HANDBOOK ©

CK10

ONE TONNE TESTING MACHINE

FOR MICRO-CRACK DETECTION,
EDGE TOUGHNESS TESTING,
VICKERS HARDNESS TESTING,
3 & 4 POINT BEND TESTING,
COMPRESSION TESTING

by
ENGINEERING
SYSTEMS (NOTTM)

Issue 3, Feb 2001

REF.	CONTENTS	PAGE

REF.	CONTENTS	PAGE

REF.	CONTENTS	PAGE

DIAGRAMS & FIGURES

1. INTRODUCTION TO THE CK10

The CK10 is a one tonne benchtop testing machine and was designed by Engineering Systems in conjunction with Oxford University, Department of Materials. It was specifically designed for the detection of micro-cracks in ceramic materials. This and other uses are outlined below.

1.1 FEATURES

CAPACITY: The standard load range capacity is 0 to 10,000 Newton's (0 to 1,000kg) and a peak hold facility is built in so that the maximum load can be captured, held and displayed.
ACOUSTIC SENSING: An acoustic sensing facility is built into the machine. The machine is supplied with an acoustic sensor which has a centre frequency of 90kHz.
UNITS: A choice of units i.e. N, kg or lb. is available and can be selected by operation of the UNITS button (see later).
DATA OUTPUTS: Outputs of Test Results, Analogue Load, and Acoustic signal are provided at the rear panel of the machine.
OVERLOAD: Overload & over-travel protection is built into the control electronics.
ERROR MESSAGES Are displayed on the LCD if test procedures are incorrect. i.e. the guards are not closed, the load cell has become unplugged etc.
TOOL DRAWER: Situated underneath the machine, contains the Handbook and some essential tools and equipment.

1.2 USES

1.21 MICRO-CRACK DETECTION IN CERAMIC & BRITTLE MATERIALS

The CK10 can determine surface flaws by Hertzian Indentation. A hard ball, preferably of the same material as that which is being tested, mounted underneath the load cell, is pressed onto the surface to be tested and the load is increased. The contact zone between the ball and the specimen, increases in size with increasing load. A stress field is created and if this field intercepts a surface flaw above a certain size, the crack will extend abruptly around the contact zone to form a ring crack. This event is detected by the inbuilt acoustic sensor. The ring crack diameter is measured by using the curtain microscope. The materials constants for the material under test must have been entered correctly into the machine (see later). The CK10 can now work out (by an iterative process) the original flaw size. See Appendix 4 for the equations.

1.22 DETERMINATION OF FRACTURE TOUGHNESS

The above testing technique can be used to obtain a value for Fracture Toughness. This traditionally 'difficult to measure parameter' can be determined without having to pre-crack the specimen. The only measurement is the loads at which a series of ring cracks form.
A value for K_{IC} can also be obtained from the following testing technique.
See Appendix 5 for further details.

1.23 EDGE TOUGHNESS TESTING OF BRITTLE MATERIALS

This method was developed by the National Physical Laboratory in Teddington, London, England. The Edge Toughness (or resistance to chipping) of hard and brittle materials, such as cutting tool tips, can be determined by applying a point load (provided by a polycrystalline 1200 Rockwell C indenter) at a small (0.3 to 1mm) from the edge of a specimen. If the material is brittle, this loading will eventually cause the edge to fracture and form an edge flake. The Edge Toughness can be determined by dividing the loading distance from the edge, by the chip fracture load.

1.24 PROOF TESTING

This can be carried out for both micro-crack detection and Edge Toughness. The specimen is loaded with loads which are below that which are expected to produce cracking or fracture.

1.25
3 & 4 POINT BEND TESTING

This can be carried out by using the optional Bend rig. The bottom contacts are either ∅3mm or ∅8mm rollers which rotate in needle roller bearings. Very small specimens can be tested when using the ∅3mm rollers.

1.26 CRACK TESTING OF COATED SURFACES

Surfaces which have been coated with hard materials can be tested for bonding by 3 or 4 point bending.

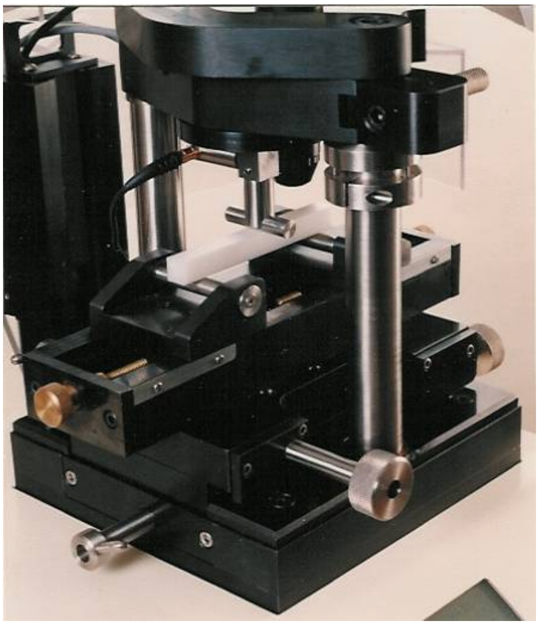

Figure 2

The acoustic sensor can either be attached to the specimen itself, or it can remain in its normal position between the load cell and the centre bend point. The acoustic sensor output can be used to detect the onset of cracking.

1.27 COMPRESSION TESTING

Compression testing up to 10kN can be carried out in the normal way, with the specimen being placed onto the bottom table and the crosshead moving downwards to apply the load.

1.28 BASIC HARDNESS TESTING

With the standard 1000kg load cell fitted and a Vickers hardness indenter installed, an approximate value for the Vickers hardness can be obtained. If the optional 100kg load cell is fitted, a more accurate value is achieved.

1.3 SPECIFICATION

Maximum Load	10kN or 1000kg
Load accuracy	Better than +/- 0.2% FSR
Load resolution	1 Newton or 0.1kg (1000kg load cell)
X table travel	50mm
Y table travel	25mm
X-Y travel resolution	0.01mm
Width between pillars	100mm
Crosshead travel	50mm
Test Speed range	0.02-3mm/min.
Power requirements	110/120 V a.c. 3.15A or 220/240 V a.c. 1.6A
Machine dimensions (including microscope)	Width 415mm, Depth 350mm, Height 550mm, with crosshead at top of its travel
Machine Weight	35kg

SPECIFICATION NOT BINDING TO DETAIL AS IMPROVEMENTS ARE INCORPORATED FROM TIME TO TIME.

2. USING THE CK10 MACHINE

Before using the machine the operator should be familiar with the various front panel controls which are described in Chapter 3.

2.1 SPECIMEN MOUNTING For ring crack testing, flat specimens could be tested by simply placing onto the CK10 X-Y table base and then testing. To save the table base from possible damage it is preferable to use an intermediate parallel plate between the specimen and the table. In some circumstances, it may be best to attach the specimen to the base. Four M5 holes and two ∅5 dowel holes are provided for this purpose. For this and for mounting various asymmetrical shaped specimens, individual mounting fixtures will have to be designed and manufacture arranged, by the user.

For micro-crack detection in ceramic & brittle materials, the following is a typical testing sequence when using the automatic mode.

2.2 SETTING UP

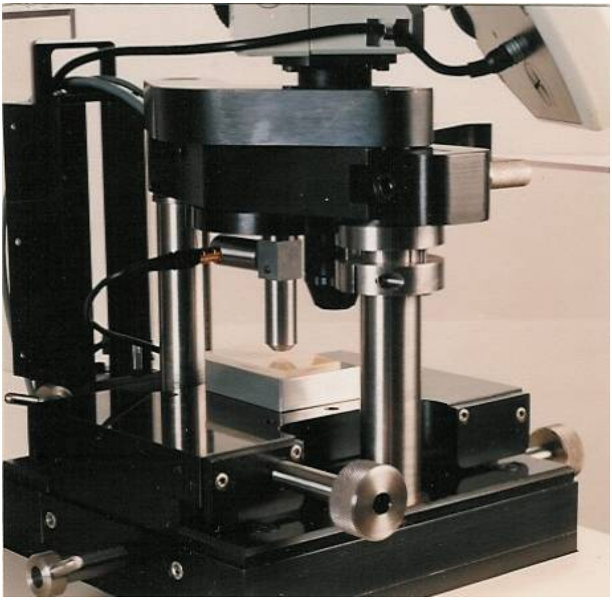

Figure 3

Make sure that the CK10 is set for Ring Crack Size calculation. This is indicated by the LCD display showing BALL SIZE = XXX) on the bottom line. (See section 3.4 for test mode selection). Having raised the crosshead sufficiently, by using the fast up button (manual crosshead control), install the specimen onto the X-Y table.

If not in AUTO mode (as indicated on the LCD display) press the TEST MODE button so that AUTO is displayed.

With the correct indenter installed, press the NEW SIZE button. The crosshead will move fast down until a small load (approx. 30 Newton’s) is detected by the load cell. (This approximate 30 Newton load is also the minimum load at which fracture can be detected). At this point the crosshead reverses and after a very short upwards movement, the crosshead again reverses direction and moves downwards but this time at a slow speed until a 30 Newton touch is detected.

This enables a more accurate height setting to be gauged. The crosshead then moves fast up (approx. 1mm) to its preset return position. Set the desired FRACTURE MODE using the Fracture Mode button situated behind the front flap.

2.3 TESTING for MICRO-CRACKS

Position the specimen to its desired position by using the X-Y table.
Press TEST. The crosshead now moves downwards at fast down speed until it is a small distance from the specimen. So that the final approach distance setting is accurate a slower downward speed is automatically engaged until the ball/indenter is within 0.1mm of the specimen. At this point the Load display is zeroed, if necessary, the Peak Hold lamp becomes active and the set test speed is engaged. Downwards movement continues until a fracture is detected. At this point the crosshead rises to its preset return position.
If an acoustic fracture (hence ring crack has been formed) has been detected, pressing the ENTER button enters the crack size calculation procedure. The ENTER lamp becomes illuminated and the LCD display changes to show only the microscope readings. At this point the machine is waiting for a 'microscope input'.
Turning the microscope curtain adjusting knob switches on the microscope lamp, continue turning the knob until the LH curtain is positioned directly over the LH side of the ring crack. Press the ENTER button again.
Move the RH curtain to align with the RH side of the ring crack and press the ENTER button. This enters the ring crack size into the machine and the crack size is now calculated and displayed on the LCD.
See Appendix 4 for details of the crack size calculation.
The machine is now ready for another test sequence but until the ENTER or TEST button is pressed the machine is otherwise inoperable. Press ENTER to return to the full LCD display or press TEST to by-pass this stage and immediately start another test.

2.4 EDGE TOUGHNESS TESTING

Mount a 1200 polycrystalline diamond indenter and adaptor into the load cell. With the specimen firmly mounted and the crosshead in its test position, bring the crosshead down and near to the specimen; then use the slow down button to touch the indenter onto the specimen whence the crosshead automatically stops at a very low load & returns. Swing the microscope into place and search for the very small indent. (If an indent cannot be seen, it will be necessary to apply a larger load by positioning the crosshead, pressing the TEST button and allowing a larger load to produce a visible indent. Stop the loading at a suitable load by pressing the RETURN button). When a small indent has been detected, use the microscope adjusting knob to position one (say the RH) of the microscope curtains directly over the indent.

This procedure has set the curtain to be coincident with the indenter centre. Do not now move the microscope adjusting knob.
Use the X table adjusting knob to position the RH curtain directly over the edge of the specimen, and press the X-zero button. Wind the X table so that the curtain (hence the indenter) is the desired amount (0.3 to 1mm) from the edge of the specimen. Swing the crosshead into its test position and follow the testing procedure as described in 2.1 and the 1st paragraph of 2.2 above. When fracture has occurred the peak load is displayed on the LCD. Dividing this peak/fracture load by the set distance from the edge gives the edge toughness.

2.5 VICKERS HARDNESS TESTING

Install a Vickers Hardness Diamond Pyramid Indenter into the special adaptor which fits into the load cell. Using the ALT button, set the test mode to HARDNESS. 'Vickers Hardness' should then be displayed on the bottom line of the LCD, in place of 'Ball Size = XXX'. Then adjust the Maximum/Hold to the loading required, A 15 second load hold delay is automatically set when the hardness testing procedure is entered (a different hold time - up to 899 sec - can be set if required). It may be better to use the machine with FRACT set to LOAD, as this will disable any possible stray acoustic signals interfering with the hardness testing. Follow the above (2.1 & 2.2) procedure, but measure the diagonal size of the indent (instead of the Ring Crack). The hardness is then calculated by the CK10 and displayed on the LCD and/or printed out on the printer.
The CK10 uses the standard formula for calculating the Vickers Hardness. This is:-
Vickers Hardness(H) = $(2 \times \text{Load} \times \sin \theta/2) \div d^2$
Where d = diagonal measurement of the impression mm,
Load is in kg, and $\theta = 136^O$ = Angle of the indenter point.
Therefore H = $\text{Load} \times 1.8544 \div d^2$

2.6 MECHANICAL ADJUSTMENTS

The microscope must be positioned so that the crack or indent image appears approximately central within the microscope's field of vision. The microscope and hence the image position can be moved by loosening the three 3mm hexagon screws which are situated underneath the swinging beam to which the microscope is attached. A further two screws are provided to provide contact points to assist in positioning. These two horizontal screws are situated on the front RHS and the front LHS side of the swinging beam.

To adjust:- create an indent or crack. Loosen the three screws underneath the microscope, with the microscope positioned over the indent, adjust the two horizontal screws and push the bottom of the microscope body leftwards. Repeat and when the correct position has been found, tighten the three microscope retaining screws.
Ring cracks can be difficult to see. Changing the angle and brightness of the light shining onto the crack can improve the visibility. The position of the microscope lamp filament can be adjusted by loosening the two knurled knobs on top of the microscope and then moving, by turning or pushing in or out, the larger thumbscrew just to the left of these screws. The optimum position is found by trial and error. The lamp brightness can also be changed by adjustment of pot 2, see 3.34

2.7 CHANGING THE LOAD CELL

For special purpose testing, the load cell can be mounted directly onto the load frame base. Normally however, the load cell is housed underneath and within the top swinging yolk. It is retained by a collar and four screws (underneath) which can be removed with a 3mm hexagon key. When the screws have been removed, the load cell should be loose and can be removed and replaced. The load cell must be recalibrated, see chapter 6.

2.8 COOLING FANS

Some electronic components become hot with continuous use. This is quite normal for certain 'power components'. The motor amplifier and the microscope lamp voltage regulator will become hot if the machine is used continuously. Miniature thermostatically controlled cooling fans have been installed within the machine to cool these components and the fans may switch ON and OFF at any time whilst the machine is being used.

3. DESCRIPTION OF THE FRONT PANEL CONTROLS

A 40 column by 4 line Liquid Crystal Display (LCD) shows the data relating to the current test set-up. This default output is replaced, as necessary, by specific instructions or data. See section 3.1
The Main Controls comprise of fifteen push button membrane switches. These are situated on the front panel and control the normal operation of the machine. See section 3.2

Secondary Controls and adjustments are situated behind the flap, on the front of the machine, and are explained in detail in section 3.3.

The photograph shows the Main Controls and the Secondary Controls. The Secondary Controls have been exposed by opening the flap. A brief version of the operating instructions are displayed inside the flap.

Figure 4

3.1 DEFAULT LCD DISPLAY

The following gives a brief description of the normal LCD display, see later for a more detailed discussion of the adjustments which are available.

TN This shows the TEST NUMBER in the current batch of tests. The Test No. is only incremented when the machine is used in the AUTO MODE. To clear the Test No. to zero, press the zero Z button.

DISTmm This shows the X & Y table distances and the Z or Crosshead Position. This Z position is the absolute position of the Crosshead relative to its end points and is provided for convenience. i.e. if tests are being carried out at the ends of the range of travel, spacers may have to be used, either placed under the specimen or as extension pillars.

MAX/HOLD The MAXimum or HOLD load can be adjusted by turning one of the calibration potentiometers situated behind the front flap.

HOLD Shows a hold time in seconds. The HOLD button doubles as a % Overload facility, this is displayed as:- OV/LD.

PK/LD Displays the peak load from the last test which was carried out.

MODES - TEST can be set to MANUAL or AUTOMATIC:

Manual, The user controls the crosshead position by using the fast up and down buttons. Pressing the TEST button starts the crosshead moving downwards at test speed.

Automatic, If a series of tests are to be carried out on identical specimens, the Automatic setting allows automatic detection of the specimen height and gives a set return distance after each test.

FRACT Fracture detect can be either by the acoustic emission fracture detect facility or by % drop from peak load or both.

START The test can be started either by pressing the TEST button or by closing the GUARD.

T.SPD This shows the set test speed

BALL DIA. This shows the ball diameter which is currently being used.

PRT ON/OFF, the printer output is enabled or disabled.

3.2 MAIN PANEL CONTROLS

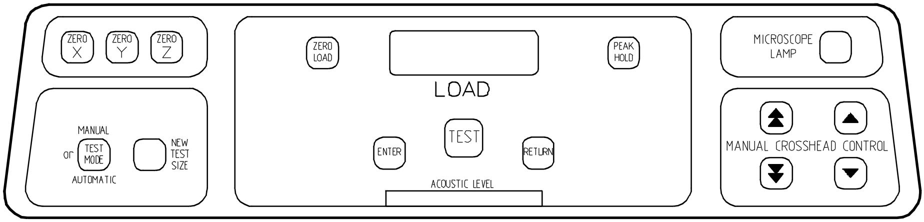

Figure 5

LOAD DISPLAY Displays the current load detected by the load cell which is situated in the crosshead assembly. The units, which can be changed (see later), are also shown.

ACOUSTIC LEVEL BAR GRAPH This is provided so that the filtered & damped acoustic emission output can be viewed. i.e. the filtered output from the sensor logarithmically illuminates the bars.

ZERO X & ZERO Y Pressing these buttons zeros the X or Y tables

TEST MODE - Can be set to:- MANUAL or AUTOmatic:

Manual mode, The FAST UP & DOWN buttons can be used to drive the crosshead up or down to the required starting position, When the ball/indenter is close to the specimen, pressing the TEST button starts the crosshead moving downwards at its set test speed. When a fracture (acoustic or load) is detected, the crosshead will move upwards, a small distance (0.4mm).

Automatic mode, If a series of tests are to be carried out on identical specimens, the automatic setting allows automatic detection of the specimen height and gives a set return distance after each test (see next paragraph). Pressing the Test button causes the crosshead to move downwards at fast speed until it is a short distance from the specimen. At this point, the speed changes to medium down speed and after a short time to Test Speed. The crosshead continues at this speed until a fracture is detected. Then the crosshead returns a preset distance (see below).

NEW TEST SIZE (This only operates when in AUTOMATIC MODE) Pressing this button starts the sizing procedure which automatically sets up the test and return position for a new batch of tests. See USING THE MACHINE for a more detailed explanation.

ZERO LOAD Zeros the load display. This facility also operates when the machine is first switched on and also if the load reading has drifted by more than a few digits.

PEAK HOLD When the peak hold button is illuminated, the peak hold is engaged, the peak hold is automatically engaged when a test is commenced. Sometimes it may be necessary to disengage the peak hold i.e. when calibrating. Pressing the button disables (or engages) the peak hold.

ENTER
The guard and the crosshead clamp must be open otherwise the calculation will be abandoned.
Stage 1. Press this button when it is required to measure a ring crack size or hardness value and subsequently calculate the micro-crack size or hardness. The load units must be set to Newton's(Ring Crack) or kg(Hardness).
Stage 2. You are prompted to set the LH curtain in alignment with the LH side of the ring crack. This is achieved either by turning the microscope cursor knob or by moving the X-table. Movement of the microscope cursor knob causes the microscope lamp to illuminate. The lamp will automatically switch off approximately 100 seconds after the last time that the knob has been moved. Press ENTER to zero the LH curtain.
The ENTER procedure can be abandoned, whilst waiting in stages 2 or 3, by closing the crosshead clamp.
Stage 3.You are now prompted to set the RH curtain in alignment with the RH side of the ring crack. When this has been done, press ENTER to register the result.
The CK10 now works out the micro-crack size, using the above result and the materials data which is stored in the CK10. After a short period, the micro-crack size is displayed on the LCD.
Error messages are displayed if the calculation has failed. In this case, check that the materials properties, including Ball diameter are correct.
The results are also output via. the rear RS232 output, in the form:-

P = Fracture Load in Newton's
2a = Contact Diameter in mm
d = Ring Crack Diameter in mm
x = Micro Crack size in m.

If the printer is ON, the above results are also printed.
Stage 4. To exit, either press ENTER again or, if another test is to be carried out, press TEST to exit and immediately start a new test, or, close the guard when the new test position is ready.
The microscope lamp is automatically switched OFF at this stage.

TEST The peak hold is reset and the crosshead starts to move downwards in the chosen test mode (see above). However, before the crosshead motor is allowed to start, various checks are carried out by the CK10. These are:- Acoustic setting, Maximum load setting, Crosshead clamp and Guard position, Load cell zero. Messages are displayed on the LCD if errors are detected.

RETURN Pressing this button at any time during a test sequence will abort the test and return the crosshead to its preset position.

MICROSCOPE LAMP This switches the microscope lamp ON. The lamp is automatically switched OFF after approx. 100 sec. This switch does not work when in the ENTER mode, the lamp can then be switched on by a slight movement of the microscope curtain knob. Also the lamp cannot be switched on when the crosshead clamp is in position, furthermore, if the lamp is on and the crosshead clamp is subsequently closed, the lamp will automatically be switched off.

The above 'lamp saving' features are necessary because the lamp consumes a comparatively large current causing heat to be generated on the main electronic board. The heat generated is dispersed by a fan, however, minimising the use of the lamp is good housekeeping because it generates less heat.

See section 2.6 for optimising the lamp position.

MANUAL CROSSHEAD CONTROL The crosshead can be moved fast & slow, up & down by pressing these buttons. Fast speed is approx. 60mm/min. and Slow speed is approx. 5mm/min. Overload & Over travel protection are built in.

3.3 CONTROLS SITUATED BEHIND THE FRONT FLAP

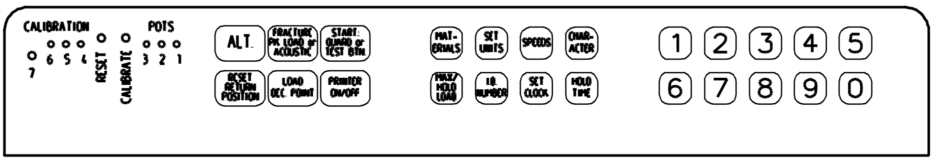

Fig. 6

3.31 THE LEFT HAND SIDE BUTTONS are further machine settings
ALT Enables alternative or special functions menu's - see later under 3.4.
FRACTURE, PK LOAD or ACOUSTIC (or both) Sets the end of the test mode detection method. If in FRACTURE mode, a fracture is detected when a specimen has been loaded up to a peak load and the load then drops below a preset percentage of this peak load. If in ACOUSTIC mode, a fracture is detected after the Acoustic Sensor has detected a signal greater than the preset level (POT1 adjusts).
START: GUARD or TEST BTN. The test can be started either by pressing the TEST button or by closing the GUARD.

RESET RETURN POSITION (AUTOMATIC MODE ONLY) After a fracture has been detected, the crosshead automatically returns approx. 1mm. This distance can be overridden by setting a new position with the MANUAL CROSSHEAD CONTROL buttons and then pressing the RESET RETURN POSITION button to allow this new setting to be retained. This is used for subsequent tests in the series.
LOAD DEC. POINT This changes the position of the LOAD decimal point, for use if the load cell has been changed.
PRINTER ON/OFF Enables or disables the printer.

3.32 THE MIDDLE SET OF BUTTONS, when pressed, are illuminated and stay illuminated until the operation is complete or the button is pressed again. When parameters are being changed, the cursor waits at the start of each value. Pressing the relevant change button, moves the cursor to the next line or exits, if on the last line. Pressing the digit buttons change the numerical values.

MATERIALS When pressed, the screen changes to display the materials constants. These are: Young's Modulus, Fracture Toughness, Poissons Ratio & Ball Diameter. If this button is pressed whilst the machine is first switched on, default values are entered into the machine, i.e.

Young's Modulus (E) =350,000 N/mm^2	Poissons Ratio (PR) = 0.236
Fracture Toughness (KIC) = 111 Nmm$^{-3/2}$	Ball Diameter (d) = 5.00 mm
Test Speed = 1.00 mm/min.	Hold Time = 000 sec
Return Speed = FULL (approx. 50mm/min.)	

The displayed values can be changed by pressing the numeric buttons. Pressing the MATERIALS button moves the cursor to the next line and exits from the last line. Exit automatically occurs when the final digit of the Ball Diameter has been changed. If the printer is ON the results are printed out.
SET UNITS Each press changes the units to one of the three available, i.e. N, kg or lb.
The MAX/HOLD load is also updated to take into account the new units.

SPEEDS When pressed, the display is changed to show the TEST SPEED & RETURN SPEED.
The required test speed (0.01 to 3.00 is allowed) is entered on the numerical keys. An entry of 3 digits is required. The machine will not allow speeds outside the above range to be set. If zero speed is entered, the machine interprets this as being 0.01 mm/min. If a speed above 3 is entered, the machine automatically sets the speed to 3.00.
The return speed can also be set to a value other than maximum. i.e. a slow return speed can be set. This slow return speed will only operate when: a slow return speed is set and the MAX/HOLD load is reached.

Attempted settings greater than 3, will automatically set the FULL return speed. Full return speed will be applied when the load has reduced to approximately zero, whence the crosshead stops when the set return position is reached. When the slow return is operating, the peak hold is disabled, but if an acoustic fracture is detected during the slow return, a bleep is given, the peak hold facility is activated (so that the fracture load is retained) and the crosshead immediately returns at fast speed to its preset return position.

CHARACTER Enables the input of alphabetical characters into the I.D. number.

MAX/HOLD When this button is pressed, the Maximum or Hold Load is adjusted by turning pot 3. The minimum allowable setting for MAX/HOLD is approximately 100N and an error message will be displayed for settings below this level. Note that if pot 3 is turned when not in the MAX/HOLD mode, the updated MAX/HOLD value will not be shown on the LCD. However, the LCD MAX/HOLD will be updated when TEST mode is next entered and any minimum setting errors will then be detected.
If the MAX/HOLD load is reached, with hold time=0, then the peak load displayed on the LCD may be slightly less then the MAX/HOLD load setting. This is because there can be a slight difference between fracture load and maximum load.
If the HOLD time is set to an integer value, the load will be held within 2 digits of the MAX/HOLD load (above) for the set period of time (see HOLD TIME). Pressing the MAX/HOLD button exits this routine.

I.D. NUMBER. Identification of test. A 10 digit numeric number can be entered, this will be printed out on the printer at the start of each batch.

SET CLOCK Starts the procedure for setting or resetting the internal clock. If it is not required to change the clock setting, press the SET CLOCK button to exit the routine. The numeric buttons are used to change the clock setting. The seconds are zeroed each time any of the clock settings are altered but are not changed if the clock routine is exited without making any clock changes. Pressing the SET CLOCK button at any time exits the procedure.

HOLD TIME Sets the load hold time. The HOLD TIME button also doubles as OV/LD (% Overload) facility.
The hold time can be set to any time between 1 & 899 seconds. If the hold time is set to non-zero, the crosshead will remain stationary (after loading) for the time shown before it returns. This will occur after a fracture detect (load or acoustic) or if a MAXimum load has been detected.

During holding, the peak hold facility is disabled but the peak load is retained on the LCD. If the load relaxes (reduces) during the hold time, the crosshead is automatically driven downwards so as to retain the set hold load. The crosshead automatically returns after time up.

% OVERLOAD Sometimes, ring cracks are not fully formed and/or not easily visible. This facility enables ring cracks to be seen more easily - by applying an overload after the initial ring has been formed. The (original) diameter is not affected by this procedure. The initial cracking (peak) load is retained on the LCD and used in the crack calculation routine.
This facility is accessed from the HOLD TIME menu, follow the instructions displayed on the LCD.
Note that the hold time facility is disabled and that overloads will only be applied following an acoustic fracture.

3.33 THE RIGHT HAND SIDE SET OF NUMERIC BUTTONS are used in conjunction with the middle set of buttons for entering the variables such as Speed, Material properties etc.

3.34 ADJUSTMENTS The left hand set of holes in the panel, provide various 'hardware adjustments'.

RESET this is similar to switching the machine OFF & ON again.

CALIBRATE BUTTON When pressed, shows a preset reading on the load display.

CALIBRATION POTENTIOMETERS

POT1. Acoustic sensitivity
POT2. Microscope lamp brightness
POT3. Maximum or Hold load
POT4. % Load fracture detect
POT5. Rear panel load output zero
POT6. Rear panel load output range.
POT7. (set back) Load cell range or calibrate.

ADJUSTMENT OF THE CALIBRATION POTENTIOMETERS

POT1. Acoustic sensitivity. This determines the point at which an acoustic fracture is said to have occurred during a test. Also, if the CK10 is used in a noisy environment, and depending upon the frequency and volume of the noise generated, this could trigger false fracture detects. There are two parameters to be considered:-
1. The expected frequency band of the noise generated by the formation of a ring crack. Experience has shown that lower frequencies, below ~ 60-70kHz are not generated by ring crack formation. The centre frequency of the acoustic sensor supplied with the CK10 is 90kHz, the CK10's electronic circuitry filters out the lower frequencies. This filter is not adjustable by the user.

2. The volume of the noise generated by cracking. The detecting level is adjustable by the user and is described below.

Press button 'ALT' and then numeric button 0 to enter the acoustic adjustment mode. Generally follow the instructions displayed on the LCD. The most sensitive setting is reached when Pot1 has been turned anti-clockwise to the 'quiet point' after the bleep tone was introduced by initially turning Pot1 clockwise. Hysteresis has been added so that the maximum suggested setting is slightly below the threshold acoustic detect level. Also, the motor can be started - to introduce some further noise (more than is generated during testing, because the motor is running faster than the maximum test speed) this slightly decreases the suggested maximum setting. This is the point of maximum acoustic sensitivity.

Settings near to this maximum sensitivity may cause false fracture detects and it is suggested that the sensitivity is further reduced by turning Pot1 a further 1 to 4 turns anti-clockwise so that the acoustic fracture detect point is somewhat below its maximum sensitivity. Note: if POT1 has previously been incorrectly set, an acoustic error message is displayed when a new TEST is started. User experience will enable the best sensitivity level to be set.

POT2. Microscope lamp brightness. Turn this pot clockwise to increase the brightness. Care must be taken not to use the microscope with the brightness set too high. This may obscure cracks which can be seen with less brightness and also damage to the users eye may result with prolonged exposure to a too bright setting.

POT3. Maximum or Hold Load. This is discussed in the MAX/HOLD section 3.32. Turning this POT clockwise increases the load setting.

POT4. % Load fracture detect Sets the % fall off load point for fracture detect. Fracture is detected and the crosshead motor is stopped when the instantaneous load measured by the load cell falls below a preset % of the maximum load (i.e. the peak held load) attained during testing. The fracture detect pot can be adjusted to give any fracture detect % up to 100% (Typically 60%-70%). Turning anti-clockwise increases the % setting.
See appendix 1 for a further discussion and adjustment details.

POT5. Rear panel load output zero. Zeros the above setting.

POT6. Rear panel load output range. The Load analogue output value can be changed, to match the digital load output shown on the display, or to match the input required for driving pen recorders, computer A/D card inputs etc.

POT7. Load Cell Range or Calibrate. For use only when the load cell is being calibrated with a proving ring or by dead weight loading. This pot is set back to discourage accidental adjustment - which would change the load cell calibration leading to inaccurate results.

3.4 ALTERNATIVE FUNCTIONS MENU

Pressing the ALT button accesses the alternative functions menu. This is shown on the LCD display.

The alternative functions are:-

0=Sens (Acoustic sensitivity)

This has been described in the previous section, see Pot1 adjustment.

1=R_Crack (Ring Crack)

Pressing numeric button 1 returns the machine to normal (Ring Crack size calculation) operation which is described in sections 2.2 & 2.3.
result - a feature of this operation is that the last hold load value is displayed on the LCD and, if necessary, i.e. the hold load has been lost by resetting or adjusting the machine, can be used for calculating from the 'previous' ring crack size.

2=Cal (Calibrate)

This enables calibration with a proving ring. Under normal operation it is not possible to load by using the fast & slow down buttons, for safety reasons, the crosshead always stops & returns whenever a small load is detected. When in the calibrate facility, this safety feature is disabled, so that the down buttons can be used to move the crosshead thus loading the proving ring without the low load restriction.

3=E-Tough (Edge Toughness)

Edge Toughness Testing, see section 2.4.

4=Hard

Hardness testing, this has been described previously in section 2.5.

5=Z-zero (Crosshead Zero)

This is set when the machine is first manufactured. Normally this never needs to be set again. Follow the instructions shown on the LCD.

6=Cycle

Cycles, at test speed, between Low-limit and Max/Hold load.

7=Magnify (Magnification Factor)

This is for setting the scaling factor of the microscope. This is to ensure that the microscope curtain readings are accurate. See Appendix 3 for the setting details.

4. REAR PANEL

4.1 REAR PANEL CONNECTORS

Situated on the REAR PANEL are:-
Mains input combination plug, switch & fuseholder.
Analogue & Digital (RS232) outputs.
Guard & Microscope inputs.

The rear panel looks like this:-

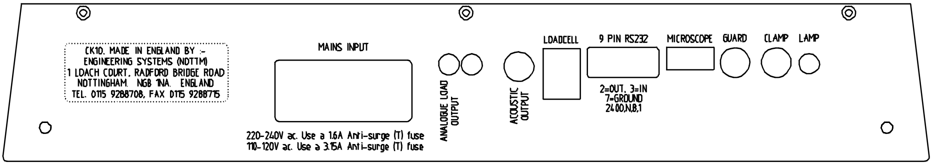

Figure 7

The following is a detailed discussion of the rear panel controls and adjustments.

4.2 MAINS INPUT

This comprises an IEC plug, rocker switch and captive fuse drawer. An IEC/MAINS connector lead is supplied with the machine and should be fitted with a 5A SLOW BLOW (T) fuse. If the machine is switched OFF & ON again quickly, malfunction may occur! An interval of at least 5 seconds must be left between switching the machine OFF and ON again.
The mains input voltage is normally set to 220-240 V a.c., this can be changed to 110-120 V a.c. by removing the bottom cover (see section 8, maintenance and repair) and switching the VOLTAGE SELECTOR SWITCH which is situated on the base-plate. When this has been done and the bottom cover replaced, the 1.6A SLOW BLOW fuse which is normally fitted should be changed to a 2.5A SLOW BLOW fuse.

4.3 ANALOGUE LOAD OUTPUT

A 0V to 10V d.c. voltage is output via. the ∅4mm terminals. BLACK is GROUND and the RED output is proportional to LOAD.

4.4 ACOUSTIC EMISSION OUTPUT

This is via a 50Ω BNC connector which allows the unfiltered amplified acoustic signal to be viewed on oscilloscopes. The amplifier gain is approximately 100. See section 3.34 (Pot1 adjustment) for further information.

4.5 DIGITAL RS232 DATA INPUT/OUTPUT

The 9 way 'D' type female connector provides the RS232 output which is transmitted when a fracture is detected. Data appears at the RS232 output at the same time that it is printed on the printer.

Whilst the RS232 output is exactly the same format as the printer output, provision has been made internally so that the RS232 and printer outputs can be different. Customised outputs are available to suit individual requirements. Contact Engineering Systems for details.

The data is transmitted in the format:-

2400 bits/sec, No parity, 8 Data bits, 1 Stop bit.

The CKD10 is configured as a TERMINAL device but is fitted with a female 9 way 'D' connector.

RS232 output, is transmitted from the CKD10 on pin 2.

RS232 input, is on pin 3.

Pin 7 is GROUND.

Correct polarity of externally connected equipment must be observed.
The remaining pins on the 9 way connector are not connected.

4.6 VARIOUS CONNECTORS

These connectors are all different and can only be plugged into their correct position.

Load Cell

If the 4 way load cell connector is disconnected, the machine cannot be operated. A load cell error will be detected and an error message displayed on the LCD display.

Microscope Data Connector

This is a 10 way connector which receives the data sent from the microscope.

Guard

3 way. When the guard is plugged in, the machine cannot be operated in TEST mode without the guard being closed. If the guard is opened during testing, the test will be abandoned and the crosshead returned to its preset position. If the guard is unplugged, the machine will not be disabled if the guard is open. It may be necessary to use this facility during some setting up procedures, however, when testing commences, the guard plug should be reconnected. Instead of having to press the test switch on the front of the machine, the guard can also be used to start the next test, see 3.31.

Clamp Connectors

4 way. The machine will not operate in TEST mode until the crosshead clamp is fully in position. An error message will be displayed in this case. Likewise, the Ring Crack size and Hardness calculations cannot be made until the clamp is open.

Microscope Lamp Connector

This is a 2-pole connector which supplies the power (5V, 2A) for the microscope lamp.

5. PRINTER

5.1 THE PRINTER automatically prints the peak reading at fracture, as indicated on the digital display. The printer also prints the other information related to the mode of testing.
The printer can be disabled by the printer on/off switch.
The printer is fitted with two external vertical bar controls which are situated at the top left hand side of the printers front cover. The left hand bar is for opening the printer door and the right hand bar is the paper feed switch.

5.2 CHANGING THE PAPER ROLL AND CARTRIDGE RIBBON
The printer door is hinged vertically on its right hand side. To open the door, rotate (anti-clockwise) the left hand (of two) vertical catches and the door will swing open to reveal the paper roll and the ink ribbon. To release the print mechanism and ribbon from the front panel, push the door and the chassis horizontally apart.

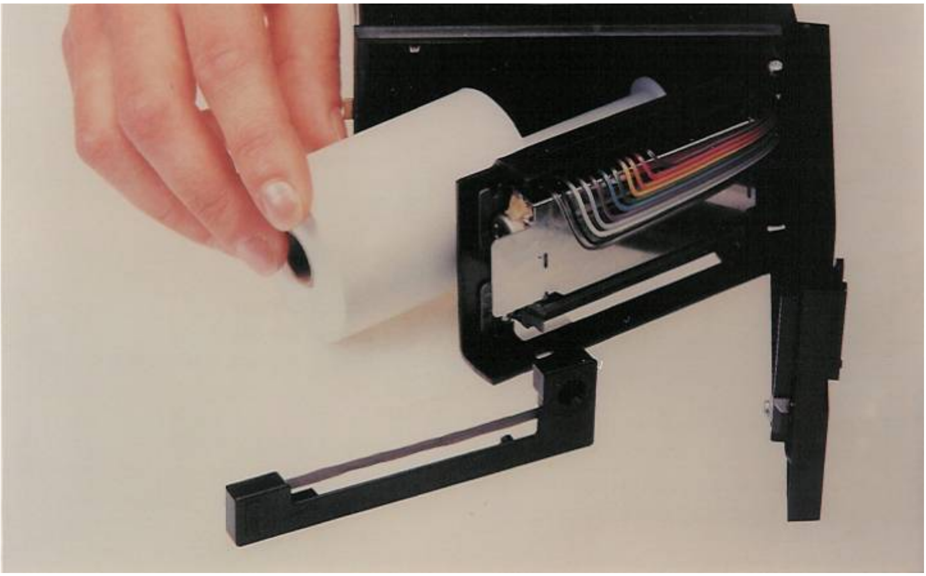

Figure 8

5.3 PAPER ROLL REPLACEMENT

Open the printer door as described above and swing the door open to expose the paper roll.

Remove the old paper roll by pressing the black paper roll retaining button situated at the end of the paper roll spindle. Slide off the old roll and tear off any remaining paper. Pull any remaining paper out from the front of the printer.

Take a new roll of paper and separate the end from the rest of the roll. Remove any damaged or gummed part of the paper and cut the free end into a 'V' shape using scissors. Put the new roll onto the spindle with the paper unspooling in an anti-clockwise direction when viewed from the outer end. Insert the end of the paper up and into the printer mechanism and press the paper feed actuator rod which is situated inside the top left hand portion of the printer casing. Wait and check that the paper emerges from the front of the printer before releasing the actuator rod and closing the printer door.

The printer mechanism which is used is from the standard EPSON M160 series. Paper rolls and printer ribbons should be available from local suppliers worldwide.

Use 57mm wide, 50mm maximum diameter, 13mm internal diameter paper rolls,
or use 58mm wide, 45mm diameter, 13mm internal diameter paper rolls.

In the UK, these can be ordered from:-

Able Systems Ltd. Tel. 01606 48621 and their order code is A160PR.

Order codes correct, April 1995.

5.4 RIBBON CARTRIDGE REPLACEMENT

After approximately five paper rolls have been used, the ribbon cartridge will need replacement. To expose the Ribbon Cartridge, position the forefinger underneath the outer edge of the door and the thumb on top of the printer mechanism chassis and press in vertically opposite directions until the catch is released and the chassis swings away from the door.

DO NOT FORCE OR PULL THE DOOR AND CHASSIS APART WITHOUT FIRST RELEASING THE CATCH.

When the chassis and the door have been parted the ribbon can be removed by pressing down on the end of the cartridge marked PUSH.

Carefully remove the old cartridge and replace with the new one ensuring that the paper lies between the ribbon and the steel printer platen. Check that the ribbon cartridge is correctly seated over the printer ribbon drive shaft and snap the cartridge into place.

Ensure that the ribbon is tight and parallel to the paper and if necessary tighten the ribbon by turning the faceted disc clockwise.

Replacement ribbons can be ordered from:-

Able Systems Ltd. order code is A160IRCP.

(Order codes correct at April 1995)

6. CALIBRATION

Before each machine leaves the factory it is calibrated using a dead weight loading system. The machine can also be calibrated using a proving ring, as shown in the photograph. Extension pieces are required to accommodate the ring.
Similarly larger objects can be tested using various length extension pieces.
An electronic calibration switch is provided so that a daily calibration check can be made.

6.1 CALIBRATION BY DEAD WEIGHT LOADING

This can be done by Engineering Systems by using a purpose built rig so that the machine can be tested according to ASTM E4 standards.

6.2 PROVING RING

A proving ring is available as an optional extra. This ring is supplied in a wooden case and is also supplied with ball ended end mountings, extension pillars and two adaptors for use with the CKD10. A calibration certificate is also supplied with the ring.

6.3 PROVING RING CALIBRATION PROCEDURE

1.) Remove Crosshead and Load Cell and fit extension pillars, replace crosshead and Load Cell onto the extensions. See section 8.

2.) Remove the load cell indenter/platen and fit the concave adaptor piece into the load cell.

Figure 9

3.) For calibration with the proving ring it is necessary to enter the special functions menu. This was briefly described in section 3.4. When the correct menu has been entered, set up the proving ring so that its bottom end is resting in the plain concave adaptor, use the manual crosshead control buttons to lower the crosshead until there is JUST no load applied. i.e. so that the proving ring is held in place.

4.) Zero the display.

5.)Using the slow down button, apply suitable load increments and note the LOAD and PROVING RING READINGS. Check the calibration i.e. that the proving ring calibration chart readings correspond with the load cell readings. If necessary, adjust the load cell range by turning Pot7 (see section 3.34).

6.) Make a note of the new electronic calibration value.

6.4 ELECTRONIC CALIBRATION

Pressing the calibrate switch, section 3.34, connects a high stability resistor into the load cell circuit and gives an apparent load reading on the digital display.

A calibration value for the load cell is shown on the calibration certificate. When the calibration button is pressed this calibration value should be displayed on the digital display.

Calibration using a proving ring or dead weight loading should be carried out from time to time.
When re-calibration has been completed, the calibration value should be noted and the value of the read-out noted. future calibration can be carried out by using the calibrate switch; the digital read-out should correspond to the value of the digital read-out noted above.

7 COMPONENT PARTS

The following parts list, component layout and circuit diagrams show only the major parts. Small items are not listed.

7.1 PARTS LIST

Main casing
- including LCD display, Trident-M4024-OA
- & lifting handles

Bottom cover
- including tool drawer

Baseplate

Load Frame, bottom section only.
- including Gears, Timing pulleys & Belts
- & Motor-Tacho-Gearbox Unit (McLennan M586TE)
- & Clutches
- & Digimatic scale unit for Z travel

Load Frame, X,Y table section only
- including Digimatic scale units for X & Y

Load Frame, Crosshead assembly only
- including Load cell
- & Acoustic sensor XT/90
- & Curtain Microscope + eyepiece

Main Circuit Board (CK10M.PCB)
Display Circuit Board (CK10D.PCB)
Toroidal Transformer (ILP 6D486P)
Mains RFI Filter, Sterling 6EQ1
Mains Input Voltage Selector Switch (Farnell 947-911)
Printer, Able Systems AP24+IN

7.2 ELECTRONIC BOARDS FITTED

There are 2 electronic boards boards fitted to the CKD10 machine, these boards are identified by a name and number. The name is self explanatory, the number is composed as follows:-

- CK10 stands for Crack Detector 10kN load cell
- The LETTER, e.g., D, is the board type i.e. DISPLAY.
- The Numbers, e.g. 9502 gives the date on which the board was designed or last updated. i.e. Week 02, 1995
- The letters, e.g. DC are the initials of the designer of the board

Boards fitted:-
CK10 Main board..........................CK10M.PCB-9502-DC
CK10 Display Board.......................CK10D.PCB-9443-MF

In addition there is an EPROM situated on the main board

EPROM..CK10-v..........

The toroidal transformer which is fitted, is designed and manufactured to Engineering Systems specifications. Toroidal transformers are more efficient, smaller and most important, give less electromagnetic interference than a conventional transformer. The penalty is a higher unit cost.

Toroidal Transformer............................6D486P

7.3 MACHINE SERIAL NUMBER

The serial no. is to be found on the underside (bottom) of the base plate. This number should be quoted in any correspondence regarding the machine.

Serial No. ....

7.4 LOAD CELL SERIAL NUMBER

This is etched on the load cell

7.5 TOOL KIT

The tool kit and the CK10 HANDBOOK are contained in the draw underneath the base plate.

7.6 TOOLS & SPARES SUPPLIED

1.5, 2 x 3, 2.5, 4, 5 & 6mm hexagon (Allen) wrenches
3mm hexagon ball driver
Trimmer for rear set back adjusting pots.
Small screwdriver
2 off, 1A SLOW BLOW (T) fuses
3 off, 5A SLOW BLOW (T) fuses
2 off, 3.15A or 1.6A SLOW BLOW (T) mains fuses
Printer ribbon
5 off Paper rolls
6V 10W Tungsten Halogen Lamp for Microscope

TOP VIEW OF COMPONENT LAYOUT

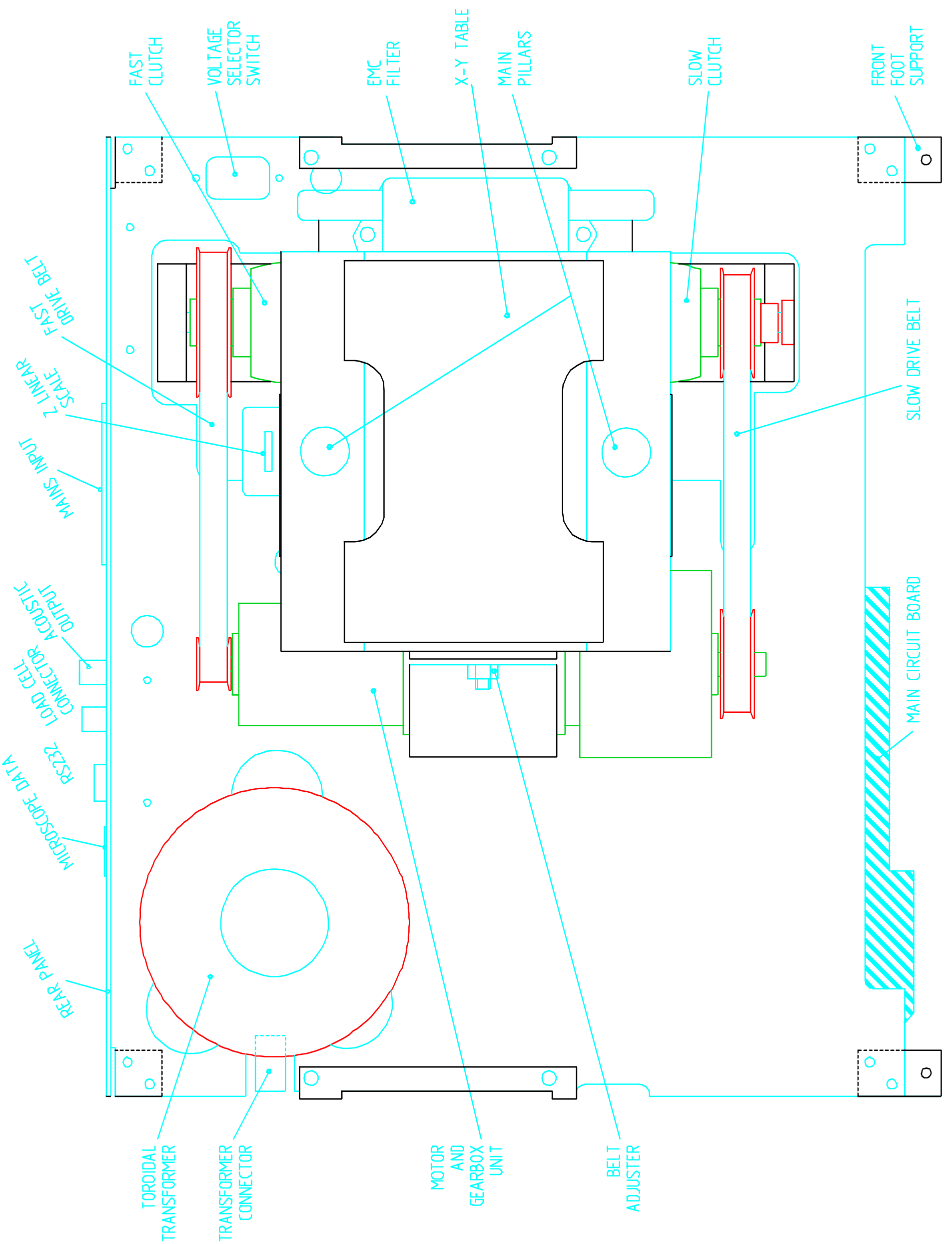

Figure 10

BOTTOM VIEW OF COMPONENT LAYOUT

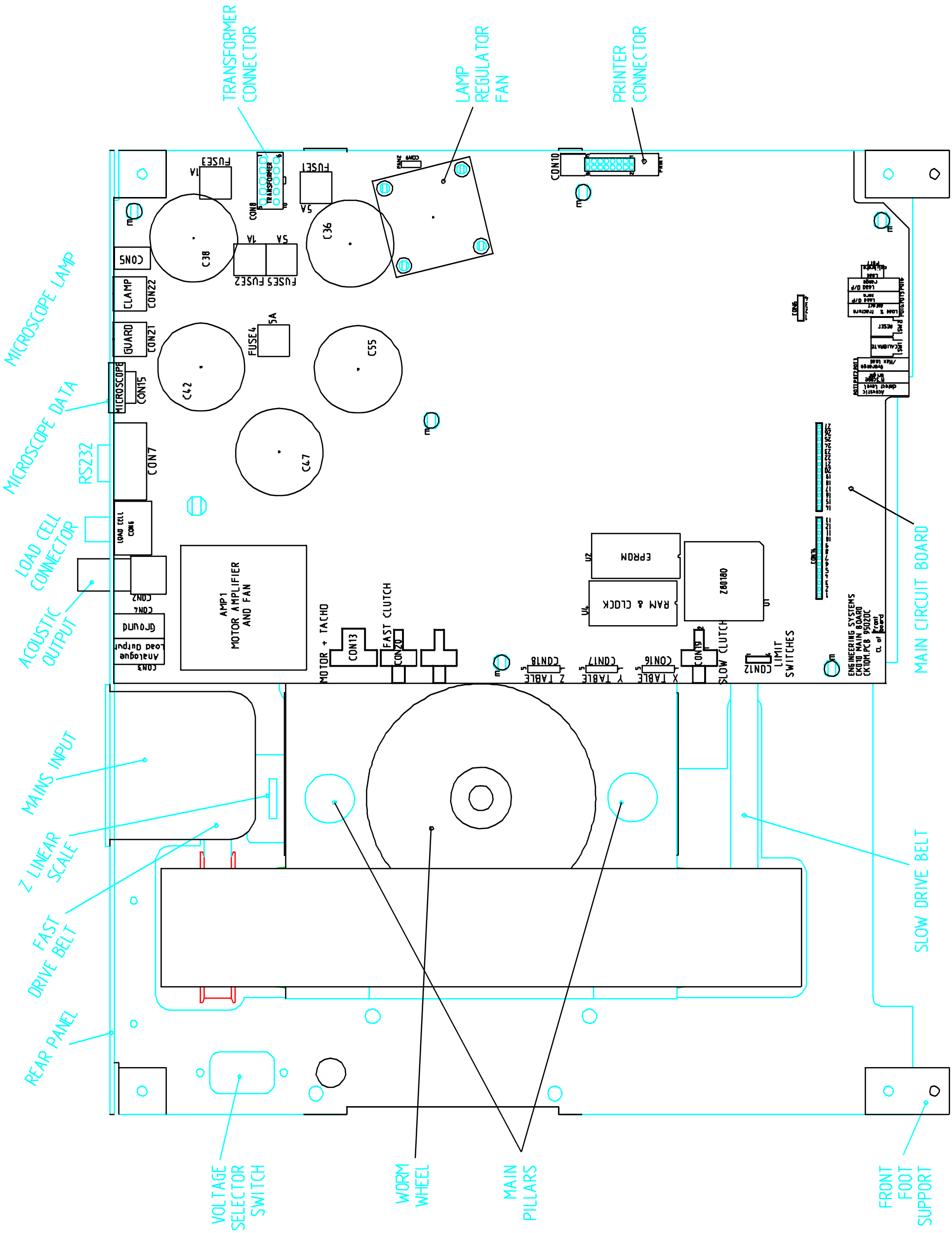

Figure 11

ENGINEERING SYSTEMS CK10 WIRING DIAGRAM

(CK10.WIR-9516-0C)

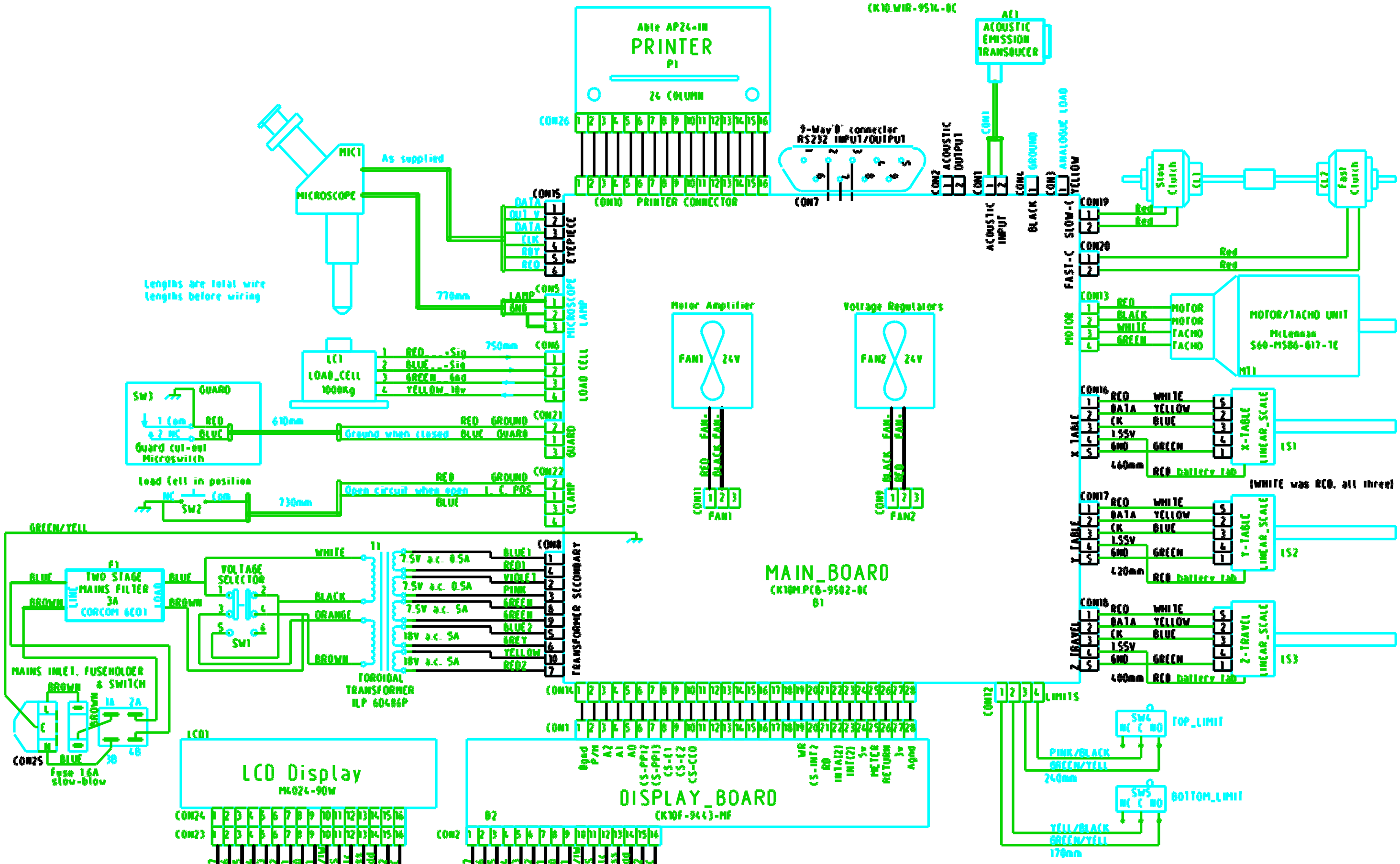

Figure 12

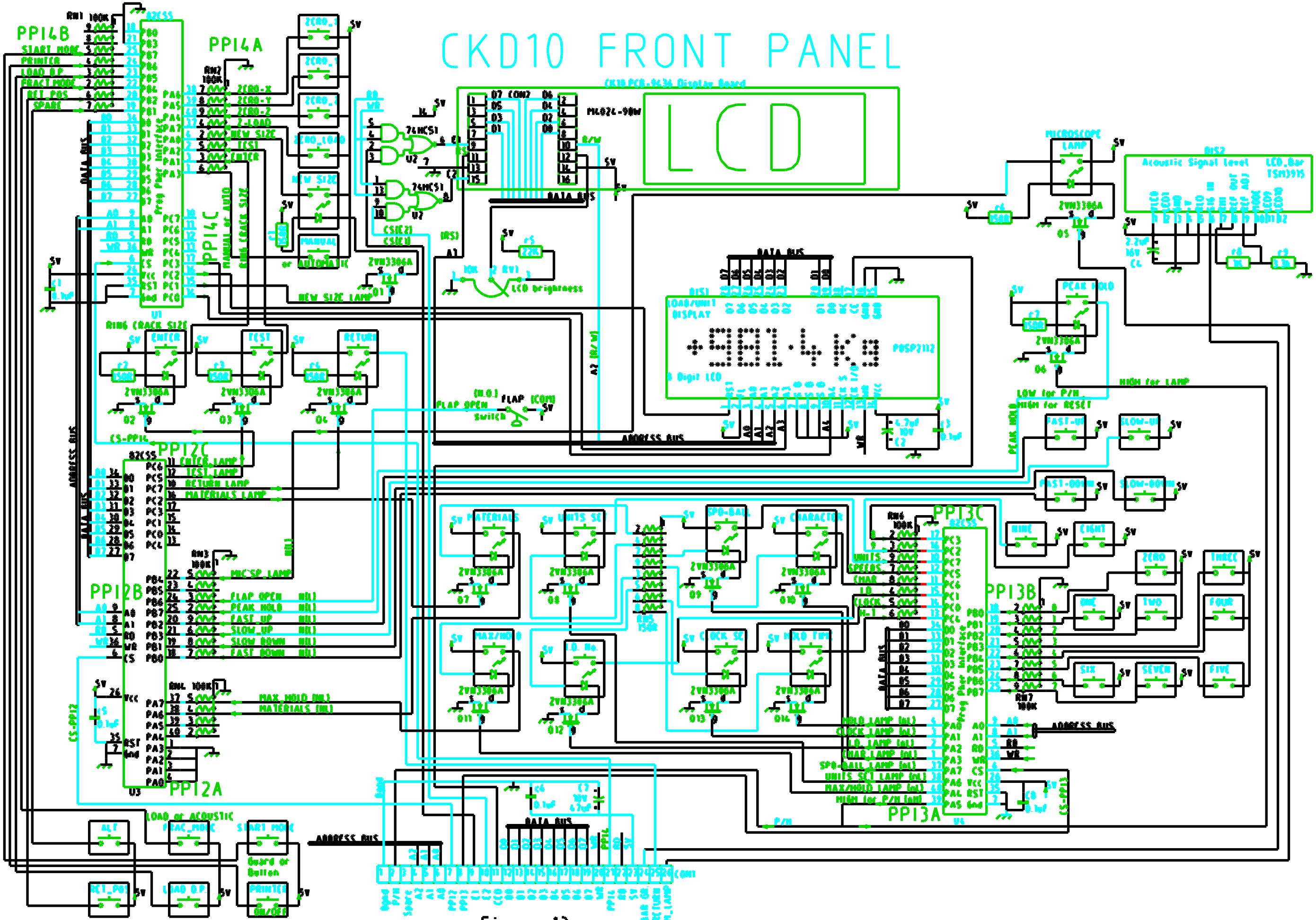
CKD10 FRONT PANEL
CK10 PCB-0636 Display Board
LCD
PPI4A
PPI4B
PPI4C
PPI2A
PPI2B
PPI2C
PPI3A
PPI3B
PPI3C
DATA BUS
ADDRESS BUS
LCD brightness
Acoustic Signal Level
LCD Bar TSM3915
HIGH for LAMP
LOW for P/H
HIGH for RESET
8 Digit LCD
LOAD/UNIT DISPLAY
PDSP2112

Figure 13

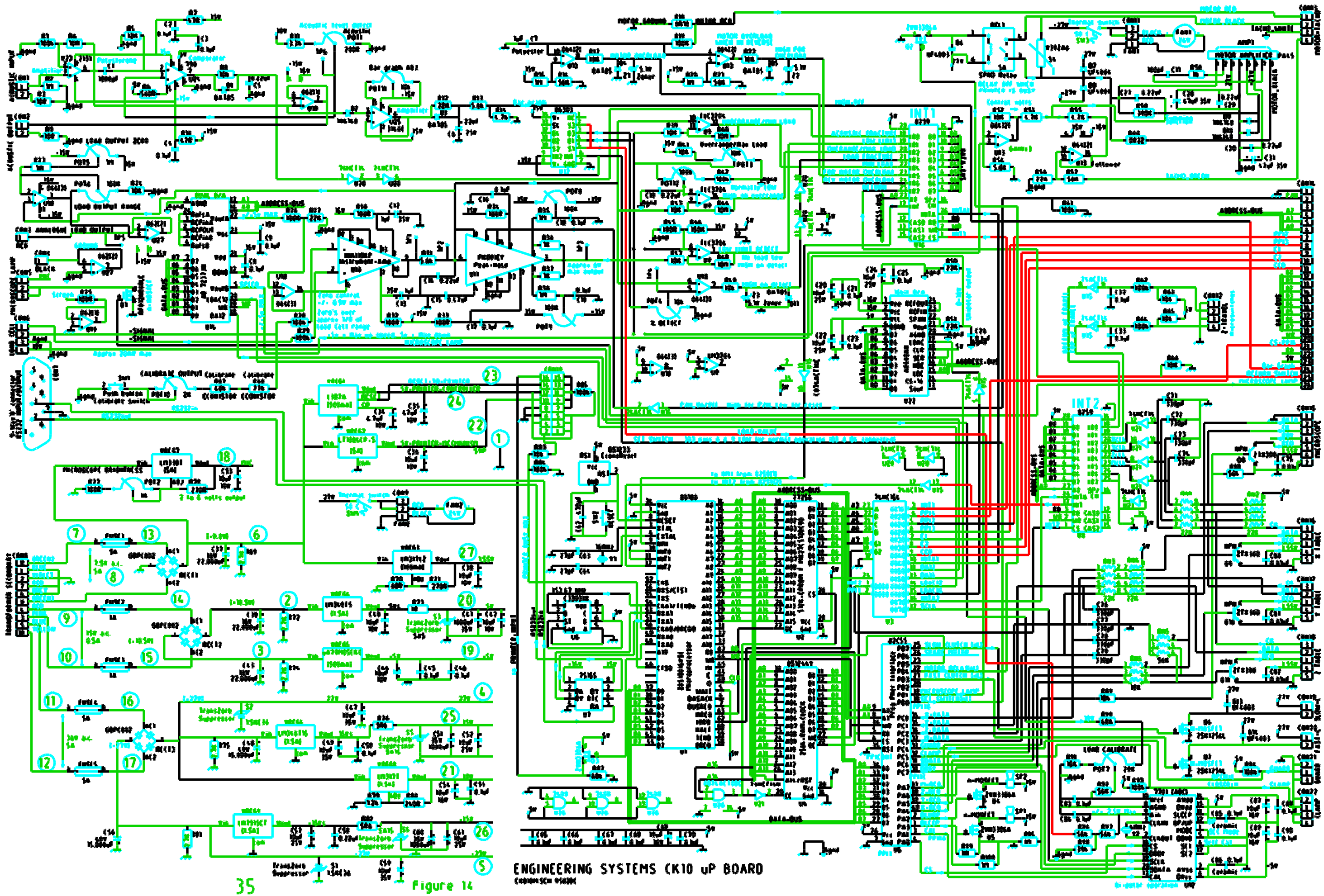

Figure 14

8. MAINTENANCE & REPAIR

8.1 ROUTINE MAINTENANCE

Oil: Occasionally apply a few drops of light oil to the main pillars.
Microscope battery: The microscope unit contains a battery which has a life of approximately 18 months. This is contained within a round cover which is situated at the bottom rear of the micrometer/curtain box. This battery, type - SR44 - should be changed annually otherwise the microscope curtain measurement will cease to work correctly.
Routine mechanical maintenance: involves removing the outer casings and cleaning any powder, dust etc. from the inside of the machine.
The load frame gearing and ball screw should be inspected after a period (2 - 3 years, depending on usage) and lightly lubricated if necessary. A small quantity of light oil only should be applied to the ball screw thread and the suggested grease for the gears is ROCOL MTS 1000.

8.2 MACHINE CONSTRUCTION

The construction is modular. The mechanical loading frame and motor are combined and are mounted onto a baseplate. For efficiency, a recirculating ball screw is used to drive the crosshead up and down. The curtain microscope assembly is mounted on top of the main pillars. The Load Cell is purpose designed and built and is normally positioned under the microscope assembly. So that interconnecting wiring is minimised only two electronic circuit boards are used. The main electronic board is positioned below the baseplate and is exposed when the bottom cover is removed. The main box or cover is made of steel and houses the printer and the second circuit board which incorporates the main control panel. The LEXAN guards, which enclose the test area, hinge about a rear pillar assembly which is screwed to the rear of the load frame base.

8.3 REPAIR

There are basically two types of faults which can occur - MECHANICAL or ELECTRICAL.
Sometimes faults are very simple to cure!
Faults such as - 'nothing happens when the machine is switched on' can sometimes be cured by anyone who knows how to change a fuse.
However, more serious faults can sometimes occur and the machine can either be returned to ENGINEERING SYSTEMS for repair or the following notes may help to make an in-house repair possible.
Think logically about the nature of the fault - is it likely to be electrical or mechanical? Faults can usually be isolated into small areas.
Perseverance is necessary when tracing INTERMITTENT faults.

Instrument mechanics and/or electronic engineers should have no difficulty in replacing any of the major modules which are all available as spares and are detailed in the spares price list.
The main replaceable modules are :-
MECHANICAL   Load Frame mechanism, including the sub-modules,
Motor + tacho, Load Cell.
ELECTRICAL   Toroidal Transformer.
ELECTRONIC   Main board, Display board, Printer.
Only qualified personnel should be allowed to check for faults if any of the outer casing has been removed and the mains supply is connected.
WARNING:- Whilst mains voltage is not present on the Main board, a large d.c. potential voltage exists as there is +27 Volts & -27 Volts present on the board.

8.4 MECHANICAL FAULTS

These are usually more easy to find than electronic faults. Unplug the mains supply and remove the outer cover(s). A close visual inspection quite often reveals the fault which may be minor and easy to cure, or major and disastrous! Check the tightness of all 'nuts & bolts' etc., check the gears for tightness. Now with the main casing removed, but connected with a Front Connector Adapter, try connecting the mains supply and pressing the start button, listen for, and isolate any peculiar noises.

8.5 DISMANTLING

If the machine needs to be dismantled first switch off the mains and remove the IEC/MAINS lead.
Be aware that static electricity, which can be present in the human body can damage or destroy electronic components and board assemblies.
Care should be observed when handling the electronic boards. Preferably work in a static free area. In practise this is not always possible. If the electronic boards have to be removed try to hold them at their edges and not by their tracks or components. Touch a grounded surface before and whilst commencing work.
AVOID AREAS IN THE VICINITY OF NYLON CARPETS etc.

Figure 10 on page 31 shows the view from above and identifies the various components and connectors.

1.) Unplug all the connecting cables from the rear panel. Also detach the cable from the acoustic sensor.
2.) Use a 3mm hexagon balldriver to remove the LEXAN guards by unscrewing the two hexagon screws which hold the guard assembly to the load frame base. Position the machine so that its front faces forwards.

3.) Also, using the same balldriver, remove the X & Y table adjuster knobs and the corresponding clamping levers from the load frame base.
4.) Detach the crosshead assembly by unscrewing the two 6mm hexagon screws which holds the elbow beam to the main pillars. Note that the front screw should always be undone first (and tightened last on reassembly). The elbow beam may be tight and require 'upward assistance' before it will become loose. Once this has been removed and with the crosshead clamp open, lift off the main yolk assembly. Also (noting the order) remove the tensioning washers which are resting on the rear pillar.
5.) Turn the machine to rest on its left hand side. The machine is unstable in this position and it is advisable to rest the top of the main pillars or the load frame base onto a wooden block. The block should be 190mm or 150mm tall respectively.
6.) Using a 25mm A/F wrench, unscrew the 4 feet which attach the bottom cover assembly. Do not remove screws which are situated inside the rubber feet. Remove the bottom cover & drawer assembly.
7.) To avoid damage to electronic components (when the main box has been removed) replace (without the bottom cover) and screw on the 4 feet.
8.) Before removing the main box, first disconnect the two part ribbon connectors which join the main board (underneath the baseplate) to the front board (mounted behind the front of the Main Case). The ribbon connectors pull out from the front board, some care is needed during disconnection otherwise the leads may get bent. If they do get bent, they must be straightened out with a small pair of pliers before reassembly.
9.) Also disconnect the printer connector which is situated on the extreme right hand side of the circuit board, and slightly towards the front. Pressing the levers situated on each side of this connector, release the sixteen way plug from its socket.
10.) Turn the machine to rest on its feet, in the upright position.
11.) The side lifting handles are attached to the main box by five screws. The top two screws on each side also attach the box to the main base plate. Remove only the top two handle retaining screws from each handle. The main box can now be eased upwards. At this stage it is very to ensure that the acoustic connecting cable does not become trapped and damaged. Note that the printer connector cable is still attached to the printer and this must not tangle with the baseplate whilst the box is being lifted clear.
For reassembly it should be noted that the case fits between the baseplate and the rear bottom back panel.
12.) Before the load frame can be removed, the main circuit board must also be removed. Turn the machine onto its right hand side, and disconnect the 10 way lever clamp transformer connector which is now positioned at the top and back of the baseplate.

13.) Remove all 8 connectors shown in the diagram. Some of the connectors have a small lever on the side which must be pressed to enable disconnection. Pull out the acoustic sensor cable, now positioned at the top front. Also disconnect all seven connectors which plug into the right hand side of the main circuit board. Three of these connectors are of the lever clamp style. The remaining four, have a locking device to retain the plugs. To remove, insert a small screwdriver between the plug and locking plate, twist the screwdriver and wiggle the plug off.
14.) Using a Pozidriv screwdriver, unscrew and remove the upper and middle screws which hold the rear cover in place. Loosen, but don't remove, the lower rear cover screw.
15.) Remove the five mounting screws which hold the main circuit board in place. It is important to ensure that the star washers which accompany each screw are accounted for. If one of them falls into the circuit board and becomes wedged, out of sight, underneath a component, it must be recovered otherwise it may cause a short and the electronics could be damaged when the machine is switched on after reassembly.
16.) Hold the rear cover outwards so that it clears the acoustic connector and lift the main circuit board clear of the baseplate.
17.) The load frame assembly can now be detached, by unscrewing the 6mm hexagon screws which hold it to the baseplate.

Reassembly is the reverse of dismantling. Points to note are:-
Fitting a new main circuit board is the reversal of removing, but be sure to remember to connect the earth connector to the central mounting screw, and make sure that it is very secure!
The connectors can logically only be fitted the correct way round.
Now refit the main case remembering to reconnect the printer and taking great care when re-connecting the board interconnecting ribbon connectors. It may be necessary to put one's fingers behind and in front of the ribbon cable whilst pushing it home. Make sure that it is fully into the socket.
Refit the bottom cover and check that the machine works correctly. If a new main circuit board has been fitted, it will need to be 'set up':-
The load cell must be calibrated as in Section 6.
Further adjustments should also be carried out:-
Pot 6 (load output range) and Pot 3 (maximum or hold load).
The adjustment of these potentiometers is described in section 3.

8.6 FIRST STEPS IN 'ELECTRICAL' FAULT FINDING.

Digital Displays do not illuminate when switched on.

MAINS FUSE

Check the mains fuse which is incorporated into the fuse/switch unit fitted at the rear panel of the machine. This fuse can be replaced by pulling out the fuse retaining drawer. Use a 1.6A fuse for 220-240V and a 2.5A fuse for 110-120V, both 20 mm, anti-surge type (T) or slow blow type fuses.

Motor does not start when motor button pressed. Check internal fuses

FIVE INTERNAL FUSES are fitted and they are accessible when the bottom cover is removed. To gain access to these fuses turn the machine to rest on its side and remove the bottom cover. The fuse No's. and values are marked on the board.

The fuse must be pushed in whilst unscrewing.

The values which should be installed are:-

Fuses 1, 4 and 5 - 5A slow blow or anti-surge (T)

Fuses 2 and 3 - 1A slow blow or anti-surge (T)

However the ability to cure the more subtle or elusive faults requires some understanding of how the machine works. The following diagram shows, in outline, how the CK10 operates :-

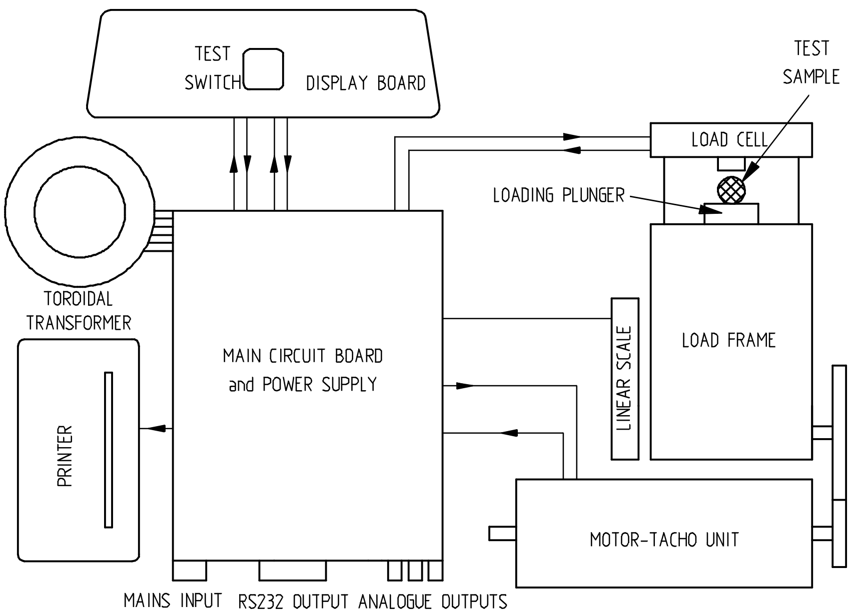

Figure 15

The preceding picture is not quite the whole story as low voltage d.c. POWER has to be supplied to the various components and boards. The following diagram completes the picture.

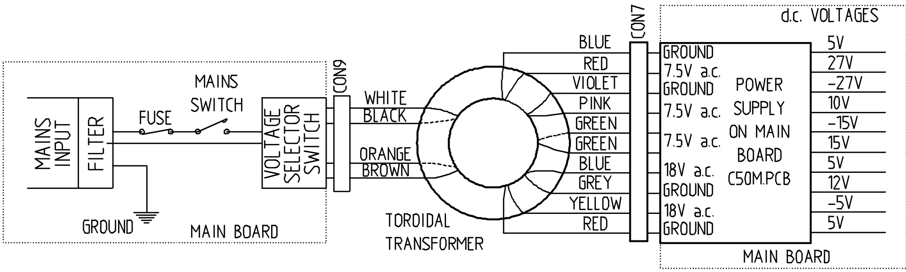

Figure 16

This diagram reads left to right, and shows how the mains input voltage is FILTERED, FUSED, TRANSFORMED and finally RECTIFIED & STABILISED by the Power Supply into the required d.c. VOLTAGES.

One does not necessarily need to be an expert in electronics to cure 'modular electronic faults'. For example, if the printer is not working correctly but the RS232 output is working correctly, then it is most likely that the printer is faulty, which is just a case of removing the main casing and plugging in a new printer. However, fault finding is not always easy and to cure those subtle faults an awareness of electronics will be needed.

8.7 MAINS FILTER

The mains voltage is filtered when it enters the machine. However possible disturbances to the smooth running of the machine could be caused by large power supply fluctuations or by other nearby electrical equipment being switched on and off. Additional filtering may be necessary and an additional FILTER ADAPTOR such as the Farnell stock No. 150-219 or FILTER PLUGS such as 146-887 or 151-317 may cure any mains problems.

8.8 CONNECTIONS

Check, visually and by wiggling, that all electrical connections, plugs, sockets and board inter-connections etc. are properly connected. Check also for 'loose' wires and loose soldered connections anywhere. Check for loose foreign bodies, especially of metal, which may short out a circuit board. Check for continuity between connectors and boards.

8.9 POWER SUPPLY - CHECKING THE VOLTAGES

The main board contains a section which converts the a.c. supply from the transformer into the correct d.c. voltages. Check that the correct voltages are being supplied by this power supply section. A voltmeter will be needed to check this. To aid diagnostics the d.c. voltages are indicated, at various points, on the main board tracks. If the voltages measured are not correct, either a faulty 'power supplied component' could drag the power supply voltage(s) low or a power supply component itself could be faulty. If a faulty 'supplied' component is present within the main board or display board the component may get hot indicating a fault within that component. Note that some of the power supply components such as voltage regulators normally get warm or hot. Cure - replace the main board or the toroidal transformer

There are 27 numbered test points situated at the power supply end of the board. To check the d.c. voltages connect between GROUND and the relevant TEST POINT. To check the a.c. voltages connect between the relevant TEST POINTS.

No.1 is GROUND (0 Volts).

d.c. Voltages are :- 4 is 27V, 5 is -27V, 25 is 15V, 26 is -15V,
21 is 10V, 20 is 5V, 19 is -5V, 24 is 5V, 22 is 5V, 27 is 1.55V.

a.c. Voltages are :- 9 & 10 also 14 & 15 are 15V,
11 & 12 also 16 & 17 are 36V, 7 & 8 are 7.5V

FUSE continuity Fuse 1 is 7 & 13, Fuse 2 is 9 & 14,
Fuse 3 is 10 & 15, Fuse 4 is 11 & 16, Fuse 5 is 12 & 17.

8.10 SPECIFIC FAULTS

ERROR MESSAGES Some error messages are displayed on the LCD.
Usually these errors can only be cured by pressing the RESET button.
Please note that the TEST MODE always defaults to BOTH after reset.

CROSSHEAD returns before specimen has been tested.
Make that the specimen has not started to load before the test speed or position has been reached.
Maximum load is set too low.
Bottom of travel reached.

DISPLAYS do not light up.
Check fuses especially the 5A fuses on the Main board. These fuses must all be of the anti-surge (T) or slow- blow type.
Check that the two ribbon connectors between the display and the main board are properly connected.

FUSES blow on switch on
Check that anti-surge (slow blow) fuses are being used.

LCD DISPLAY Gives error message at switch on.
Check load cell platen is not obstructed.
Fault with load cell, is it plugged in to its connector? is there a possibility that the load cell has been overloaded? check for linearity etc. with weights or a proving ring.

LOAD DISPLAY will not settle to a constant value.
Main board faulty.
Load cell or connections faulty.

LOAD DISPLAY jumps up a few digits when peak/hold is switched on.
Incorrect internal adjustment of trimmers on peak hold chip on Main board.

MACHINE malfunctions or the stored variables, i.e. Ball Size, Microscope scaling, Z travel range etc. are corrupted when switched ON after switching OFF. An interval of at least 5 seconds must be left between switching the machine OFF and ON again.

MICROSCOPE scale reading does not function correctly.
Renew the battery, described under 8.1

MOTOR will not start
Faulty main board.
Faulty motor amplifier.
Faulty Motor
Has the crosshead travelled too far downwards or upwards? If so the lower or upper travel limiting microswitch may be faulty.

MOTOR starts but no crosshead movement
Gears slipping.

PRINTER not working correctly.
Make sure that the paper is not trapped inside the printer body.
Check that the internal printer connector is connected correctly.
Replace the 8 leg IC. - U6, on the main board which is a 19.6608MHz Oscillator.
Replace printer if a spare is available. If possible check that the RS232 output is working correctly, if this works the fault is unlikely to be on the Main board as there is only a small amount of extra circuitry on this board to drive the printer. Replace Main board if a spare is available.

TIME & DATE incorrect.
This is controlled by a special chip. This chip is situated on the Main board and incorporates the RAM. If the time is incorrect - adjust by pressing the SET CLOCK button and adjusting as described previously. If the time is again incorrect the next time the machine is switched on, then the clock may have reached the limit of the internal battery life (10 years)? Cure :- renew the 'clock chip'. The part no. is DALLAS DS1244Y.

NOTE: the various internal trim adjustments, on the main board, are set before leaving the manufacturers. These settings should never alter - but - if for any reason they change, the operation of the machine will be upset. Section 3.4 in this handbook gives details of the majority of adjustments which can be made. If malfunction is still suspected, return the Machine or Main board to Engineering Systems for complete readjustment.

8.11 BOARD CHANGING

If it is suspected that a fault lies within a particular board, replace it with a spare board (module). However if a spare is not available and an electronics workshop is available, it may be possible to repair boards 'in house'. Otherwise a spare will have to obtained from the manufacture's or the machine sent back for repair.

8.12 GUARANTEE

The guarantee operates for one year from delivery date and covers parts and labour only. Malfunction due to misuse or accidental damage are not covered. Defective components or machines should be returned, at the users expense, to the address below where they will be examined and wholly or partially replaced if necessary.
Users or customers must contact Engineering Systems, before any returns are made, as problems can often be solved by telephone or FAX. See back cover for the address and Tel. & FAX Nos.
The Serial No. is on the under side of the base plate and is visible when the bottom cover is removed. The serial No. is also shown on the back cover. This number should be quoted in any correspondence regarding the machine.

APPENDIX 1

Further consideration of the % fracture detect and low limit settings. (see also section 6.10) The following graph shows the relationship between Low Limit load, % Fracture Detect, Peak Hold load, Test Load, Load Cell Load and Fracture point during a typical test. (Time is proportional to test speed.)

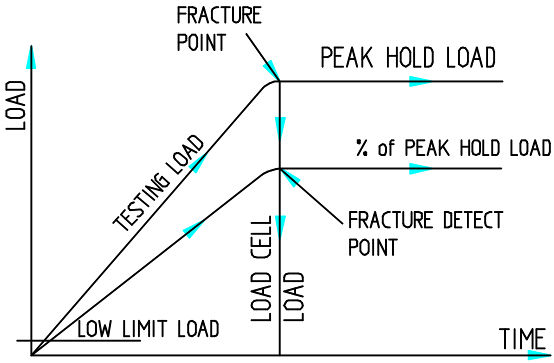

Figure 17

On loading the peak held load follows the load cell load up to the point of fracture, at this point the load cell load drops to zero (unless the test object is spongy or crumbly) and the peak held load remains constant. Fracture is detected by the electronic circuitry when the load cell load drops below the % peak hold load line (or setting).

The usual % setting for this 'line' is 60-70% but the material properties of some test objects may demand a revised setting before meaningful test results can be obtained.

When using the machine for general purpose testing, the following discussion may prove useful :-

Soft crumbly objects If used for general purpose compression testing, a lower % setting may be required because the testing load may drop momentarily (causing a fracture detect) during loading, due to localised surface crumbling prior to the object fracturing or substantially failing. Some experimentation will be required to obtain a satisfactory % setting for these 'difficult' materials. A fracture may not be detected at all if too low a % setting is used, the test object may just be gradually crushed into a powder. Different platen Geometries i.e. convex, may have to be considered.

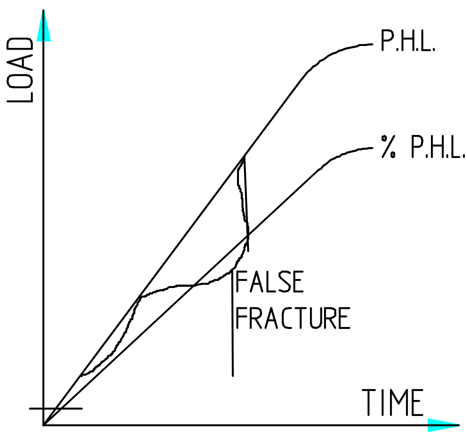

Figure 18

If the CK10 is used for compression testing, hard objects may fracture but leave some of the fractured test object in the test position between the loading platens. If the % setting is too low a fracture will not be detected. If the setting is too high, small departures of the load cell load from the peak held load, especially at the start of a test, will give a fracture detect and the test will be halted.

CHECKING THE % SETTING.
Connect a digital voltmeter, set to its 200mV d.c. range, into the load cell output terminals (see Fig. 7).
With the peak hold switch on, and with the TEST SPEED set at a low speed setting press the Test switch (i.e. crosshead moving down). Slowly depress the load cell by hand to obtain a reading of say 5kg, and note the voltmeter reading, gradually release the pressure on the load cell until the motor stops. At this point (and without further releasing the load on the load cell) note the reading displayed on the external digital voltmeter. Comparison of the peak hold load and the digital voltmeter reading gives the % fracture detect setting.
Note : some practice may be required before consistent percentages are obtained.

ALTERNATIVE SETTING METHOD
With the bottom cover removed and the machine resting on its LHS, set pot 4 so that TP4 reads approx. 70% of the reading on TP2 when the calibrate button is pressed.

ADJUSTING THE % SETTING Turning Pot. 4 clockwise decreases the % setting.

APPENDIX 2

SETTING UP THE MAIN BOARD FOR THE CKD10

This is the procedure for setting up the main board during manufacture. This procedure should not be used for setting up an existing board. The instructions given in chapters 3 & 6 should be followed for existing boards.

Turn the machine onto its right hand side and support the crosshead top with a suitable block of wood i.e. a block which is approx. 70mm high.

Install board into machine without any IC's installed, make sure that the ground connector is in position, check that the d.c. supply voltages are correct, i.e. that they are not being pulled low by a short etc.

Remove the board and insert the IC's and then recheck the d.c. supply voltages.

Approximately calibrate the Load Cell by using a 10kg weight and adjusting POT7 (Load Calibrate)

Adjust POT1 (acoustic sensitivity) as described in section 3.34.

With the PEAK HOLD disabled (unlit), adjust Pot9 so that TP3 - pin 3 (PKD01) is equal in voltage to TP2 - pin 6 on the PKD01.

Adjust Pot8 so that TP3 - pins 3 on the PKD01 is the same when the Peak Hold is enabled or disabled.

Set Pot4 (% Detect) so that TP4 - pin 5 on the 064 (U18) reads approx. 70% of the reading on TP2 - pin 6 when the calibrate button is pressed.

Set Pot5 (Output Zero) so that the Analogue Load Cell Output = 0V.

Set Pot6 (Output Range) so that the analogue load cell output voltage corresponds to the Load reading when the calibrate button is pressed.

Calibrate the Load using the Proving ring and adjusting Pot7.

Press the Max/Hold load button and set the required Maximum/Hold Load by turning Pot3.

Carry out a series of 'max load tests', adjusting Pot12 so that the maximum set load and the maximum test load are equal, then 'back off' the setting slightly to allow for the few (approx 5-10) digits overshoot which occur after a fracture detect. Turning clockwise increases the maximum load.

Set the microscope scaling as described in Appendix 3.

APPENDIX 3

Setting up the microscope scaling factor

The microscope has an eyepiece which contains a curtain measuring arrangement, this is similar to the curtain measuring eyepiece which is found on most traditional hardness testers.
It is vitally important to ensure that the scaling is correct, otherwise all the Ring Crack, Vickers Hardness & Edge Toughness results will be in error.
The scaling is set in the software and the indicated curtain width must coincide with the numerical reading which is displayed on the LCD display.

For accurate settings, an optical scale should be used. The only required markings are 0 and 1mm. This scale should be placed onto a spacer block (say 10mm thick) resting on the X-Y table. Press the microscope lamp button and bring the scale into focus by using the fast and slow up and down buttons.

Since the optical scale is etched onto a mirror surface, a large amount of lamp light is reflected, prolonged exposure may damage the human eye and the microscope lamp brightness should be turned down when viewing the optical scale.

To set the scaling factor, enter the alternative menu by pressing the ALT button. Then select the magnify routine by pressing numeric button 7. Follow the instructions shown on the LCD, i.e. Adjust the curtain width (right hand knob) and the curtain position (left hand knob) so that the curtain ends coincide with the 0 & 1mm markings on the scale.
(the microscope lamp will illuminate as soon as the microscope adjusting screw is turned).

After scaling, you are given the option of altering the settings.

The setting can easily be checked, when the CK10 has been ENTERed into its ring crack measurement mode, by viewing the scale and checking that the curtain movement corresponds to the digital read-out. The curtain width can also be checked in this way.

If an optical scale is not available, the settings can be approximately checked:
View a mark, with the LH or RH curtain, on the X-Y table and zero the X-Y table
ENTER the ring crack measurement mode and exit by pressing ENTER three more times.
Move the X-Y table 0.50mm
Again ENTER the ring crack measurement mode and move the curtain to coincide with the chosen mark, if the 3rd decimal place reading on the microscope reading is disregarded, the microscope reading should correspond to the 0.50mm movement of the X-Y table.

APPENDIX 4

Crack size calculation.
Full details of the ring crack method used to determine the micro-crack size in ceramic materials are published in:-

Journal of materials research, Vol. 9. 3194-3202, 1994
Surface flaw distribution and Hertzian fracture in brittle materials.
By Warren, Hills & Roberts.

The following is a précis of the above and shows the equations which are used by the CK10 to calculate the original micro-crack size.

The Hertzian Stress Field.
When a sphere of radius R and with elastic constants ν_1 & E_1, is pressed, with a load P into the flat surface of a substrate whose corresponding elastic constants are ν & E, the load is supported over a circular contact area, radius a, given by:-

$$a = \left(\frac{3RP}{4E^*} \right)^{1/3}$$

where

$$1/E^* = (1 - \nu^2)/E + (1 - \nu_1^2)/E_1$$

The peak contact pressure under the indenter, p_0, is given by:-

$$p_0 = 3P/2\pi a^2$$

Fracture mechanics.
When Hertzian fracture occurs (at a load P_F) then a small pre-cursor flaw (depth c) grows into a ring-crack, radius r. This ring-crack is visible on the surface of the substrate. By measuring P_F and r, the depth of the original crack, c, can be calculated by solving (numerically) the following cubic equation:

$$\frac{K_{IC}}{p_o\sqrt{\pi a}} = \left[1.12 \frac{(1-2\nu)}{3(r/a)^2} - \frac{2\alpha}{\pi} \left(\frac{c}{a} \right) \right] \left(\frac{c}{a} \right)^{1/2}$$

where

$$\alpha = \frac{-1}{\sqrt{u}} \left[\frac{(1-\nu)}{(1-u)} u + (1+\nu)\sqrt{u} \tan^{-1}\left(\frac{1}{\sqrt{u}} \right) - 2 \right] \qquad a = \left(\frac{3RP_F}{4E^*} \right)^{1/3}$$

and $u = (r/a)^2 - 1$ $\qquad p_o = 3P_F/2\pi a^2$

APPENDIX 5

Fracture toughness calculation via Hertzian indentation.

Hertzian indentation testing can be used to calculate values for the fracture toughness, K_{IC}, of a material. Full details are given in:-

Journal of European Ceramic Society, Vol. 15. 201-207 , 1995.
Determining the fracture toughness of brittle materials by Hertzian indentation.
P. Warren.

The procedure is as follows:-

(i) Abrade the surface of the substrate with a course diamond paste (14μm should be sufficient) - to provide a large density of seed cracks.

(ii) With a sphere ideally made out of the same material as the substrate, make a series of tests, say 25, over the substrate surface. Note the smallest of the 25 fracture loads, P_{min}.

(iii) The following formula can be used to calculate the fracture toughness:-

$$K_{IC} = \sqrt{\frac{E^* P_{min}}{RC}}$$

where R is the radius of the indenter sphere

and:

$$\frac{1}{E^*} = \frac{(1 - \nu_1^2)}{E_1} + \frac{(1 - \nu^2)}{E}$$

ν & E are Poisson's ratio and Young's modulus of the substrate and ν_1 & E_1 are the corresponding values for the indenter.

and

C is a number whose value depends solely on the value of Poisson's ratio for the substrate and is given in the following table:-

ν	C	ν	C	ν	C	ν	C
0.14	1082	0.19	1677	0.24	2810	0.29	5267
0.15	1175	0.20	1847	0.25	3153	0.30	6080
0.16	1279	0.21	2040	0.26	3555	0.31	7071
0.17	1396	0.22	2261	0.27	4029	0.32	8293
0.18	1528	0.23	2515	0.28	4593	0.33	9817

The table compilation details are given in the above reference

Fracture toughness calculation via Edge Toughness testing.
There is a relationship between M, the edge toughness, and G_{IC}, the critical strain energy release rate. At present this is an empirical relationship, but the existence of a master curve allows the critical strain energy release rate to be predicted from the Edge Toughness. It is therefore possible to predict the value of anyone of the four variables; Edge Toughness, Fracture Toughness, Young's Modulus and Hardness, by a knowledge of the other three.
The following curve was presented in :-

Journal of Hard Materials, Vol. 1, No.1, 1990
Edge Flaking of Brittle Materials
N. J. McCormick & E. A. Almond.

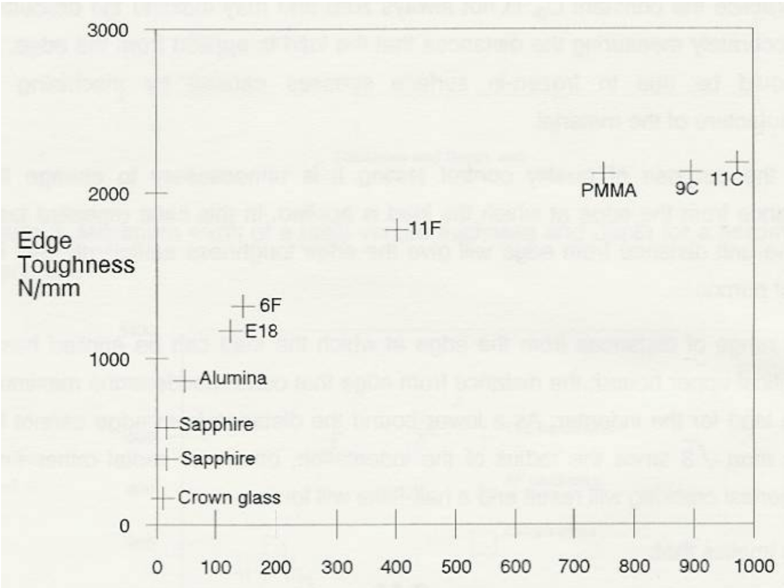

Figure 19 Critical strain energy release rate G_{IG} J/m^2

Although this study is still in its infancy, it is possible to determine the fracture toughness of the specimen material simply by carrying out an edge toughness test and knowing some information on the physical properties of the material. To calculate the critical strain energy release rate of the material being tested requires a reading from the following curve of the value of the critical strain energy release rate corresponding to the measured edge toughness. Using the following formula it is possible to calculate the fracture toughness of the material:

$$K_{IC} = \sqrt{G_{IC} . E} \qquad (1)$$

An alternative technique is to use the following empirical formula, which has been derived from measurements of hard brittle materials, like ceramics and hardmetals.

$$\frac{M}{C_{GI}} = -14.13 + 894.6 \frac{H}{E}$$

where:

M is the edge toughness in N/mm

G_{IC} is the critical strain energy release rate in N/m or J/m^{-2}

H is the hardness in units of GN/m^2

$$H = \frac{\text{Load}}{\text{Projected area of indentation}}$$

The projected area is the area of the indentation when looked at from above the test surface.

E is Young's modulus and has units GN/m^2

Therefore from (1)

$$K_{IC} = \sqrt{\frac{ME^2}{894.6\,H - 14.13\,E}} \quad Nm^{-3/2}$$

However the empirical parameters in the preceding equations may necessarily be refined as more materials are investigated.

The above was published in a booklet, written by Nick McCormick of the National Physical Laboratory, Teddington, London, England. and produced by Engineering Systems (Nottm).

APPENDIX 6

Notes:-

Erratica

One character within the LCD module has been changed by the manufacturer. When using the CK10 to calculate the micro crack size (µm) the display should show µm but it actually shows øm. i.e. the µ is changed to a ø.

Page 20. 6=Fatigue.......... has been changed to :

6=Cycle
Cycles, at test speed, between Low-limit and Max/Hold load.