrow keys are used to input the steps. These auto-repeat when held down, so a continuous motion may be generated by selecting a small increment and holding down the appropriate key. The left INC and right INC keys select the next smaller and next larger increments, respectively. OWN requests the input of an increment value. Enter the value, in the appropriate units, and then hit the RETURN key. Just hit RETURN to escape from increment selection if you press OWN by accident. The handset display (a variant of that shown in Figure 1) is drawn at the top of the user-interface screen. It shows the available increment values, the accumulated increments and the modes. Currently-selected values are in reverse video. Only the keys labelled in Figure 2 remain active. The HANDSET key is used to return to the USER> prompt. The default on first selecting the handset is the X_Y mode with an increment of 1.0 arcseconds. Thereafter, the accumulated increments in each mode and the currently-selected mode and increment value are remembered on exit to USER> level and restored when the handset is next used. They are reset on source change (using the GOTO, GOCAT, NEXT or BLIND_OFFSET commands).

4.2 Handset modes

There are seven handset modes, each of which can be selected using the labelled function key on the user interface keyboard. The seven functions divide naturally into three groups:

- RA_DEC and X_Y increment the demand position in the input coordinate system and differ only in the directions of the increments. The increments displayed are therefore the accumulated values from both modes in the coordinate system of the current mode. The tracking position on the information display also changes.
- OFFSET and APOFF are used in conjunction with the STORE command to set up positional and aperture offsets interactively. The tracking coordinates do not change.
- FOCUS and ROTATOR move individual mechanisms.

Figure 2: The portion of the user-interface keyboard used in handset mode. Only those keys with labelled functions are active.

We describe each handset mode in more detail below:

4.2.1 RA_DEC mode

Changes the demand position in right ascension and declination (units are arcseconds). The image is moved in the east-west or north-south direction. Increments are defined in the tangent plane, so their magnitudes do not depend on declination. Image movement on the TV and detector will depend on the chosen sky position angle. At a sky position angle of 0°, the movements in X_Y and RA_DEC are identical. RA_DEC mode is most useful for wandering around finding charts and establishing orientations on the instrument. It can also be used for offsetting from a reference source although this can be done more flexibly with other methods such as the `BLIND_OFFSET` command.

4.2.2 X_Y mode

Changes the demand position in directions fixed in the focal plane (units are arcseconds). This is the most commonly used of all the modes. It moves the telescope in a sensible way corresponding to the customary sense of x, y coordinates on the acquisition TV screen (independent of rotator orientation and with equal steps in x and y) and is the normal method for final alignment of an object on to an instrument aperture such as a spectrograph slit, unless the guiding loop is already locked (see APOFF, below).

4.2.3 OFFSET mode

This is used in conjunction with the `STORE POSITION` command to set up positional offsets which may be recalled with the `POSITION` command. To define an offset, move an object to the start position using one of X_Y or RA_DEC. Then switch to OFFSET mode, move the object to the end position, exit from the handset and store the offset with `STORE POSITION` <`position_number`>, where <`position_number`> is in the range 1–10. `POSITION` <`position_number`> recalls the offset, which is defined in the tangent plane.

4.2.4 APOFF mode

This mode changes the aperture offset interactively. It is intended to be used to shift an object to an instrument aperture away from the reference position. The aperture coordinates may be recorded for future use with the command `STORE APERTURE`. The image moves in x and y on the TV and/or detector. To set up a new aperture, move an object to the reference position using X_Y or RA_DEC mode, switch to APOFF, move it to the new aperture (spectrograph slit or whatever), exit from the handset and type `STORE APERTURE <aperture_number>`, where `<aperture_number>` is in the range 0–10. `STORE APERTURE 0` redefines the reference position.

The APOFF mode may be used even when the autoguider loop is locked. This is useful for making small corrections (*e.g.* to optimise a target position on the spectrograph slit). The telescope offset and the reference pixel coordinates on the autoguider are changed simultaneously in such a way that the guiding errors remain zero. The image appears to move in the same way as in the X_Y mode. Small increments (<1 arcsec) should be used, in order to avoid losing the guide star.

4.2.5 FOCUS mode

Changes the telescope focus (units are millimetres). Always allow time for the focus to settle after an increment, as the drive is a bit sticky. It should eventually stop within 0.01 millimetres of the requested position.

4.3 Sign conventions

For the modes which cause the image to move in the focal plane, the sense of motion for the keys has been set so that the *image* moves in the obvious way. The displayed cumulative totals for each mode refer to the motion of the *telescope*. This, coupled with the variety of different 'hand' conventions of astronomical coordinate systems, requires the sign conventions summarised below:

- **RA_DEC** mode.
  - $\Leftarrow$ Image moves east; −right ascension displayed;
  - $\Rightarrow$ Image moves west; +right ascension displayed;
  - $\Uparrow$ Image moves north; +declination displayed;
  - $\Downarrow$ Image moves south; −declination displayed.
- **X_Y** mode. The sign convention has been used to be consistent with that used for apertures (set up with the `BEAMSWITCH` and `ENTER APERTURE` commands).
  - $\Leftarrow$ Image moves left on TV; $-x$ displayed;
  - $\Rightarrow$ Image moves right on TV; $+x$ displayed;
  - $\Uparrow$ Image moves up on TV; $-y$ displayed;
  - $\Downarrow$ Image moves down on TV; $+y$ displayed.
- **OFFSET** mode. As for **X_Y**.
- **APOFF** mode. As for **X_Y**.
- **FOCUS** mode.
  - $\Leftarrow$ −Focus;
  - $\Rightarrow$ +Focus.

If the image appears to move in a direction opposite to that expected, check that the TV scan switches are in their correct positions for the optical configuration in use.

5 The TCS Display

5.1 General

The display has four screens, arranged as follows:

- Source and telescope information (appears on startup);
- Encoder and temperature readings;
- Limit, computer mode and emergency stop indicators and alarm indicators;
- Manual overrides, dome and mirror cover status, interlocks and focal station information.

The first screen is intended for normal operation, the rest for fault-finding. The user-interface command `PAGE` (*q.v.*) is used to cycle through them. The following sub-sections describe the contents of the pages in more detail. Note that reverse video and bold-face type are not shown in the diagrams.

5.2 Source and telescope information

The layout of this, the default screen, is shown in Figure 3. Its contents are as follows:

- Time.
  - Date
  - UT—Universal time (UTC) from the time service.
  - ST—Local apparent sidereal time.
  - MJD—Modified Julian date (*i.e.* Julian date − 2400000.5), in days.
- Input data for the current source.
  - Name.
  - Right ascension.
  - Declination.
  - Equinox—Mean pre-IAU76 (B), post-IAU76 (J) or apparent.
  - Differential tracking rates (blank if not specified).
  - Proper motions and epoch (blank if not specified).
  - Parallax and radial velocity (blank if not specified).
- Apertures and offsets.
  - Positional offset currently enabled (blank if zero). If the `POSITION` command was used, then the offset number (1 – 10) is given in the first field (this is left blank if the `OFFSET` command was used instead). The second two fields give the offset components in the RA and Dec directions. For an offset specified in tangent-plane coodinates (by `ENTER ARC`), the values are labelled XI and ETA and given in arcseconds. For an incremental offset (`ENTER TIME`), they are given in seconds of time and seconds of arc, respectively, and are called ?? and ??.
  - Aperture offset currently enabled (blank if zero). If the `APERTURE` commmand was used, then the first field gives the aperture number (1 – 10); if `BEAMSWITCH` was used instead, then the field is left blank. The next two fields give the x_A and y_A components of the offset, in arcsec.
  - Reference position (alias aperture 0) offset from the rotator centre in x_A and y_A (arcsec).
  - Topocentric azimuth and elevation *of the target* (i.e. not the telescope).
- Telescope state. The possible messages are:

```
1997 October 07     UT  15 00 39        ST  14 54 19        MJD  50728.6255

 SOURCE                N15+37
                       RA   15 24 29.43          DEC  37 22 37.79       J2000

 Proper motion                    -0.0122 s/yr              0.0869 "/yr 2000
 Parallax                          0.0300 "
 Radial Vel                      -10.0 km/s
 Offset             2  XI    0.4 "  ETA   4.5 "
 Aperture           1  X     3.0  Y     4.0  Reference  X     0.0  Y     0.0
 Topocentric           AZ  034 07 46.15          EL   079 19 29.28

 TELESCOPE   TRACKING RA  15 24 29.49           DEC  037 22 42.10       J2000
                       HA -00 29 51.30           DEC  037 35 41.43
 Position Error        HA  00 00 00.00           DEC  000 00 00.00

 LIMITS  Sets in      06 14  HA limit in   06 30

 TURNTABLE   STOPPED   Cassegrain
                                           Mount PA      045 00 00
                                           Par. Angle    218 24 14

 FOCUS    17.14mm TC -0.37mm DF      mm   DOME    034 09  Air Mass   1.018
```

Figure 3: The telescope information display. This is the first of the display screens and is the default on startup.

  - ENG MODE: (the system is in engineering mode.
  - STOPPED: the telescope drives are stopped.
  - MOVING: the telescope is in motion, but has not yet reached its required position.
  - TRACKING: the telescope is within 1 arcsecond of its demanded position during a sidereal track.
  - TV GUIDE: autoguiding on signals provided by the TV system (not normally used for the INT).
  - A/GUIDE: autoguiding on signals provided by the CCD autoguider.
  - S/W LIM (flashing): the demanded position is inaccessible. This will occur when the telescope tracks into a software limit or, on source change, when the new object is below the horizon.

- Telescope position.

  - Right ascension or hour angle and declination (displayed only when the telescope is tracking). This is in the coordinate system set by the `DISPLAY` command and indicated by the equinox field (see below).
  - Equinox (usual conventions).
  - Topocentric hour angle (HA) and declination (DEC).
  - Position errors in hour angle and declination. Note that the pointing error in HA *on the sky* is $\Delta h \cos \delta$, so a relatively large Δh may be tolerated at high declination.

  Note that the coordinate system may be changed using the `DISPLAY` command. The available `DISPLAY` options are:

  - `INPUT` (default)—the coordinate system used to input the source data. Any space motions have been removed, so the position refers to the *current* epoch. If proper motions, parallax or radial velocity are specified, then the position will differ from the input position even in the absence of offsets.
  - `B1950`—available for pre-IAU76 mean input coordinates only. Current epoch.
  - `J2000`—available for any mean input coordinates. Current epoch.
  - `APPARENT`—geocentric apparent coordinates of the current date. Always available.
  - `HA_TOPO`—topocentric hour angle and declination. Always available.

- TV / autoguider coordinates
  - If the telescope is being autoguided using a TV camera or CCD autoguider, then the pixel coordinates of the requested position of the guide star are displayed.
- Limit information
  - Elevation limit information (this refers to the *software* limit of 20°). If the object is circumpolar, the message displayed is "No El limit". If it is currently visible above the limit, but will eventually set, the message "Sets in", together with the sidereal time remaining is shown. If the object has set, the message is "Rises in", followed by the sidereal time interval until it becomes visible again. Finally, for objects which are too far South ever to be seen, the message is "Never rises".'
  - Hour angle limits. The message gives the sidereal time remaining until the positive hour angle limit (6^h) is reached or the time until the source becomes visible if it is currently outside the observable range of -6^h – $+6^h$.

  Note that there is no entry for the southern declination limit, since the telescope cannot encounter this in the course of normal tracking.

- Turntable information.
  - The message STOPPED or MOVING is displayed.
  - The focal station currently selected. This means that the software has been configured for that focal station and that the appropriate turntable will be driven. The options are Cassegrain and Prime.
  - Mount position angle (effectively identical to the sky position angle for an equatorial telescope, although there are subtleties to do with the coordinate system.
  - Parallactic angle.
- Miscellaneous.
  - Focus position (mm). This is a virtual focus position which should not depend on temperature, elevation or the presence of filters in the beam. It should, in theory, remain constant for a given focal station.
  - The focus offset, TC (mm) applied to compensate for expansion of the structure.
  - The focus offset, DF (mm) used to correct for additional optical elements (*e.g.* filters) in the beam.
  - Dome azimuth. The label flashes if the dome is out of position. This will occur during a slew and, briefly, during tracking. If the flashing is continuous and the dome is mot moving to the correct azimuth, then there is likely to be a fault in the dome drive (most likely the TEM-L system).
  - Air mass (relative to the zenith).

5.3 Encoder display

The second page displays the encoder readings for altitude, azimuth and all of the instrument rotators, together with relevant displacement transducer values. In addition, the positions of the dome, shutter, windshield, primary mirror cover are shown. The layout is shown in Figure 4. In case of pointing difficulties, it is particularly useful to compare the individual encoders on the same axis. The values displayed are as follows:

- Hour angle (units are hours:minutes:seconds). The encoder combination used for tracking can be changed using the `ENCODER` command.
  - HA Ferranti 1
  - HA Ferranti 2
  - HA Ferranti 3
  - HA Baldwin (used only when driving in slow motion)
  - HA worm gear phase in the range $0 - 360^\circ$, updated only in slow motion. This is used to calculate the worm error correction.
- Declination (units are degrees:minutes:seconds).
  - Declination Heidenhain head 1
  - Declination Heidenhain head 2
  - Declination Baldwin
- Rotators (units are degrees:minutes:seconds).
  - Cassegrain rotator

```
HA Ferranti 1            00 00 00.00    Declination Ferranti    000 00 00.00
HA Ferranti 2            00 00 00.00    Declination Ferranti    000 00 00.00
HA Ferranti 3            00 00 00.00    Declination Ferranti    000 00 00.00

HA Baldwin               00 00 00.00    Declination Baldwin     000 00 00.00
HA worm gear phase            000 00

Cassegrain Rotator         220 00 00    Prime Focus Rotator        000 00 00

Dome                          010 05    Shutter                       000 00
                                        Windshield                    000 00

Focus Absolute                16.407

Top-end ring Temp                0.0    Mirror cover Temp                0.0
Serrurier Truss Temp             0.0
Centre section Temp              0.0
```

Figure 4: The encoder display screen.

- Prime focus rotator

- Dome (units are degrees:minutes).
- Shutter
- Lower windshield—broken?
- Focus (this is the encoder reading, without corrections for temperature)
- Temperatures (units are degrees Cenetigrade)
    - Top-end ring
    - Serrurier Truss (used for focus correction)
    - Centre section.
    - Mirror cover

5.4 Limit page

This page displays the state of the hardware limits and pre-limits for the altitude, azimuth, rotator and focus drives, together with emergency stop, power and engineering/computer mode indicators. The layout is shown in Figure 5.

- Emergency stop. This shows the state of the red emergency stop buttons (ACTUATED or RELEASED). None of the drives will function unless *all* the buttons are out, in which case the display shows RELEASED.
- Computer reset button. This is the button on the engineering desk which is pressed to switch from engineering to computer mode. It is ENABLED (lamp on) when switch-over is allowed; DISABLED if not.
- Mode selected. COMPUTER or ENGINEER (duplicated on the top-level display).
- Hour angle limits. These are *hardware* limits and should not be encountered in normal (computer-controlled) operation. The pre-limits are hit first, and cause the system to revert to engineering mode. The telescope can only be driven out of a main limit by hand. The display should show CLEAR for all limits and pre-limits in normal operation and SET (with the message in reverse video) if the limit has been hit. The nominal hardware limit positions are:
    - LIMIT+ ??
    - PRE-LIMIT+ ??
    - PRE-LIMIT− ??
    - LIMIT− ??
- Declination limits. As for hour angle, except that the final positive limit refers to the Access Park 3(?) position, which can only be reached under engineering-mode control from the balcony. The nominal positions are:
    - LIMIT+ ??
    - PRE-LIMIT+ ??
    - PRE-LIMIT− ??
    - LIMIT− ??
    - FINAL LIMIT− ??
- Focus limits. Hitting a limit stops the focus drive, but does not cause a switch to engineering mode.

```
Emergency stop            RELEASED      Computer reset button     DISABLED
                                        Mode selected             COMPUTER


Hour angle,  -ve prelimit CLEAR         Hour angle,  +ve prelimit CLEAR
Hour angle,     -ve limit CLEAR         Hour angle,     +ve limit CLEAR

Declination, -ve prelimit CLEAR         Declination, +ve prelimit CLEAR
Declination,    -ve limit CLEAR         Declination,    +ve limit CLEAR

Focus           -ve limit CLEAR         Focus           +ve limit CLEAR

Horizon             limit CLEAR


Oil alarm                 CLEAR         Mains alarm               CLEAR
                                        Power amplifier           WORKING
                                        Mirror support alarm      CLEAR



HA SM clamp               NOT ON        HA SM clamp               OFF
Dec SM clamp              NOT ON        Dec SM clamp OFF          OFF
```

Figure 5: The limits screen.

- LIMIT+ ??
- LIMIT− ??

- Alarms
  - Oil alarm. Normal state CLEAR, alarm state SET.
  - Mains alarm. Normal state CLEAR, alarm state SET.
  - Power amplifier. Normal state WORKING, alarm state FAULTY.
  - Mirror support alarm. Normal state CLEAR.
- HA clamp status. This refers to the state of the clamp which is engaged when the telescope is being driven in slow motion. There are two status bits:
  - The first is set when the clamp is fully engaged (ON); otherwise it reads NOT ON.
  - The second is set when the clamp is fully disengaged (OFF); otherwise it reads NOT OFF.
- Dec clamp status: as for HA.

5.5 Dome status and manual overrides page

This page contains the engineering override indicators for individual mechanisms and the status bits concerning dome and shutters. The layout is shown in Figure 6.

- Engineering overrides. These cause computer control for individual mechanisms to be disabled and are controlled by latching buttons on the engineering desk. Overrides are on when the buttons are latched down. The yellow lamps will be lit when the mechanisms concerned are under engineering control, either because the system as a whole is in engineering mode or as a result of overrides. The display shows ENABLED when the mechanism is overridden; DISABLED otherwise. Mechanisms which may be overridden and their states in normal (computer-controlled) operation are:
  - Dome (normally DISABLED);
  - Focus (normally DISABLED);
  - HA (normally DISABLED);
  - Dec (normally DISABLED);
  - Cass turntable (normally DISABLED);
- Control locations. These show the state of the remote/local/off keyswitches on the gallery control panel. REMOTE means that the mechanism can be driven from the control room; LOCAL that it must be driven from the balcony panels.
  - Dome (normally REMOTE);
  - Shutter (normally REMOTE);
  - Windshield (normally REMOTE).
- Power. Normally ON; alarm state OFF.
  - Dome;
  - Shutter;
  - Windshield.
- Overtravel alarms. Normally CLEAR; alarm state SET.
  - Shutter;

```
Dome manual override      DISABLED
Focus manual override     DISABLED
HA manual override        DISABLED      Dec manual override       DISABLED
Cass TT manual override   DISABLED

Dome control              LOCAL         Dome power                ON
Shutter control           LOCAL         Shutter power             ON
Shutter overtravel        CLEAR
Windshield control        LOCAL         Windshield power          OFF
Windshield overtravel     CLEAR

Cassegrain focus          SELECTED      Prime focus
Coude focus

Primary mirror cover      NOT CLOSED    Primary mirror cover      OPEN


Declination tie           OUT
```

Figure 6: The alarms screen. **ought to be called something else.**

    - Windshield.

- Primary mirror cover.

    - CLOSED/NOT CLOSED. Reads CLOSED when the cover is *fully* shut; NOT CLOSED otherwise.
    - OPEN/NOT OPEN. Reads OPEN when the cover is *fully* open; NOT OPEN otherwise.

- Declination tie. If IN, this disables motion in Declination. Normally OUT.