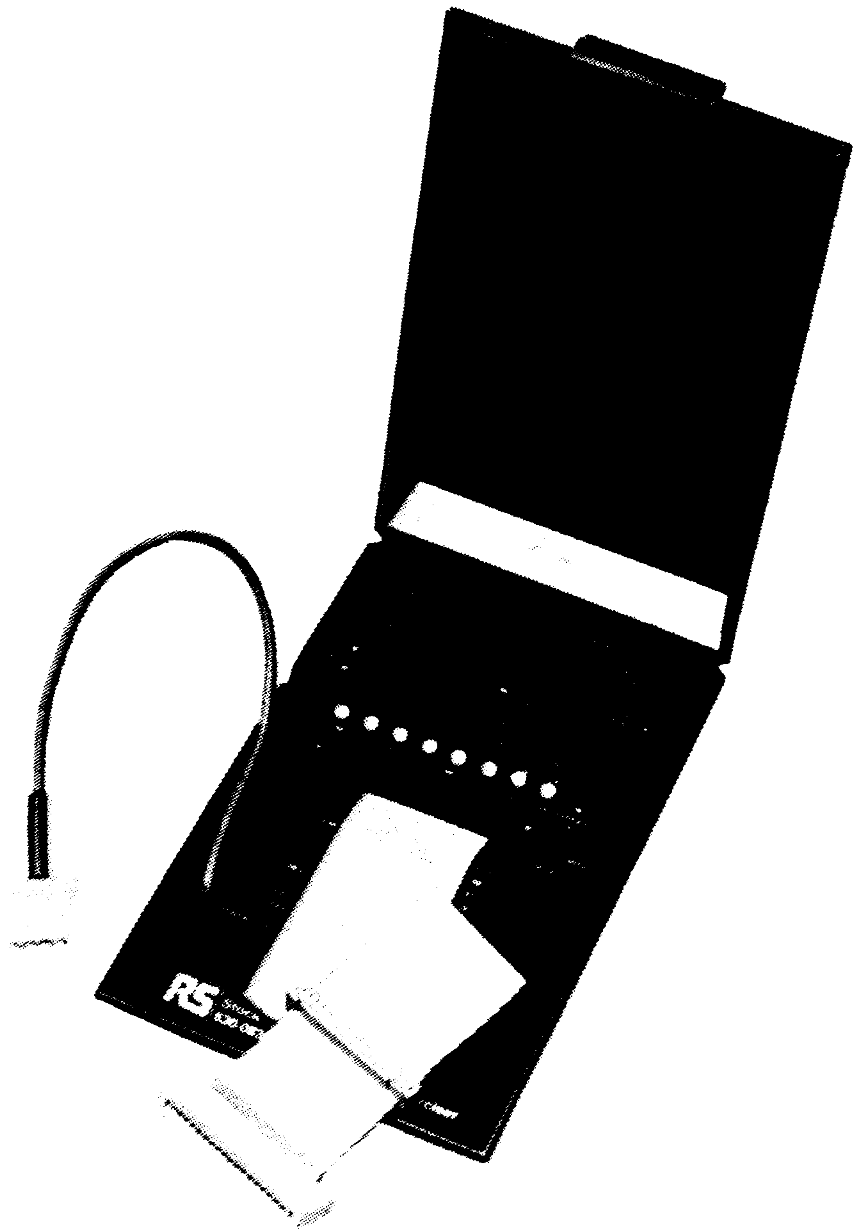
Disc Drive Exerciser

User Instruction Manual

Stock No. 630-083



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1. BASICS

1.1. Introduction.

The RS Disc Drive Exerciser is a robust compact unit capable of exercising the interfaces of most 3½", 5¼" and, via an adaptor pod Shugart compatible 8" drives.
It contains two sections, an active and a passive. The active section allows drives to be stepped to 3 sets of the most commonly used tracks on alignment discs (also known as CE discs, Customer Engineering discs, and Cat's Eyes discs). The stepping rate can be set in half octave bands from 2.25ms per step to 24ms per step, (the value the unit defaults to on 'power up').
The active section requires that the track zero indicator line is working properly and if there is a fault in this part of a drive, it may be cleared using the passive section of the unit where stepping commands are given manually.
The standard interface connector consists of widely available ribbon cable parts so that if it is damaged or worn out, it can be easily replaced. The assignment of the interface lines is based on the US standard with the addition of the 'ready' signals on pins 6 and 34, which are widely used on European and Japanese drives respectively.
The unit is not self powered, it has a standard drive power connector at the back and a flying power lead at the front. When "daisy-chained" in series with the drive power connection, the unit picks up its 5V power (380mA) and indicates the 12V power (20mA).
The interface lines are all TTL compatible being either pulled up by terminating resistors of 150 ohms on drive outputs or pulled up by 1kΩ resistors which are switched to ground. The "step" and "direction" lines are driven by open collector 7438 drivers with 1k pullups to +5V, so that the drive can be tested with or without a terminating resistor network with equal effects.
All interface lines can be checked for addressability except drive select '2' and '3'. If a drive with this address is tested, it will need to be patched to either drive '0' or '1' temporarily. The ability to check that all lines can be addressed by the interface is useful where a drive may have suffered electrical damage leaving some or all of the outputs stuck 'Enabled'. (This is a typical failure mode for drives which have suffered nearby CRT flashover).
The unit is robust enough to live in the toolbox, the only socketed component being the programme EPROM. If this escapes from its socket when the unit is dropped, it should be replaced with its pin 1 to the 'Left' of the unit when looked at in the units working orientation.

i) Getting Started.
If at all possible, it is better to start familiarisation with the RS Exerciser with a drive that is known to be good. A power source will be needed which can power both the drive and the unit. 5V at 2A and 12V at 3A will be needed and a linear type will introduce very much less interference than a switched mode type making the (sometimes quite complex) pattern found on CE discs very much easier to decipher.

ii) Start Up Switch Settings:
DATA central.
LINE TO GND central.
SIDE 0. (up)
MOTOR ON. (down)
DRIVE No. 0 (up)
HEAD LOAD on. (down)
PASSIVE STEP IN/OUT central (spring biased)
PASSIVE STEP SINGLE. (up)
PASSIVE. (up)
REPEAT STEP off. (up)
TK0 SW/CE ADJ central.
TK switch central. (40 Tk)

iii) Connecting Up.
If using the unit on site rather than at the bench, open the installation covers, locate the drive and check whether free access can be gained to the electronics p.c.b. If so, turn off the power, remove drive power socket, insert it in the "power in" plug and connect the flying lead of the Exerciser into the drive power connector.

Plug the ribbon link into the header in the centre of the unit with the tracer or brown wire to the right. Identify pin 1 on the drive and plug the 34 way socket onto the interface connector on the drive with the tracer or brown wire towards pin 1. (Most drives have a slot cut in the board edge connector between pins 4 & 6 so pin 1 will be at that end of the p.c.b.)
Plugging the interface lead upside down into either the drive or the exerciser may ruin a CE disc engaged in the drive. All lines, including 'Write' are asserted so if the drive happens to have its head over one of the active tracks on the alignment disc, this will be erased, permanently.

1.2. First Steps.
Power up and check that both 5V and 12V l.e.d.'s are on and do not flicker as the motor starts or the head loads etc.
Place a scratch disc in the drive and check that the INDEX l.e.d. is flashing once per revolution. (If it is on dimly, the disc is hard sectored and will be unsuitable for most of the tests).

i) Scope Connection.
Hook the ground clip of the scope to 0V and the probe to INDEX. Set the Y amp up to 2V per div, d.c. coupled. Set the timebase to 20 ms/div, there should be two index pulses visible at the extremes of the display.
With the other probe's ground clip hooked to the drive p.c.b's. ground tag and with its Y amp set to 50 mV/div, a.c. coupled, identify the read pre-amp testpoints (usually marked as "TP1" and "TP2"). With a formatted disc, there should be a band of signal on the trace. If not, check the position of the head cartridge, if it is sitting at its outermost stop, (furthest from the spindle) give one or two steps in 'Passive Step' (toggle pushed up and released). Then, watching the 'TK0' l.e.d. a few steps out, until the l.e.d. comes on. (Toggle pushed 'down' and released).

ii) Read Amp Protection.
Be very careful identifying the pre-amp testpoints, if the circuit used is the MC 3470, and the test point is shorted to ground or to its neighbour, the i.c. may 'burn out'.

iii) Noise Checks.
Once the pre-amp and index waveforms are displayed, transfer the first probe to the RAW DATA testpoint and set the timebase to 2 μs/div and look at the quality of the pre-amp waveform. If the power source is a switching PSU, there may be substantial interference on the trace. If this is present, alignment may be difficult because a clear picture of the recovered patterns on the CE discs will be unobtainable.

iv) Balanced or Common Mode Reject Scope Connection.
If heavy switching interference is found, transfer the first probe to the external sync input on the scope and switch the trigger to 'ext'. Take a third probe and hook its ground to the p.c.b. ground tag, and its tip to the other pre-amp testpoint. Set this Y amp to exactly the same settings as the second probe, switch the channel to invert and add the channels. The picture should now be very much clearer with the common mode noise removed.
Take the timebase back to 20 ms/div and adjust the display to get a clear band of data covering most of the screen.

v) Poor Data Pattern.
If the pattern on the lower head is heavily amplitude modulated (and probably absent entirely on the top head), the head load solenoid may not be pulled in. Alternatively, the top head may be damaged or the pressure pad may have been pulled of. Any of these symptoms must be cured before alignment can take place. The HEAD LOAD line may go via pin 4 rather than 2, so setting the LINE TO GND switch to 4 (down) may load the head.
In certain types of drive, the top head or head load pad can be damaged by rough insertion and withdrawal of floppy discs.

vi) Active Mode.
As long as there is a 'TKØØ' indication before the head cartridge meets the outer stop, the exerciser can be set to ACTIVE. If there is not, the PASSIVE STEPS switch must be used to find the cause.

vii) Setting Step Rates.
If the drive is known to be able to step at a high speed (3 or 6 ms step rate for example), the step rate is set by holding down the relevant track select push-button while switching from passive to active. The processor checks these switches for about a second after the passive/active transition and as the first test to be done is to restore the drive to track zero, it is quite easy to inadvertantly select the 2.25ms step rate instead of restoring the drive by pressing the switch too soon.

viii) CE Protection.
Keeping the scratch disc in place, select track 'zero' and check that there are no notches in the band of data. To be certain, hold down 'INDX' pushbutton so that the head passes over the track boundary several times. Check the data band again for integrity. If notches are seen, the erase circuit is stuck 'Active' and will destroy the CE Disc, if it enters the drive.
When withdrawing the scratch disc, check both sides for scoring or other damage both of which will also ruin the CE disc when it is inserted (see section 3.6, on Cleaning).
Assuming all is well, place the CE disc in the drive and engage it gently with the motor running. The track zero pattern, a continuous band of signal, should be seen. If this is absent and the TKØØ l.e.d. is on, the drive's track zero switch needs adjustment (see section 3.1). Check that there is no obvious bulging of the band, indicating that the disk is running eccentric, (see section 5 on CE discs). If eccentricity is obvious, keep re-engaging the CE disc to minimise it. If it cannot be removed, there is usually a problem with central cone runout which should be visible looking along the side of the drive.
As the CE disc is inserted, check the condition of the write protect (WP) l.e.d. and change the condition of the notch in the disc as necessary, to make the l.e.d. come on when the disc is engaged.

ix) Alignment Patterns and Drive Track Density Selection.
If all is well, select the CE track and look for the alignment pattern (two lobes of signal or a castellated band). If this is absent, select '80' track (track switch down) and switch ACTIVE/ PASSIVE/ACTIVE again so that the processor reads the switch. (Hold down the relevant step rate switch if necessary).
If the alignment pattern is now seen when CE is again selected, make a note of the drive's type number as an 80 track drive. If not, refer to section 3.2, on Alignment.
Switch on the CE 'ADJ' programme and, if the mechanics allow, set up the alignment with the programme running. (See section 3.2, Radial Alignment).

x) Double Sided Drives.
If the drive is double sided, check the top head first and optimise it for hysteresis, (see section 3.2.(i)). The top head is selected with the 'side' switch down (side 1). If the pattern disappears, check that the CE disc is double sided or if the head mounting is visibly deformed. If the latter is the case, the head carriage must be replaced in its entirity.

xi) Double Sided Alignment.
With the top head now within specification, check the bottom head and share errors if necessary. If any of the settings cannot be brought into specification, check the free movement of the carriage when the power is removed and clean if necessary (see section 3.6). If the exact 4/8 track difference between the top and bottom heads cannot be obtained, (both heads in specification) the heads will need replacement because the adjustment of the upper head requires highly specialised jigs and is beyond the scope of the normal facilities in a repair shop.

xii) Suspect Top Heads
If both heads cannot be brought into proper alignment, check the top head's azimuth, (see section 5., CE Types). If the head has been pulled out of alignment, the azimuth is usually wildly out anyway so replacement will be necessary.

xiii) Dynamic CE Checks.
Once the drive has been aligned and if this had not been done before, select the correct step rate for the drive and run the CE ADJ programme again. If the alignment now falls outside specification the drive probably needs cleaning, (see section 3.6), or running in if the heads have been replaced or the drive is new.

xiv) Running In.
To run the drive in, the CE disc is removed and a high track number selected with the REPEAT switch 'down'. (The ADJ programme locks out the 'Repeat' function so make sure it has run to completion before removing the CE disc). The drive is then left for some ten minutes with the carriage running in and out before the alignment check is done again at rated speed.

xv) Index Adjustment.
The index position is now checked at both track zero or one and track 34 (using the azimuth burst if necessary, see section 5 on different CE types). If the drive is to be used with hard sectored discs, the adjustment of index is critical and must be at or very close to nominal on both tracks. The crystal controlled 4kHz squarewave on the RS Exerciser gives a convenient method of calibrating the scope for index checks. The timebase should be adjusted to 100 μs/div and two complete cycles adjusted to coincide with 5 horizontal divisions. (See section 3.3 for speed checks and skew).

2. WRITE AMPLIFIER CHECKS.

During this phase of the testing, make completely certain that the CE disc is removed from the drive (except during 2.6.(iii), the comparison stage). The write protect circuit on the drive should never be relied on to completely protect the disc and the check should always be made before the 'W' button is pressed.

2.1 Scope Setup.

The scratch disc is now inserted in the drive and the write section of the drive checked out. For these tests, access to two separate traces on the scope will be required so if 'Common Mode' operation has been set up (as in section 1.2.(iv)), one trace will need to be freed off and set up as in section 1.2.(i).: (2 V/div, d.c. coupled). This channel's probe is attached to 0V and RAW DATA testpoints on the RS Exerciser.
The timebase is set to trigger off this channel as before: internal triggering, d.c. coupled and negative going and sweep speed at 1 μs/div.

2.2 Blank Write.

The drive is restored to track zero and the band of data displayed on the scope. With the data switch central, check that the track can be erased entirely by pressing the 'W' button on the RS Exerciser. Change the 'Side' on a double-headed drive and do the same test.

2.3 Write Protect.

Change the state of the disc's write protect notch and step to track 1. With the WP l.e.d. 'On' at the RS Exerciser check that the 'W' button has no effect on the data there.

2.4 Write All Zero's.

Restore the drive again and set the DATA switch to 62.5k. This frequency corresponds to a chain of FM encoded zero's. Press 'W' to write it to disc and monitor the raw data. This should consist of a pair of negative going pulses between 250ns and 2 μs wide. The recovered data may show significant interference until the DATA switch is returned to centre.

2.5 Write All One's.

Switch DATA to 125k and press 'W' again. The 'Raw Data' should now show three or four of the same pulses. Again, switch off the 'Data' when checking the waveform.

2.6 Jitter Check.

Select the INDX track and write all zero's. Change to 'Side 1' and do the same. Restore to track 'zero' and write all zero's on side 1. Select the higher of the two AZ tracks and write zero's on both sides. Select the MAX track and write all one's on both sides.

i) Scope Adjustment.
If the pre-amp waveform is a single (probably rather distorted) sinewave, slightly adjust the variable timebase so that the signal becomes two interwoven sinewaves and check the second negative going pulse of the 'Raw Data' for each condition (head, write frequency and track).

ii) Jitter Measurement.
Checking again that the DATA switch is 'Off' (central) measure the approximate width of the superimposed set of falling adges of this second 'Raw Data' pulse. This pulse edge modulation is referred to as 'Jitter'. For a double density disc drive this should not be greater than around around 200ns under any of the various conditions. For a single density drive the figure would be better than around 400ns.

iii) Disc Comparison.
If the results are very much worse than this, check the all zero's and all one's tracks on the CE disc. If results here are very much more respectable, the problem is in the write amplifier of the drive. Otherwise the read amp. balance pot. should be adjusted to give the best compromise between the various conditions of head frequency and track.

2.7 Formatted Data Comparison.

With the drive and RS Exerciser set up as above, the effect of the read amplifier balance pot. with 'real' data can be seen. If a disc written with 'real' data is available, insert it and select the MAX track. By gently varying the balance pot., the raw data can be seen to lose definition as the correct setting is left and recover it as it is approached again. It is more convenient to minimise jitter using 'real' data written on the system the drive will be used with. If however, this is not available, the test frequencies on the RS Exerciser allow the drive to be set nominally.

3. DRIVE ALIGNMENT AND CLEANING.

Warning: In this section, the alignment of the drive may be changed. Make sure that the drive's user realises that this may make some or all of his previously recorded data unreadable. If possible, request a sample disc written previously with the drive and check its amplitude before and after the drive is realigned. If more than about 40% of amplitude at the pre-amp is lost after alignment, such discs may be very difficult to read later.

3.1. Track Zero Setup.

i) Early Switch Design.
Early drives used a simple limit switch to send a signal to the interface when the head carriage reached the outermost track. This mechanism was very prone to failure because the track pitch is only just over half a millimetre and the switch had to be able to open and close reliably over this short distance. If substantial mechanical advantage was given to the actuator, this tended to push the head carriage away from track zero so that, as the positioning mechanism wore, the alignment of the first three or four tracks became less and less perfect.

ii) Stepper Motor Phases.
To ease this problem, later drives used the same limit switch to gate a signal which was decoded from one of the three or four possible phase relationships of the stepper motor. Since this phase relationship is only valid once every three or four steps and hence tracks, the opening and closing of the switch could be allowed to occur over a much wider mechanical range. Whether the switch is mechanical or optical, the use of stepper decoding also eliminates bounce which comes from the intentional dither which is introduced into the stepper motor to minimise hysteresis. (See section 3.2.(i). hysteresis).

iii) Setting Order.
The very useful feature of stepper phase decoding does, however contain one serious trap. If a drive happens to be very badly out of alignment and the CE track is used first, there is a danger that when the drive is restored, the current phase at which the head has now been set may not be that decoded by the electronics. For this reason, it is very important to set up the head alignment at track zero first, aiming for maximum amplitude from the pre-amp as a guide, then make the final adjustment to the position with the CE track.

iv) Phase Number Check.
To optimise the actual opening and closing point of the limit switch, the number of stepper phases should be found. This is done by holding the switch closed (or inserting a mask in the optics) and

using the RS Exerciser in 'Passive'. Set the PASSIVE STEP switch to ON INDEX (down) check that the head carriage is away from the switch. Load a scratch disc, hold up the PASSIVE STEP switch (in) and count the number of stepping pulses for each flash of the TKØØ l.e.d. There will be three steps per flash for a three phase motor and four for a four phase motor. If the l.e.d. comes on constantly, the drive does not use phase decoding and the switch must be set with particular care to change state between tracks one and zero.
Most drives inhibit stepping out when track zero is 'Active' so the switch must be released to restore the drive.

v) Switch Setting.
With mechanical switches, the opening and closing point can be heard. With optical switches, access needs to be gained to the phototransistor amplifier to measure opening and closing. Switching the RS Exerciser to ACTIVE and with a scratch disc loaded, the TKØØ SW programme is selected. This programme steps the carriage using the index pulse as a trigger but waits for two index pulses at track zero itself for identification.
For three phase steppers, the switch should usually change state between tracks one and two, for four phase steppers, between tracks two and three. While the switch is being set, the scope can be set to around 200ms per division with index on one trace and the switch output or post phototransistor amplifier on the other. For three phase steppers, the switch should be fully closed for two index pulses, for four phase steppers, one index pulse.
Transferring the probe back to the 'read' pre-amp and loading the CE disc, the hesitation on track zero will allow the signal on track zero to be clearly seen. (See section 5., CE Disc Types).

vi) Optical Switches.
Care should be taken to set up an optical switch in subdued light. If working on drives by a window or under a strong benchlight, the RS Exerciser may suddenly appear to malfunction because there is enough light falling on the phototransistor to stop the track zero signal appearing. This warning also applies to drived in situ where inspection lamps are used while a programme is running using a disc drive.

vii) Over-restore.
The other very confusing problem which can affect drives is over-restoration at power-up/down. As the power dies away, the drive may receive a stepping pulse which kicks the head out beyond track zero against the backstop. The adjustment of this stop is very important because when power is reapplied, and the stepper motor counters are cleared, the drive may be signalling to the interface that it is at track zero but, with the stop too far out, the head may indeed be at track -1 or so and producing no signal.

viii) Stop Adjustment on Early Drives.
The stop must be adjusted so that the head cannot kick back more than just less than ½ a track pitch on drives where step pulses are inhibited by the presence of the track zero signal. This position of the stop is meant to cause the carriage to bounce off the stop into a stable position at track zero when restore pulses are given during initialisation of the disc system. If mis-set, these installations will give intermittent failures to power up correctly depending on whether the carriage happened to over-restore the night before as they were powered down.

ix) Stop Adjustment on Stepper Phase Type Drives.
On drives where stepping past track zero is allowed, the counters are usually cleared on power-up to a phase relationship which does not allow the track zero signal to come through, forcing the system to issue step-out pulses to restore the drive during initialisation. On these drives, the stop must be set to allow less than 2 steps of over-restore for four phase motors and 1½ steps for three phase motors. The usual limit for such drives is to set them to around one step of over-restore unless the carriage hits the stop repeatedly during the post step dither when a little more leeway is given.

x) Checking the Stop.
To check for correct positioning, the drive is powered up with the carriage held manually against the stop. The carriage is then released and 'Passive Step-out' pulses given from the RS Exerciser until the TKØØ l.e.d. lights. The CE disc is loaded and the correct position over track zero verified.

The exerciser is then set to ACTIVE and the REPEAT STEP switch is selected (down). MAX track is selected so that the drive cycles back and forth. Any tendency for the carriage to hit the stop is then adjusted out and the process repeated.

3.2 Radial Alignment.

Once the track zero switch has been set or checked, the head carriage can be finally aligned to fall directly over the standard position used on all drives of a certain type. Although only one track on each side of the disc is used to test the radial position, the mechanical design of the positioner is such that, in theory at least, all other tracks will then be in their correct places.

There are faults that can make this check invalid. If the mechanism consists of a spiral cam which moves the carriage in one direction and relies on spring pressure to move the carriage in the opposite direction, any significant increase in friction caused by matter caught in the lubricants on the moving surfaces or even flexing of badly dressed headleads may cause the alignment to drift when the spring is providing the force (especially when it is at its minimum extension).

Band positioners using a thin steel band wrapped round a pulley can also give trouble if a foreign body becomes stuck to the band or the pulley or if the band itself is deformed by rough handling. For these reasons, a frequent cause of intermittently poor alignment comes from operating the drive in dirty environments and a good cleaning often works wonders for an unreliable unit.

i) Hysteresis.

In terms of radial alignment, hysteresis is used to signify the difference between the actual 'stepped-out' and 'stepped-in' positions for any particular track. If there is heavy friction in the positioning system, the carriage will end up not quite reaching the nominally correct position and will be misaligned in the direction from which it came.

So stepping from a lower track to a higher (stepping in), the head will take up an actual position further out from the spindle than vice versa approaching the track from a higher one (stepping out). Where the friction is gross, say in a drive mounted with an unfiltered fan blowing on it for several months in a smoke filled office, some software may be found to run on it and some not.

The reasons for this may be found in the way the software copes with disc errors. When it gets an error, the software should first restore the drive and 'seek' to the track again and try to read the data. If the error persists, it should then try stepping out and back again so that the track is approached from the opposite direction and carry on doing the operation alternately until a large number of tries have been made.

ii) CE ADJ Programme.

Because the actual position taken up by the head can be so variable, there is a special programme in the RS Exerciser to measure it. It is selected by switching the CE ADJ switch down with the unit in 'Active' mode. When this is done, the drive restores, selects the CE track (16,32 etc.) and using index as a trigger, steps away from the track and back from each direction alternately.

iii) Scope Setup

The use of index is important because, if the scope is set up as in section 1.2, (20ms/div, INDEX testpoint to trigger and pre-amp signal on one or both channels), the scope will display the two alignment patterns superimposed on each other for comparison. If this display does not appear clearly, the timebase knob is switched up a notch and back until it does. (The sweep speed chosen gives two index pulses per sweep and the dither of the head carriage should occur on the second of these pulses so that it does not get displayed).

iv) Head Carriage Adjustment

If at all possible, the drive manual should be available so that the correct way of adjusting the head's radial position can be found. This is especially true for drives using a band positioner because the design relies on having a stepper motor with a very small step angle, 1·8° for some 80 track 5·25" drives. This very small angle of step makes setting an extremely delicate operation if the body of the stepper itself has to be rotated to adjust the head position.

Moving the whole stepper motor is the commonest method of adjustment but another, much more delicate method is rotation of the pulley or actuator of the stepper shaft itself and the method outlined below will be unsuitable for this type.

v) Moveable Stepper Drives.
If the mechanical design permits, the fixing screws of the motor are slackened so that slight rotation or movement is possible. The CE disc is inserted and the scope set up as in section 3.2 (iii) and the CE ADJ programme selected with the lowest (default) step speed. With the head cycling over the alignment track, the motor is gently moved or turned until the correct pattern is seen. (See section 5, for CE types). (As above, make sure track zero has been set up first if the drive is a long way out of alignment).

vi) Double Sided Alignment.
The two superimposed patterns will be very slightly different depending on the degree of hysteresis in the mechanism and each side will be slightly different as well. By sharing errors, all four patterns should be within specification. If a choice has to be made to optimise the drive within three settings, stepped out on the bottom head (Side 0) is the safest to jepoardise if it will bring the other three into specification. Obviously the degree of misalignment here is a matter of judgement and other factors (such as recent head replacement without running-in the carriage) should be taken into account.

vii) Rated Step Speed Alignment Check.
The CE ADJ programme should be run at both the lowest step speed and the rated step speed to make sure that the drive can be driven accurately at both. If the drive starts to mis-step (the alignment pattern dissappears), at the faster speed, the drive should be run-in or cleaned or both.

viii) Fixed Stepper Drive Alignment.
The adjustment of non-moveable stepper type drives is very much more tedious because it cannot be done with the CE ADJ programme 'Active'. Where the adjustment method involves slackening off grub screws in the pulley, very great care indeed is necessary to avoid damaging the band positioner nearby. If the positioner has a lead screw arrangement with an adjustable coupling, this must be treated with respect because any misalignment of the stepper shaft and the lead screw may cause severe friction in the mechanism and consequent mis-stepping at rated speed.

It is highly recommended that, unless the drive is obviously giving misalignment problems and is clearly a long way from its nominal setting, no attempt be made to adjust it without reference to its manual and if this gives no assistance to the maintenance engineer, the job should be treated with great circumspection.

ix) Alignment Technique.
With a non-moveable stepper drive, the scope and exerciser settings are identical to those above except that the CE ADJ programme is *not* used until the checking phase is reached. The CE button is used instead to select the correct track. The technique may be to rotate a pulley or coupling very slightly with the CE disc in place checking the pattern on the scope as this is done. After each adjustment, all screws etc. are firmly tightened and the CE button pressed again. This restores the drive and sends it back to the track. It will usually be found that the post-step dither causes the dynamic position to be far enough out for another adjustment to be needed and so the process is repeated again until a setting within specification is obtained.

3.3. Speed Checks and Skew.
With modern drives and phase locked loop data separators, the chief enemy to watch for is a tendency for a drive to overspeed. The phase locked loop separator can usually be relied on to cope well with data written on a drive which was running quite slow and the increased bandwidth of such signals when read by a drive running slightly fast is usually tolerated by modern read amplifiers.

There is a growing tendency, however, to pack more and more data onto each track by reducing the clock run-in, sector and track gaps to the absolute minimum. Overspeed under these circumstances runs the serious risk of the end of a track overwriting its beginning during formatting.

If the fault complained of is that a drive does everything but format, and this tends to give trouble towards the higher tracks, the first thing to do is check its speed with the motor running free (without media). Most belt driven drives have motors with quoted power-on-hours of around 5000 which usually means that users tend to run them with the motors stopped except during disc access

High starting current, especially with dead-loaded, high friction media present may cause the motor brushes to wear prematurely unless this is intentionally limited by the motor servo circuit. Fast-start drives are particularly vulnerable to this problem and, in a few cases, the motor might even last longer if it is kept running (bearings allowing) the whole time.
In virtually all cases, the symptoms of premature wear is for the motor resistance to rise. Some servo circuits compensate for this by causing the motor speed to rise off-load in sympathy. In other circumstances, the loop is closed by the user who notices that the strobe is running slow and adjusts the servo circuit himself.
Media friction is also a very variable quantity as can be appreciated by turning the spindle pulley by hand with the head loaded on various brands of disc. As a rule, most drives should be set to their correct speed with the heads loaded over the maximum track. When the heads are unloaded, the speed should not rise above the rated maximum for the drive and when the heads are restored, it should not fall below the rated minimum tolerance.
Older drives usually have a speed tolerance of ±2·5% and this should be checked under the above conditions. Modern direct drive units manage a tolerance of around ±1·5% and use crystal control to achieve this. Where it is known that a unit is being used with a tight format, special attention should be paid to getting the speed setting as near optimum as possible but with overspeed eliminated entirely.

i) Speed Setting to Index.

If a timer/counter is available, the drive should be checked with the head unloaded to have an inter-index time of 195ms maximum (±2·5% types) or 197ms maximum (±1·5% types). (Normal setup, MOTOR ON (down) HEAD LOAD off (up) on the RS Exerciser). With the TKØØ selected and the head loaded, this figure should not rise to more than 205ms (±2·5% types) or 203ms (±1·5% types). The adjustment pot for motor speed will usually be found somewhere near the motor servo circuit (probably the hottest part on the drive p.c.b.).

ii) Speed Setting to Strobe.

If there is a strobe fitted to the spindle pulley it should have 20 bars round the periphery for use with 50Hz mains and 24 bars for 60Hz use. The strobe should not be appearing to move by more than 2½ bars/second in either direction past a stationery reference (50Hz mains) or 3 bars/second (60Hz mains) for ±2·5% types under the same conditions as above.
The tolerance for ±1·5% types under the same conditions are ±1½ bars/second (50Hz) and 1·8 bars/second (60Hz). (±9 bars in 5 seconds).

iii) Making a Strobe.

If the drive is not fitted with a strobe, this is relatively easy to make from a circle of card which can be stuck to the pulley for test purposes with Blu-Tak. The card is marked with spots at north, south, east and west; then four more spots are placed equidistantly between each of thse cardinal points. This gives a 20 spot strobe for use on 50Hz mains.
For 60Hz use, the four spots are again, north, south, east and west, then four more at north-east, south-east, south-west and north-west. Between each of thse eight spots, two more are placed equidistantly giving a total of 24 round the periphery.

iv) Skew.

Being a flexible medium, the disc can be deformed inside its jacket especially if there is too much pressure from the stabilising pad. This is a felt or foam pad that rests on the jacket just to the left of the head looking at the drive from the front onto the label side of the disc. This deformation is known as Skew and can be measured using the index markers at high and low track numbers. Some CE discs provide two index markers, one at track zero and another on the higher AZ track.
Skew can be a serious problem with 8" drives especially if they use hard sectoring but with the substantially smaller mechanical advantage of 5¼" media, it is almost irrelevant.
If the stabilising pad is adjustable or has been replaced, the index timing between the INDX track and the higher AZ track's index burst or second index track (see section 5 CE disc types) may be seen to be different. If they are very different, (say 50μs or so, the stabilising pad is pressing far too hard on the disc and should be eased if possible. As the pad is eased, the amplitude variations on the TKØØ band should be monitored, and if excessive, the pad should be readjusted.

3.4 Index Timing.

Previously, where hard sectoring was in wide use, the setting of the index detector was of very great importance. If mis-set, drives became unreliable for data interchange because the sectoring information was fixed by the disc rather than the drive.
Most controllers today only ever make use of index during the formatting process where it initiates the writing of the track. At other times, some controllers make use of it as an integral timing signal so it has to be present but its actual position can be around $\pm 100\mu s$ wrong without causing complaint.
It is set by adjusting a phototransistor/l.e.d. pair placed either side of the disc scanning the hole in the jacket for the passage of a hole punched in the media.
The most serious problem found with index is not its timing but its presence, If the drive has been operated in a dirty environment, dust and fumes can reduce the optical efficiency of the pair to such an extent that the drive only works out on the bench where there is enough extraneous light to tip the balance between working and not. The edges of the hole in the media are well defined and small acceptance angle devices are usually used so monitoring the phototransistors voltages with a scope will usually point to trouble if the rising and falling edges are badly defined.
Access to the devices for cleaning is sometimes not so easy. Modern direct drive motors are necessarily larger in diameter than the index hole's position and taking this assembly apart may make a simple intermittent index problem into quite a major job. Because of the greater electrical stress on the l.e.d. half of the pair, this should, in principole be the accessable part. However, adjustment has traditionally been done by moving the phototransistor and thus this is usually the only visible element.

i) Index Adjustment (mechanical).

The scope is set up as in section 1.2 (xv) ($100\mu s$/div calibrated with the 4kHz squarewave from the RS Exerciser. One or both Y channels on the pre-amp testpoints. Trigger off INDEX testpoint, d.c. and negative going). The INDX track is selected or TKØØ, depending on the CE disc type and the phototransistor holder and adjustment screw located. The timing of the falling edge of index to the timing reference on the disc is adjusted by very slight movements to the holder.

ii) Index Adjustment (electrical)

In some drives, the index pair are so difficult to get at that the adjustment is done by having fixed optics and providing an adjustable monostable delay circuit in the drive electronics. Because delay is the only parameter that can be provided simply, this arrangement can suffer another minor problem. The phototransistor has to be mounted so that it scans the leading edge of the hole punched in the jacket to give the widest possible range of adjustment. If the jacket is slightly undersize and can locate too far into the drive, the edge can partially obscure the index hole giving intermittent pulses. Again, the worst problems encountered with this symptom are when the optics are dirty and marginal anyway.
To identify a mechanically adjustable index drive from an electrically adjusted one, the mechanical type will usually turn the INDEX l.e.d. on the RS Exerciser fully 'on' when the disc is removed from the drive, the other will give a 'flash' as the disc is inserted and will be 'off' otherwise.

3.5. Settling Times.

Most 8" double headed drives are fitted with a means of lowering the head onto the media gently using a dashpot and solenoid arrangement. In some early drives this was made adjustable so that the headload time could be predictable. With the advent of slimline drives of both sizes, this arrangement has been replaced by making the unloaded flying height as low as practicable so that the inertia of the head itself prevents a high terminal velocity as the head meets the media surface.
The shock produced by the two heads meeting when there is no media present is quite capable of fracturing the delicate ferrite magnetic circuit around the rear gap and thus the dashpot arrangement was of very great importance. The same is true of drive shipment, especially when there is no dashpot fitted. ALL double headed drives should be shipped with a disc in place, preferably placed in sideways so that the jacket acts as a shock absorber but NEVER with the label side downwards where the sealed edge of the jacket can catch on the top head when the disc is withdrawn.

Head settling times are expressed as the time taken for perceptable amplitude modulation to die away after the assertion of the head load line on the interface. Both unloaded flying height and dashpot damping have a bearing on this parameter, but with 5¼" drives it is slightly less important. If it is seen to be excessive in dashpotted 8" drives, it should be adjusted down to a reasonable level, but never too low (for the above reasons) for preventing headcrash.
Another important parameter which is often ignored is the post-step settling time. Most controllers provide a monostable to prevent writing operations during headload settling time, (usually referred to as "HLT" head-load timing). This can often be put to fuller use by 'OR'ing' the step line into its input at the controller. The problem which needs curing here is caused by advances in the design of phase locked data separators.
A writing operation can only begin (formatting excepted) when the controller has read the address of the sector it wishes to write to. If this sector is the first one after a step has taken place, the dataseparator may be quite capable of identifying the track as the head moves over it during the post step dither. It will then start to write the data while the head is still moving back and forth over the track and put down data that can be seriously misaligned.
Post step dither is introduced specifically to combat hysteresis. The stepper's magnetic circuit is intentionally under-damped so that, as the energy introduced to give the step alternates between the coils and driver, the motor itself vibrates with a decaying oscillation after each step.
The final step to the required track will leave the motor, and thus the head, dithering over the track for a few milliseconds. (Around 30 for a new drive but up to 80-100 ms for a well run in older drive).
The problem of post step dither misalignment thus only begins to show itself after the drive has properly run in and the friction which improved settling time has reduced substantially. Checking media which has been written by the drive will often show up the problem. Running track by track through each side looking at the envelope of the data at the pre-amp testpoints will sometimes give surprising results with sectors written up to half a track out of alignment at the peak excursion.

i) Post Step Settling Time Measurement.
To measure settling, set the scope up with one or both Y channels on the pre-amp outputs as in section 3.2. The timebase is set to 5 or 10ms/div triggering from the INDEX testpoint, d.c. coupled and negative going. A formatted disc is placed in the drive and the head loaded.
The drive is restored and the RS Exerciser is then set PASSIVE (up) PASSIVE STEP ON INDEX (down) and the PASSIVE STEP key is held 'In' (down).
The time is measured from the start of amplitude distortion of the read amplfier waveform to where it perceptable ceases.

ii) Post Load Settling Time Measurement.
With the above settings but triggering off pin 2 of the interface connector, the HEAD LOAD switch is toggled and the time for perceptible modulation to decay is taken as the settling time.

3.6. Cleaning and Lubricating.

Cleaning of heads is one important area where the customer tends to be inundated by the large number of available products from his normal suppliers. However the user does need to be educated to their proper use. Over enthusiastic use of cleaning solvents is obviously to be avoided as is a damaged cleaning disc. Once the surface of the fibrous type begins to break up, it can be lethal to double headed drives where the top head's fine phosphor bronze suspension is quite unable to withstand the onslaught of a spinning piece of crumpled cloth.
Abrasive types are very, very much safer from the point of view of top head damage but they can all too easily be left in the drive, with the heads loaded during a coffee break with disastrous results. Single sided types with a fibrous surface backed by an ordinary unburnished disc can also deposit foreign matter on the top head because of the lack of polish on the top side. The problem here being that the operator may not know whether the drive is double sided or not, only that after cleaning the drive, severe problems arose.
The vital importance of keeping heads clean is probably lost on most operators, until trouble starts to happen. The worst culprit is shedding media. Small sites of damage cause the surface to break up and deposit a minute 'cake' of binder and oxide on the head. As the cake works away at the disc surface, more oxide and binder accumulate on the head leading to complete loss of signal.

The classic reaction to this situation is to try another disc in the system without inspecting the surface of the faulty disc first. The cake chews its way through this disc too and when this is transferred to another drive, to find out if the disc is legible anywhere, another cake starts to build up on this drive ready to destroy the next disc loaded. This problem strikes worst at 8" installations because the 'media' to 'head' speed is so much greater on this type of drive and the buildup is very much faster.
The answer is to inspect the surface of any disc giving trouble immediately. Keep an abrasive cleaner in secure hands and make the backup, if vital, file by file with a three second clean between each copy across. It may be quite difficult to remove a cake with the normal fibre disc, especially used dry. The abrasive type is safer, and given the number of applications that may be necessary, very much quicker.
From the maintenance point of view, the cleaning of moving parts, especially the sliding elements is very important to general drive reliability. If CE checks reveal severe hysteresis, the cause is usually found in dirt caught in the lubricants on the sliders and positioners.
If it becomes necessary to strip a double headed drive for cleaning, certain rules must be obeyed. If the heads are allowed to snap together while the sliders are removed, the top element is very unlikely to survive. Even if it does, the surface of the head may be chipped at the point of contact leading to an outbreak of shedding. Before and while the heads are removed, they should be held gently closed with a small piece of ordinary paper between them. This should only be allowed to fall out when the heads are safely back in situ.
If there is evidence of any lubricants which have migrated onto the carriage from the sliders, this must be carefully removed with solvent. Only those solvents and lubricants recommended by the manufacturer may be used for maintenance. The real culprit here is household lubricating oil which migrates everywhere and if allowed to form a film between touching heads, makes them difficult, sometimes almost impossible to separate. The surfaces which make contact with the disc are optically flat in some drives and the force necessary to pull them apart with a liquid film between can deform the suspension of the top head.
As outlined above, band positioners should be carefully inspected for foreign bodies etc. and for any signs of damage or abuse. Foreign bodies are very likely to accumulate on the film of oil which migrates from attempts to quieten the stepper motor with lubrication, rather than the correct solution which is to run it at the right step speed.
Manual checks should be made after reassembly to make sure there is no tendency for the carriage to stick anywhere and the headleads are dressed to allow completely free movement of the carriage.
Another area to check is the motor bearings. If the user has used oil here, the belt will be slipping and/or tightened up too far to compensate.
If a drive tends to give very erratic performance, check that the disc is not slipping on the cone/spindle assembly where the centre bearings or the cone and/or spindle have been oiled.
Always advise an over-enthusiastic customer that disc drives rely on friction, as well as the lack of it for their operation.

4. CATASTROPHIC DRIVE FAILURES.

The most common total failure mode is where high and low supply voltages are wrongly connected, which is usually fatal for the majority of the TTL on the drive electronics. The usual method of visual examination of package tops for signs of explosion is of benefit before any power is applied to the drive.
The other cause of total or partial failure is in drives mounted in VDU enclosures. Flashover in the tube is a fairly common occurance and often results in some more obscure faults. A few of the more common are headload solenoid stuck on, erase stuck on, read pre-amplifier blown and most obscure of all, output or input buffers not responding to the drive's address line and being permanently activated, thus totally confusing the controller.
The first of these can, depending on the mechanical design of the drive, result in decapitation of the upper head as the disc is dragged out. The forward end of the slot hooks round the sharp edges of the head and thus causes total failure.
The next erases all the positional information of a CE disc leaving, maybe, just a little nick in the pattern where the erase head passed.

The third is always encountered in a hurry, none of the usual check having been done. The CE disc is inserted and every track is accessed to try to find out where the signal went.
The last one can be quite difficult to locate because the drive seems to be responding rationally. A quick check with the DRIVE NO. switch gives immediate evidence that all is not well and substitution of known good I.C.'s is in order.
As mentioned before, the very widely used MC 3470 read pre-amplifier takes very unkindly indeed to any slipped probe or overvoltage.
Some thoughtful manufacturers put resistors in series with the testpoints on the p.c.b., others do not.
Pre-amplifiers may also be destroyed by switched-mode power supplies under certain conditions. If the power supply has not been correctly loaded, the 12V rail may rise to an unacceptable level. Note that most SMPS units require at least a 20% load on the 5V rail for both rails to operate correctly.

Installation Related problems.
Other installation related, rather than drive related problems, come from the soft high voltage rail. If the 12V rail has a high source impedance, this produces two different problems. Heavy intermittent loads cause it to sag, probably activating the power-down trip in the drive's write circuit in the middle of a sector. Motor ripple gets reflected straight into the 'read' pre-amplifier's supply giving high track number reading problems.
Heavy intermittent loads are not difficult to find in disc drives. Many manufacturers spin the motor up as a disc is put into the drive or the door starts closing. With fast spinup drives, the pulse load can be up to 2·5A. Many manufacturers also pull the head load solenoid in with a 50ms pulse from the 12V rail then leave it held in with the 5V rail. The pulse load here can be up to ½A giving, in total, a startup load of around 3A for around 50ms, if the drive is configured in the more or less standard way of 'ready' triggering headload. In a dual drive installation, with one drive writing away, as soon as the operator puts a disc into the other, the first gets a corruption in the file it is writing.

5. CE DISC TYPES.

CE discs are also known as Alignment discs, Customer Engineering discs or Cat's Eyes discs.
CE discs come in two broad varieties, standard and so-called "digital".

5.1 The Standard Alignment Disc. (80 track drive).

The standard disc usually has some or all of the following patterns:

Track ØØ: A band of a single frequency, usually 62·5kHz (all zero's for FM modulation) recorded with a fairly narrow trackwidth so that eccentricity can be spotted as an amplitude variation as the disc turns. It also identifies track zero.

Track 1 (2): A short burst of tone recorded 250μs after the index has passed its nominal point. The index sensor is set up so that the falling edge (first edge) is 250μs before the start of the burst.

Track 16 (32): The alignment track, recorded by writing zero's on tracks 15 (30) and 17 (34) but with the disc displaced laterally by one track pitch in each direction for the two tracks so that each track is written one track-pitch eccentric. The direction of eccentricity is opposite for the two tracks. As the head scans the centre of track 16 (32), the signals from 15 (30) and 17 (34) add. When the head is exactly on the centre line of 16 (32) the two contributions are equal.

Track 32 (64): Another track of all zero's for amplitude comparison with track zero.

Track 33 (66): A track of all one's (125kHz) to check on the frequency response and jitter of the read amplifier. Any serious fall in output compared with 32 (64) indicates that the head may be dirty or worn or there is a fault in the drive electronics.

Track 34 (68): The azimuth track. The signal starts with a short burst of tone recorded with the same index setting as track 1 (2). The next burst is recorded with the head 24 minutes of arc skew to the disc centre line clockwise. The next burst is recorded with the skew at 12 minutes of arc clockwise. The next burst with 12 minutes of arc anticlockwise and the last with 24 minutes anticlockwise. If the azimuth is perfect, the two centre bursts will have the same amplitude and the outer two will be about half this amplitude. An azimuth error of 12 minutes of arc would cause one of the outer pairs to be the same amplitude. The direction of error is given by the pair in question.

5.2 The Digital Alignment Disc.

The European digital alignment disc has some or all of the following patterns.

Track ØØ: A track of all zero's recorded with a gap at the nominal index point. To set the index, the falling edge (first edge) of the index pulse is set to be 450μs before the end of the erased section. The track format also allows track zero to be identified.

Track 14 (28): The azimuth section, alternate bursts of zero's, one's and zero's as a group, with 6 groups recorded round the disc's rotation. Between each group a pair of bursts written with the first 12 minutes of arc clockwise to the disc's centre line and the second 12 minutes of arc anticlockwise. The azimuth error is calculated by adding the amplitude errors from pairs of bursts on opposite sides of the disc. The bursts of one's and zero's between the azimuth bursts more closely simulate real data allowing jitter to be set.

Track 16 (32): The Alignment section. A similar group of 6 zero's and ones to the azimuth section but between each are 6 short bursts of zero's recorded with a wide track head. The first is recorded with the head stepped about 1½ tracks in from nominal, the next at 1½ tracks out from nominal and the following as the first, 1½ tracks in, and so on round the disc. The greater advantage of the digital over the standard alignment disc is that the effect of eccentricity can be seen immediately and the test is a great deal more sensitive as far as a quick glance of the eye at the scope is concerned.

Track 34 (68): A second index alignment track identical to track zero, which allows the degree of skew to be checked and provides a useful reference for the fall in amplitiude between the low and high tracks.

6. INTERFACE ASSIGNMENT ON THE RS EXERCISER.

The signals which appear at the 34 way edge connector should, in theory, be the same throughout the industry. In practice, this is not always the case.
Early drives were not fitted with a 'ready' line, asserted when a couple of index pulses are detected at the drive's rated speed. Later drives have this feature, but, because it had not been tied down originally, it comes up in different places on different drives.
A fourth drive select line is another recent addition, on US made drives, it usually appears where the European manufacturers put their 'ready' signal (pin 6).

The RS Exerciser covers most of thse incompatabilities with such features as the LINE TO GND switch and the RDY 2 l.e.d. The LINE TO GND will sometimes be needed to activate head load if this appears on pin 4 (Switch down). Line 34 sometimes gets used to activate a 'doorlock'

(usually referred to as 'in use' or 'software interlock'). Under these circumstances, the switch should be up.
RDY 2 checks the condition of pin 34 if this is used as 'ready'.

Pin Number.	Function.
all odd pins	Ground.
2	Head Load (normal).
4	Head Load (optional).
6	Ready (Euro & some US)
8	Index pulse.
10	Drive select 0
12	Drive select 1
14	(drive select 2. not used by RS Exerciser)
16	Motor on
18	Direction. (low = step in).
20	Step pulse.
22	Write data.
24	Write enable.
26	Track 00
28	Write protected.
30	Raw read data.
32	Side select.
34	Ready (Japan, some US & Euro)

All the lines are low for true. They are usually driven by 7438 type buffers from the drive which are pulled high by 150 ohm pullups in the RS Exerciser.
Drives usually have a resistor network which pull all its inputs high. Only one of these should be present in a multiple drive installation as the RS Exerciser also pulls these lines high with 1k resistors. This allows drives without the terminating resistor network to be tested as if it were there.
Power connector assignment.

1	+ 12V
2	Ground of 12V supply.
3	Ground of 5V supply.
4	+ 5V

The power connector used individual grounds for the 5V and 12V indicators. These supplies are usually commoned at the drive so if a power input plug has only one ground on pin 3, (a common, but bad practice), the 12V l.e.d. may not come on.
For best ground noise immunity, the supply grounds should be kept separate until they meet at the drive, otherwise there will be a tendency for heavy 12V currents (motor start etc.) to raise the ground voltage and give intermittent read problems in multiple drive installations.
If the unit is not used in 'daisy-chain' mode, all that is required is to run a single lead from the + 5V supply at the drive to pin 4 on the flying lead, the return will be provided by the multiple grounds on the interface lead.

7. USING THE RS EXERCISER WITH 8" DRIVES.

The 8" Adaptor Pod (stock no. 630-099) converts the 34 way interface from the RS Exerciser into the 50 way interface widely used with Shugart Compatible drives.
In the realms of 8" floppy disc drives, there is a good deal of non-standard interfacing found. For example, some early drives used a 50 way edge connector which is totally different to the Shugart standard; most later ones comply with the standard.

7.1 8" Drive Interface Assignment.

The lines which are most commonly found to come out at standard positions are as follows:

RS Exerciser pin no.	pin no.	Function.
All odd pins	All odd pins	Ground
2	18	Heavy load.
6	22	Ready.
8	20	Index.
10	26 &	Drive select 0.
–	30	Drive select 2.
12	28 &	Drive select 1.
–	32	Drive select 3.
14	–	(Not used on the RS Exerciser).
16	2 &	Low write current. (TK 43)
–	8	Low write current. (TK 43)
18	34	Direction (low = step in).
20	36	Step pulse.
22	38	Write data.
24	40	Write enable.
26	42	Track ØØ.
28	44	Write protected.
30	46	Raw read data.
32	14	Side Select.

7.2. Single and Double Sided Exceptions.

There are other pins which can change their function depending on whether the drive is single or double sided.

RS Exerciser pin no.	8" drive pin no.	Function
4	16	Low write current or doorlock or drive select l.e.d.
32	14	On single sided, may be used to activate the erase head so if asserted, can crash CE discs.
34	10	Not used on single sided. On double sided, indicates when a double sided disc is loaded.
–	6	Not used on single sided. On double sided, may sometimes by used to activate the erase head

Note: The 8" drive pin no.'s in the above tables are assigned by means of the 8" drive Adaptor Pod (stock no. 630-099, see Computer Products Section of current RS catalogue).

7.3. Testpoints.

There are also four testpoints on the board inside the pad. TP1 has to have the +5V supply from the drive brought to it to power the pullups. The others pick up on certain outputs which may be found to be used on older drives.

TP4	24	Output of sector separator circuit on hard sectored drives.
TP3	48	Data output of internal data-separator if fitted.
TP2	50	Clock output of internal data-separator if fitted.

7.4 New Lines.

Compared with 5¼" drives, there are some new signals to take into account; low write current, erase, sector, separated data & clock and the double sided media indicator.

i) Low Write Current Line.

When drives were originally designed, it was found that there is an optimum current through the head during writing which depends on the written wavelength. The longer the wavelength, the greater the flux needed for optimum read accuracy.

In the 8" drive, the total length of the track varies from around 22½" to 12½", and in this space identical amounts of data are placed at the longer and shorter tracks. This results in an almost 2:1 change in wavelength between track zero and track 76. To obtain similar performance, the writing current needs theoretically to be reduced at each track (by using the head carriage to move a potentiometer in series with the write circuit for example). The benefits are, however, small in comparison with the complexity of such an arrangement so a simple switch which reduces the current by around 25 to 30% at track 43 has been found to give optimum results.

In some drives, this switch is made and broken by the carriage itself. In others, the line is controlled by the interface. The MOTOR ON switch at the RS Exerciser is patched through to activate the line. With MOTOR ON (down), the current will be reduced unless the function is done by the drive itself.

ii) The Erase Line.

Only on early drives was the erase by the interface. On either side of the actual read/write head are a pair of erase gaps which trim down the data track directly after it is laid down. The distance between the erase and data gaps is just less than a millimetre (about 35 thou) with the erase following the data head. This means that the erase should be switched on and off slightly after the data head starts and stops writing; (on around 200μs late and off around 500μs late).

Virtually all double sided 8" drives today use internal timing for the erase and on 5¼" drives this is always done, but some single sided 8" units still allow the interface to drive the erase head directly.

To check the circuit, the Side Select line is patched through to the erase input on a single sided drive (if used) in the adaptor pod).

Because a 'stuck on erase' circuit can have such disasterous results on a CE disc, an unknown drive should always be checked with a scratch disc first. The only serious trap to avoid is therefore NEVER to operate the RS Exerciser with SIDE 1 selected when working on a single sided 8" drive and a CE disc.

iii) The Sector Separator.

The 8" hard sectored discs have 33 holes punched in the media which pass between the index optics. 32 of these holes are regularly spaced and between two of them is the 33rd. Each hole represents the start of a sector on the disc, but the triplet of holes is detected separately and used to give an index pulse to the interface.

The circuit which detects the triplet and gates out the extra pulse (sending it to the index pin on the interface), is referred to as the sector separator disc, a regular train of pulses will be seen at the Sector output and the extra pulse will appear on the INDEX testpoint on the RS Exerciser.

iv) Hard Sector Operation Problems.

Drives which are working hard sectored in very dirty environments frequently fail because oif dirt on the optics. The problem is that the optical efficiency of the l.e.d. phototransistor pair degrades rapidly when the lenses are converted with dust and dirt. The l.e.d's. also age, and after around 1000 hours at their maximum current rating, the light output has a tendancy to drop, sometimes quite substantially. The reasons are obscure but are most likely to result from re-diffusion in the junction owing to high chip temperatures and lattice damage from the large number of high energy carriers passing through.

Because the phototransistor is usually operated with its base open circuit, the minority carriers injected by the l.e.d.'s photons into the base region have a very long lifetime. When the drive is new, the l.e.d. current will be set to only just saturate the phototransistor because any significant overdrive will cause the device to be unable to switch off fast enough to detect the sector hole. As the optics are covered with the dirt film and the l.e.d. ages, the efficiency falls to a point where the phototransistor no longer saturates and pulses come through sporadically. This will result in sectors being written in the wrong places or not at all where pulses dissappear altogether intermittently.

With a hard sectored drive which is giving trouble, the first action is to look at the waveforms at the phototransistor. If these are found to be poorly defined, the optics should be cleaned and the check done again. If the l.e.d. has failed altogether and is replaced with a modern, high efficiency device, care must be taken not to overdrive the phototransistor giving intermittent or absent pulses while giving some or all of the sector pulses.

v) Internal Data Separators.

In the early days of disc drives, the separation of the embedded clock from a single density data stream was a reasonably simple matter. Because there are always transitions at the beginning and end of a "bit cell" (one clock period), all that is required is a monostable which is triggered by the first cell transition and which times out, say, $\frac{2}{3}$ of the way through the cell.

The output of the monostable gates the data stream so that data transitions in the middle of the bit cell are stripped out. The gate output provides the clock signal for the interface. Using the inverted output of the monostable in the same way to gate the data stream, all the clock transitions are stripped out leaving only the data transitions.

The only snag with this simple "single mono" circuit is that there are certain markers recorded in the IBM standard which, to give them absolute uniqueness, have *clock* transitions deleted, one of these markers identifies the start of the track, another immediately precedes the sectoring addresses and the last marks the subsequent pattern as being data.

The missing clock technique considerably complicates the design of the circuit but on early drives which did not use the IBM standard format simple data separators were often used.

vi) Setting Up a "Single Mono" Dataseparator.

With very hard sectored drives, missing clock marking is not often used, so the very simple data separator circuit described above is quite adequate. The only adjustment usually provided on this type of circuit is the timing of the monostable. Setting this is most conveniently done by stepping the drive to a high numbered track with a previously formatted disc loaded. The separated clock line is monitored and the pot adjusted until the clock output becomes a well defined series of negative going pulses. The position of the pot is noted and it is adjusted in the same direction until interference is seen to start again. The pot is then set mid way between the settings where the output is seen to become indistinct.

vii) The Double Sided Indicator.

The 8" discs come in two different mechanical types, single and double sided. The difference between the two is that the single sided variety has an index hole in the jacket at about one o'clock and the double sided has its hole at two o'clock, looked at on the label side with the label up.

Most double sided drives have two sets of index optics and a 'flip-flop' which asserts a line at the interface when the second set detect pulses. In the pod, this line goes through to the READY 2 l.e.d.

Usually the drive will drop its ready line if 'Side 1' is selected when the flip-flop is reset.

Double sets of index optics which are OR'ed at the interface can produce a slight problem with the RS Exerciser when used with certain types of CE disc. As mentioned above, index pulses are used to trigger the CE ADJ programme cycle and double sided CE discs usually have two index holes punched in the jacket so that both sets of optics can be adjusted. This means that two index pulses come through to the interface for each revolution of the disc, preventing the clear superimposition of the stepped-out and stepped-in patterns at the scope. The soltion is to cover one of the holes with a write protect tab while the test is in progress.

8. DRIVE PROBLEMS.

8.1 The Mains Filter.

All the major problems that occur with 5¼" drives will be found with their 8" counterparts. There are one or two special cases. Most 8" drives have mains powered motors which means that the enclosure in which they are mounted often has a filtered socket for mains input. What is occasionally forgotten is that all equipment with mains filters MUST be earthed.

Most consist of inductors in series with the two mains feeds, with capacitors before and after each inductor, which are tied to chassis. These capacitors form a potential divider across the mains, placing the chassis (if unearthed) at around ½ mains potential.

Moreover, the actual capacity of the enclosure can be substantial, so at the moment when the chassis finds earth quite a large current pulse can flow. If the drive is connected to the RS Exerciser with the 0V testpoint taken to an earthed scope, it is by no means certain that one of the interface grounds will make first. A substantial current pulse may flow through one or more of the interface lines resulting in destruction of the devices driving the lines in both the drive and the RS Exerciser.

Exactly the same symptoms can occur with an earthed enclosure and an unearthed scope. In both cases, ensuring that the grounds are made through the RS Exerciser supply pins first makes sure that no large currents pulse can flow.

8.2 Skew and Media Flutter.

As mentioned above, skew, or the winding up of the media within the jacket because of high friction is more of a problem with 8" than 5¼" drives. The main cause, high stabilising pad pressure, can be relieved by lowering the force on the pad, but if this is taken to excess the converse problem of media flutter will appear.

When the head is restored and the disc surface viewed through the slot under strong reflected light, the surface can be seen to be rippling gently. These ripples are smoothed out just under the head by a combination of the stabilising pad and the top/load pad pressures.

If the stabilising pad is retracted entirely, the top head or load pad will tend to bob up and down giving variable pressure on the gap resulting in heavy amplitude modulation of the read signal.

The modulation can be differentiated from simple eccentricity because the latter gives a similar pattern for each revolution of the media whereas flutter is far more random.

Very occasionally the media itself is at fault, especially when it is new. In manufacture, both active faces of the disc are burnished after the coating has hardened. If the burnish has not extended quite far enough out from the central hole, the read voltage from the outer few tracks will be seen to have substantial amplitude modulation.

Comparison with an old disc will show if the problem comes from the stabilising pad, eccentricity or burnishing. Leaving the faulty disc with the head loaded and cycling over the outer tracks for an hour or more, often improves the read consistency but the head should be cleaned afterwards in case it has picked up any surplus coating.

9. CE DISC TYPES FOR 8" DRIVES.

As with the 5¼" types, there are two types of 8" CE discs, the Analogue and the Digital. The analogue type uses two eccentrically written tracks to produce the alignment track, the digital uses stepped-in and stepped-out bursts for the same purposes (see sections 5.1 & 5.2).

9.1 The Standard Analogue Alignment Disc.

This disc usually has some, or all, of the following patterns. (Hex values in brackets).

Track 00: A band of single frequency, usually 125 kHz (all zero's for FM modulation) recorded with a fairly narrow trackwidth so that eccentricity can be spotted as an amplitude variation as the disc turns. The pattern also identifies track zero.

Track 1: A short burst of tone recorded 200μs after the index hole has passed its nominal point. The index sensor is set up so that the falling edge (first edge) of the pulse at the INDEX testpoint is 200μs before the start of the burst.

Track 38 (26): The alignment track, recorded by writing zero's on tracks 37 and 39 with the disc turning one track width eccentric relative to the centre line through the index hole and central hole. The direction of eccentricity is opposite for each track. When the head scans the centre line of track 38, it will receive equal contributions from the two adjacent tracks. Its position is therefore adjusted to give equal heights to the two lobes produced by the counter-eccentric tracks.

Track 74 (4A): Another band of all zero's for amplitude comparison with track zero.

Track 75 (4B): A band of all one's (250 kHz) to check the frequency response and jitter of the read amplifier. Any serious fall in output compared with track 74 indicates that the head may be dirty or worn or there is a fault in the read amplifier.

Track 76 (4C): The azimuth track. The signal starts with a short burst of tone recorded with the same index setting as track 1. The next burst is recorded with the 24 minutes of the arc askew to the disc's centre line clockwise. The next burst is recorded with the 12 minutes of arc clockwise. The next burst with 12 minutes anti-clockwise and the last with 24 minutes anti-clockwise. If the azimuth is perfect, the two centre bursts will have the same amplitude. An azimuth error of 12 minutes will cause one of the outer pairs to have the same amplitude. The direction of error is given by the pair in question.

Because the alignment track uses eccentricity for alignment, any inherent eccentricity will cause the resulting setting made to be incorrect. The degree to which the head is mis-set depends on the direction and magnitude of the eccentricity.

As track zero is recorded with a fairly narrow track width, any obvious amplitude modulation shows up the problem. If the disc is engaged several times with the head over track zero, it will often be seen that some engagement are very much better than others.

At the same time, where eccentricity is very obvious, the central cone may be seen 'stirring' in the spindle cup. This problem is always very much worse if the disc is engaged with the motor static (dead loading). Dead loading on 8" drives is to be avoided at all costs because the resulting deformation of the centre hole is the disc may mak it run so badly as to be unreadable.

To check on skew, the index timing between the start of burst on track 1 can be compared with the start of the much shorter burst on track 76. Any major variation (more than 50μs) may indicate too much stabilising pad pressure.

9.2 The Digital Alignment Disc.

The European digital alignment disc has some or all of the following patterns. (Hex track numbers in brackets).

Track 00: A track of all zero's recorded with a gap at the nominal index point. To set index, the falling edge (first edge) of the index pulse is set to be 1100μs before the end of the erased section. The track format also allows track zero to indentified.

Track 34 (22): The azimuth track. A complex pattern which starts with three bursts very close together in a group. This group is repeated a total of 6 times for one revolution. The first of the bursts is all one's (250kHz) immediately followed by a burst of zero's (125kHz) and immediately followed by all ones again. There is then a gap followed by a pair of bursts of zero's, the first of which is recorded with the head 24 minutes of arc askew clockwise to the disc's centre line and the second 24 minutes anti-clockwise. The pattern then repeats. To check on azimuth, two pairs of askew bursts on opposite sides of

the disc are chosen and the difference in amplitude between adjacent bursts is summed.
The use of bursts of one's and zero's between the azimuth burst gives a simple means of checking jitter which more closely results on real data than single tones.

Track 36 (24): The alignment section. As on the azimuth track, there are 6 triplet bursts of one's, zero's and one's at regular intervals round the track. Between each triplet are a total of 6 bursts of zeros, the first of which is recorded with the head stepped about ½ a track towards the centre hole; the next is recorded with the head about ½ a track towards track zero and the next ½ a track in again and so on for a total of 6 bursts, followed immediately by the next triplet of one's and zero's.
The great benefit of this method of difining alignment is that the effects of eccentricity can be compensated for by sharing errors for worst case sets of stepped-out and stepped-in bursts at opposite sides of the disc. It is also a very much more sensitive test pattern as far as a quick glance at a scope in the electrically noisy environment is concerned.

Track 76 (4C): A second index alignment track identical to track zero allowing the degree of skew to be checked. It also provides a useful reference for the fall in amplitude between the low and high tracks.

10. POWER FOR THE RS EXERCISER WITH 8" DRIVES.

As the RS Exerciser is chiefly used with 5¼" drives, the normal daisy chaining of power through the unit with 8" drives is not possible because the power connectors are incompatable. However, as the unit only actually requires the 5V supply to be present, all that is necessary is to provide a link between pin 4 of the power cabsle and any point on the drive where access to the logic supply can be gained. The multiple ground lines on the interface cable provide a more than adequate supply return.
The only danger to watch for when selecting a point for the supply is that 8" drives use some quite unfriendly voltages, such as – 15 volts and +24 volts and, of course, mains. This should be borne in mind when probing around for a supply point.

11. USING THE RS DISC DRIVE EXERCISER WITH 3½" DRIVES.

The Sony Compatable 3½" drives come in much the same varieties as 5¼" types and most of them are plug compatible with their counterparts. The types are:

a) 40 track single sided, (125k single density, 250k double density. 80/160k).
b) 40 track double sided, (250k single density, 500k double density. 160/320k).
c) 80 track single sided, (250k single density, 500k double density. 160/320k).
d) 80 track doubled sided, (500k single density, 1M double density. 320/640k).

The drive may be referred to by its capacity which is usually an expression of the unformatted storage capacity. Alternatively the capacity may refer to a specific format, the one giving the last figures above being 16 sectors of 128 bytes for single density and 256 bytes for double density.
The drives are very much smaller than their 5¼" counterparts and, to save space, the interface frequently uses open pin header connectors rather than the usual board edge connector found on the 5¼". Open pin headers have no easy method of polarisation so it is important to check that the interface lead is connected the right way round before inserting any valuable discs into the drive. If connected the wrong way round, all input signals are activated, including 'Write' and 'Motor' so, with a dual head drive, wherever the head happens to be will be, a whole track will be erased on the top surface, with single headed types, the same may happen on the bottom surface.
With certain drives, the numbers on the p.c.b. should be used as a guide to the position of pin 1 rather than the standard triangular mark found on ribbon connectors. On some drives the triangular mark indicates pin 34.

The setup procedure for 3½" drives follows closely the same general pattern as 5¼" and the relevant sections of this manual can be followed to guide the operator through matters such as scope connection etc. (See sections 1 to 4 and 6).
The one overriding point to bear in mind is that, alignment adjustment, on the 80 track 3½" drive particularly, is quite a tricky affair requiring considerable patience and a certain amount of dexterity.
Owing to the very fine track pitch (around 7½ thou) and the usual use of band positioners with single turn stepper motors, alignment requires setting the stepper motor's angular position to within 8′ 38″ or 0·144° and twice this tolerance on a 40 track drive.

Even on the 40 track unit, this is a formidable task and can only be done satisfactorily with the correct setting tool. The tool usually takes the form of a screwdriver shaped implement which has a splined body and a cylindrical projection at the tip.
The tip is engaged in a hole in the main casting and the splined engaged with a small toothed projection on the stepper motor body. When the bolts holding the motor to the casting are eased slightly, the motor can be rotated to bring the head onto the correct centre line of the alignment track. Fortunately, the 'CE ADJ' programme can be run during alignment which cuts down the number of tries needed to get a good setting.
After setting, the bolts should be tightened slowly with the setting tool holding the motor's position as static as possible. The tightening nearly always causes slight misalignment but the tolerance should always be taken into account before deciding whethr to have another attempt at adjustment.
Phase detection of track zero is always used on 3½" drives and the motors are usually four phase so section 3.1 should be consulted before adjustment is attempted.

11.1 Setup for Standard Drives.
First check the alignment disc instructions as to which tracks are used for the various patterns. There are various types, some of which will use the same track numbers as their 5¼" counterparts. There are some special types which use combined patterns for alignment and azimuth. These types usually have different track assignments as follows: (See 11.2 for access to these tracks).
On tracks 2, (4), 20, (40) and 38, (76); there is a mixed pattern which consists of the following pulses, (80 track drive positions in brackets);
The first pulse is a short burst whose rising edge is 1ms after the initial edge of the index pulse, (for index adjustment).
The next two pulses are recorded with the head stepped out half a track pitch for the first and in half a track pitch for the second, (for head position alignment).
The next four pulses are recorded with the first 45′ of azimuth error clockwise, the next 15′ azimuth error clockwise the next with 15′ error anti-clockwise and the last with 45′ error anti-clockwise, (for azimuth checks).
The pattern of the alignment and azimuth pulses repeats eight times round the disc so that any skew or eccentricity can be checked.
The patterns can be quite confusing until analysed carefully and this is best done by means of very gently offsetting the head position when the relevant track is accessed.
As a general rule, the easiest way to do this is to take a thin non-conductive probe (a plastic trimming tool is ideal) and press this gently on the upright part of the head carriage visible from the rear of the drive, whilst watching the display on the oscilloscope.
As this is done, certain pulses will be seen to change amplitude very much more than others, these pulses are the alignment burst pairs and it is these which we require to get adjacent bursts to have as close as possible to the same amplitude all the way round the disc.
Eccentricity is shown by the fact that some pairs match while others, later on in the index-to-index scan, do not. As a scan with index pulses just visible at the start and end of the trace is showing one full rotation of the disc, we can see that the position adopted by the disc is correct at one or two points in an eccetric rotation and out of true elsewhere. Where this sympton is found, the disc should be disengaged and re-engaged several times until the eccentricty is minimised.

On 3½" drives, one other positional error can be particularly marked, that is an error where opposite sectors of the disc can be seen not to have opposite eccentricities, but errors in the *same* direction. The track is seen to be oval and not miscentred.
The effect should only be noticed when the relative humidity is very high. For example, when the alignment disc is taken directly out of a very cold environment (an equipment case in the boot of a car which has been standing all night in wintery weather) and is placed straight into a drive in a warm room. Moisture condenses on the cold medium and causes the disc to expand in a non-linear manner. The reason for the effect is that the film from which the disc was made is an extrusion and has its long chain molecules partially aligned in the direction of the original flow. As water molecules enter the polymer, they will cause expansion but because the film is not symmetrical across its surface, the expansion will be greater in the direction of alignment.
The effect is small but where the tolerances on alignment are as critical as those found in 80 track 3½" drives, they can become not only visible but actual sources of error.
The solution is to ensure that all discs and alignment discs in particular are allowed to aclimatise themselves to any sharp change in ambient before being used.

11.2 Access to Special Tracks.
The default step speed button (24/MAX) is now a 'shift' key on the track selection table. When held down while switching from 'PASSIVE' to 'ACTIVE', the track table is shifted to a set appropriate to the new alignment disc. The button need only be held down once because the new selection is only disabled when the power is removed.

11.3 Speed Selection.
The 3½" drives are usually capable of stepping more quickly than their 5¼" counterparts so stepping at 3 or even 2·25ms is often possible. To select the speed, either both the shift and required speed buttons are held down together while switching 'PASSIVE' to 'ACTIVE' or each selection is made individually during two 'PASSIVE-ACTIVE' transitions.

11.4 Index Adjustment.
As there is no hole in the disc, index is generated by clamping the disc in a fixed relationship to the spindle and generating the pulse from the spindle mechanism rather that the disc itself.
The methods of generating the pulse vary, but the most usual is to fix a small magnet to the motor hub and sense its passing with a 'Hall' effect device. Where this type of sensor is found and a screwdriver is used to slacken off the bolts holding it, the screwdriver should be removed from the vicinity before taking a reading as, if it is magnetised, the screwdriver may have a slight effect on the sensor and may change the aparrent position of the magnet and hence the index pulse.
Another technique is to sense a small mark on the motor hub optically and here, any dirt on the optics or hub must be removed completely before any change to the setting is made.

11.5 Write Protect.
There are two methods of write protecting 3½" discs, one optical and the other mechanical. They are incompatable in that discs with a mechanical write protect tab, cannot be protected on an optical system. The difference between the two can be seen at the bottom left hand corner of the case.
Discs designed for optical protection have a rectangular hole through the case which can be covered by a small slider. The mechanical protection type has no aperture through the case but a small tab moulded into the base which is broken off when the disc is to be protected. The write protect slider on optical discs is constructed so that it will activate the mechanical microswitch correctly but, apart from drilling holes in the case, there is no way for the mechanical version to activate the optical write protect gate. Needless to say, drilling holes in the case is not a good idea.

11.6 General Mechanical Points.
The shuttered case disc has been proved to be a fairly reliable structure for single sided drives although there have been some early problems with the reliability of double sided types. The head has to be very well out of the way before loading and unloading takes place and there have been a number of early head crashes on prototype double sided drives. Currently, almost all of these snags seem to have been ironed out.

The special mechanism in the drive for interlocking the head engagement with the shutter has been found to give a few problems but, as with 5¼" drives, the worst enemies of such mechanisms have been found to be dirt, excess lubricants and case fans pointing in the wrong direction, (sucking air in rather than the correct technique of blowing filtered air out through the drive). Where the dirt is also abrasive, premature wear can occur giving jamming and intermittent poor loading.

Certain discs have a latch mechanism which allows the shutter to be locked back so that the surface can be examined, and these should always be checked for proper closing when withdrawn from the drive. If there is a tendency for the shutter to stay open, this indicates that the shutter opening mechanism needs adjustment, as it is trying to push the shutter too far.

Fortunately, the mechanism found in 3½" drives is so complicated that the unexperienced operator tends to leave it alone. There is little or no access to most of the moving parts so the probability of finding drives for service which have been 'got at' is less than in larger drives.

It is however important to ensure that there are no obstructions in the path of the media when it enters the drive because there is always a danger that the interlock can be fooled and the head damaged.

On the plus side, the rigid jacket prevents the medium from flexing and damaging floating heads; on the minus side, if the disc surface does get contaminated, it is difficult or impossible to clean it and, if the contaminants are either oily or sticky, head damage is very likely indeed.

The 3½" drives operate at around 50% higher flux change density and have a track width which is 25% less than a similar capacity 5¼" drive. The media surface perfection has to be around 90% better than the larger drive and this means that any suspect media can cause very severe problems. Similarly, any dirt on heads will case poor performance almost twice as soon as with 5¼" models.

Head cleaning must be done with a disc rather than the dangerous practice of cotton wool buds and iso-propyl alcohol. On double headed units, *both* heads float so both are liable to damage by getting edges caught in worn fabric type cleaners. With abrasive type cleaners the correct cleaning cycle *must* be adhered to and the cleaner must *never* be left in the drive for more than a few seconds.