



BUEHLER

MACROMET 3100

TWIN TYPE



Declaration of Conformity

Manufacture:
Of:



BUEHLER, Ltd.
41 Waukegan Road
Lake Bluff, Illinois 60044

Declares the following product:

Macromet 3100 Twin Type

To be in accordance with EC Directive(s):

Safety of Machinery:

89/392/EEC and 91/368/EEC and 93/44/EEC
according to the following standards:

EN 292	Part 1	1991
EN 292	Part 2	1991
EN60204	Part 1	1993

EMC Directive:

89/336/EEC and 92/231/EEC according to
the following standards:

EN 50081-1:	1992
EN 50082-1:	1992

Position: Director of Engineering

Name: Arnie Buchanan

Signature: *Arnie Buchanan*

Date: 9/5/2000

THIS MANUAL IS A CUSTOM GENERATED DOCUMENT. IT INCLUDES ALL REVISIONS RELATIVE TO THIS SPECIFIC BUEHLER ITEM AS OF THE DATE DISPLAYED BELOW

The items covered in this communication including all attachments may be subject to the export laws of the United States of America, including without limitation the Export Administration Regulations and the Office of Foreign Asset Control Regulations. The export, re-export or diversion of these items in contravention of these or other applicable regulations is strictly prohibited.

This information contained in this communication is intended only for the use of the individual or entity to which it is addressed and may contain information that is privileged, confidential and exempt from disclosure under applicable law.

Table of Contents

Description	Page
Warranty	3
Unpacking	3
Assembly	3
Specifications	6
Explanation of Functions	8
LCD screen flow diagram	8
Explanation of LCD screens	9
Main Menu screen	9
Utility Mode screen	10
Measurement Condition screen	11
Select Printer screen	12
Transmission Rate screen	13
Support Center Display screen	14
Support Center Record screen - explanation of screen	15
Support Center Record screen - explanation of keys	16
Set Up Mode screen	17
Time/Date Setting screen	18
Load Holding Time Setting screen	19
Print Mode Setting screen	20
Printing Formats	21
Measurement Range Setting screen	22
Stored Data Item Number Setting screen	23
Batch Number Setting screen	24
Batch Number Setting screen - explanation of keys	25
Data Edit Mode screen	26
Edit Measuring Data screen	27
Display Conversion Data screen	29
Select Conversion Scale screen	30
.Display Total Data screen	31
Display Total Data screen	31
Print Out Mode screen	32
Printer Connection	33
Transmission Format	35
Test Precautions	38
Getting Started	40
Test Method	40
Calibration Verification	43
Appendix A	45
Standard Accessories	45
Main Dimensions in millimeters	46
Appendix B	47
Reference Data	47

INSTRUCTIONS

DIGITAL ROCKWELL HARDNESS TESTER TYPE RMT-1, TYPE RMT-3



Warranty

This unit is guaranteed against defective material and workmanship for a period of two (2) years from date of shipment by BUEHLER LTD. Warranty is void if inspection shows evidence of abuse, misuse or unauthorized repair. Warranty covers only replacement of defective materials.

If, for any reason, this unit must be returned to our plant for warranty service, please apply for prior authorization and shipping instructions. Include the following information: Customer Purchase Order Number, BUEHLER Ltd. Invoice Number and Date, Serial Number, and reason for return.

Unpacking

Carefully unpack and check contents. If any components are missing or damaged, save the packing list and material and advise the carrier and BUEHLER Ltd. of the discrepancy.

Assembly

- Step 1 Remove machine, weight box and accessory (black) box from carton.
- Step 2 Place machine on a level surface. Remove four feet from the accessory (black) box and assemble on the bottom of the unit on the four corners.
- Step 3 Remove four screws that hold on the top cover. Remove top cover.
- Step 4 Remove the shipping cardboard insert connected to the blue tyrap and discard. (**See Figure A**)

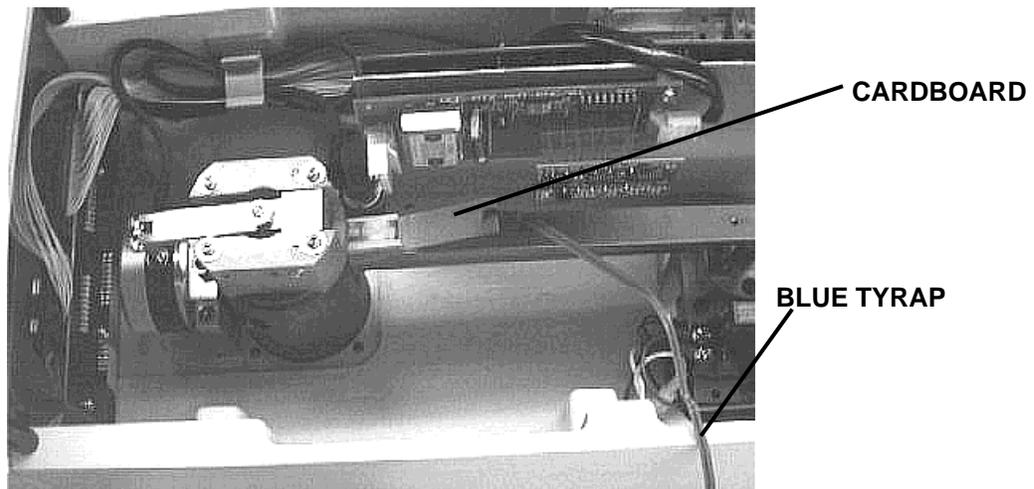


Figure A
(View from top of Macromet)

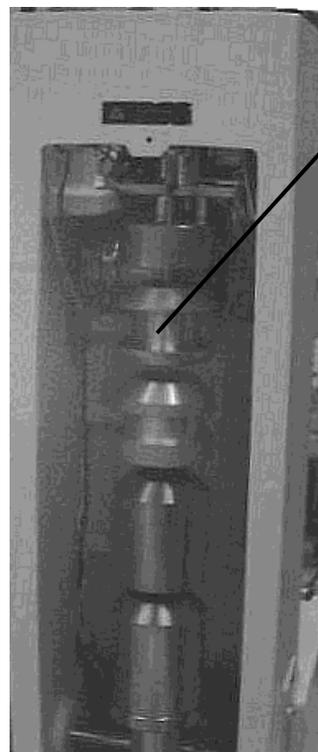
- Step 5 Replace top cover on machine and fasten with four screws.
- Step 6 Remove rear cover with one fastening screw. (**See Figure B**)

FASTENING SCREW
LOCATION



Figure B (View of rear of machine without rear cover)

Step 7 Remove weight set from box, and mount to the rear top inside of the unit as shown in **Figure C**.

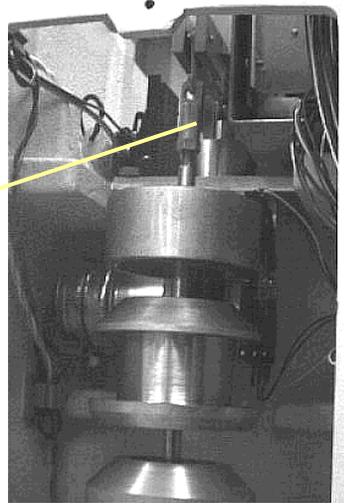


WEIGHT SET

Figure C (View from inside rear of the machine)

Step 8 Replace rear cover, attach with screw that was used to remove the cover.

Attach weight set on hook,
as displayed



Step 9 From the front of the machine; remove the blue tyrap with the Quality Assurance card and silica bag attached to the collar.

Q A card and Silica bag



Specifications

Type	RMT-1	Rockwell only machine
	RMT-3	Rockwell/superficial combined machine
Datum load	RMT-1	98.07N (10kgf)
	RMT-3	29.42N, 98.07N (3kgf, 10kgf)
Test load	RMT-1	588.4 980.7 1471.0 N 60 100 150 kgf
	RMT-3	147.1 294.2 441.3 N 15 30 45 kgf
		588.4 980.7 1471.0 N 60 100 150 kgf
Measurement scale	RMT-1	A B C D E F G H K L M P R S V
	RMT-3	A B C D E F G H K L M P R S V 15N 30N 45N 15T 30T 45T 15W 30W 45W 15X 30X 45X 15Y 30Y 45Y
Datum loading setting	Automatic setting system, bar graph display, digital audio monitor, fine adjustment unnecessary.	
Loading control system	Automatic (load - hold - release)	
Start system	Auto-start/manual start selection	
Load holding time	3 to 99 seconds. (Can be set at 1 second intervals)	
Plastic measurements	Equipped as standard. Hardness display timer 0 to 99 seconds. (Can be set at 1 second intervals)	
Operating switches	A Touch control on LCD screen	
Data display	Displayed on backlit LCD screen. (Features screen saver)	
Memory function	Capable of storing up to 256 data items.	
Hardness conversion function	SAE (J-417b) ASTM (E-140) JIS stipulated conversion display	
Acceptance evaluation function	Evaluations of HI/OK/LOW compared to preset hardness limit	

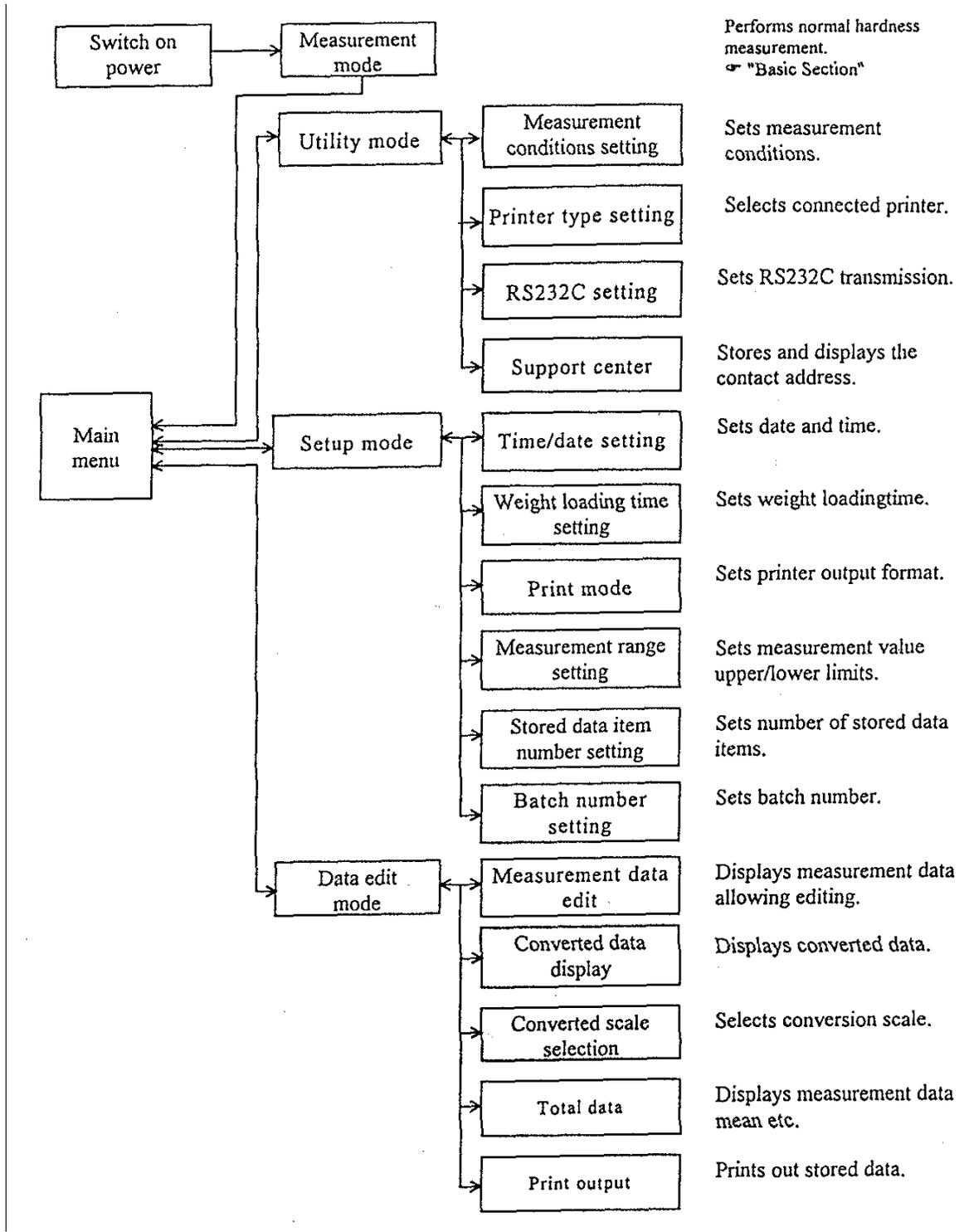
Data editing functions	<p>Edit actual measurement data (correction, deletion)</p> <p>Display converted data</p> <p>Convert stored data all at once</p> <p>Display statistical data (mean, maximum, minimum, standard deviation, variance)</p> <p>Print out after editing data</p> <ul style="list-style-type: none"> a. Actual measurements, max. value, min. value, variance, mean, standard deviation b. Converted values, max. value, min. value, variance, mean, standard deviation
Data output	<p>RS232C D-sub25P connection at rear of unit.</p> <p>Output items Measurement data, converted data, mean value, max. value, min. value, variance, standard deviation, and acceptance evaluation</p> <p>Printer Centronics output from 57F-36 at rear of unit. Serial output from D-sub25P at rear of unit. (Interchange with RS232C set at factory)</p> <p>Output items ① Measurement data only ② Measurement data and acceptance evaluation ③ Measurement data, max. value, min. value, variance, mean, and standard deviation ④ Measurement data, mean value, and acceptance evaluation on mean value ⑤ Converted data only ⑥ Converted data and acceptance evaluation ⑦ Converted data, max. value, min. value, variance, mean, and standard deviation ⑧ Converted data, mean value, and acceptance evaluation on mean value</p>
Measurable specimens	<p>Max. height: 250mm (200mm on RMT-3)</p> <p>Max. depth: 160mm</p>
Accuracy	Complies with JIS B7726, ASTM E-18
Machine dimensions and weight	220mm × 550mm × 830mm (W D H) Approx. 85kg
Power supply	<p>90-132V AC or 180- 264V AC (Supply voltage set at factory)</p> <p>Single phase 50/60Hz</p>

These specifications may be changed without notice, due to improvements.

Explanation of Functions

LCD screen flow diagram

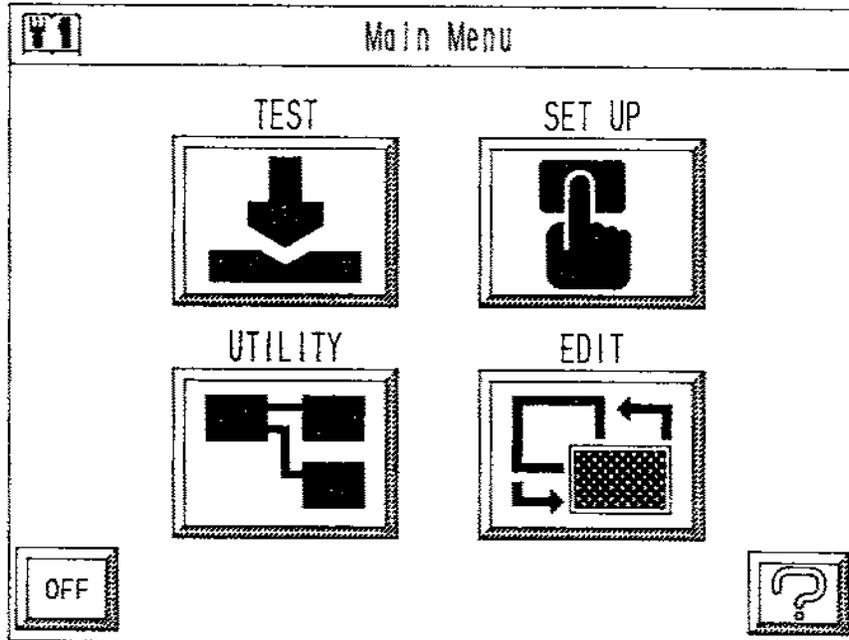
* Press the [?] key on each screen to return to the Help screen, explaining each key.



Explanation of LCD screens

Main Menu screen

The **Main Menu** screen is used to select the mode:

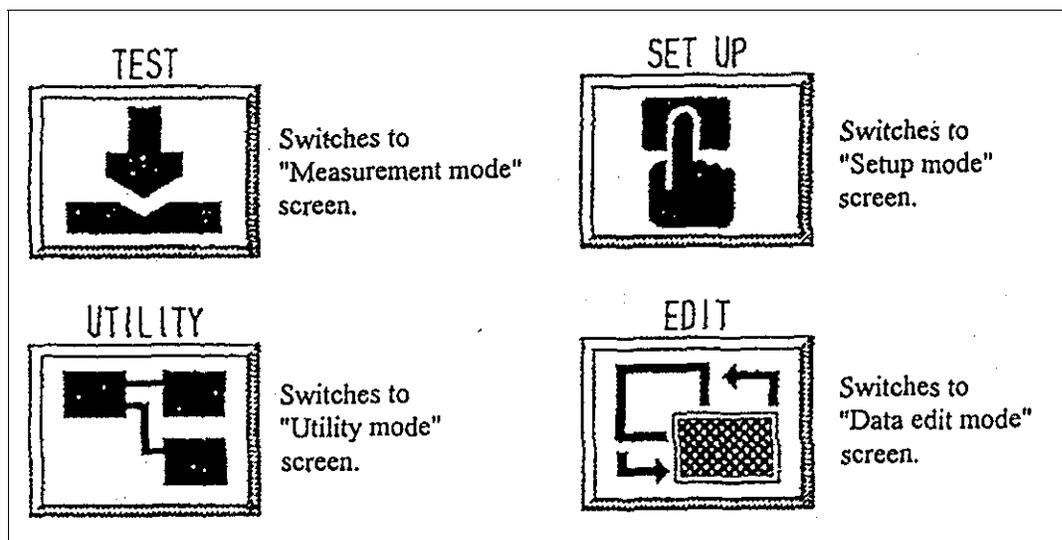


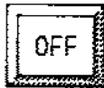
The Machine Type and Name is displayed when the power is turned on. The display will then change to the **Measurement Mode** screen.



Pressing the **Menu Key** at the bottom left of the **Measurement Mode** screen returns to the **Main Menu** screen.

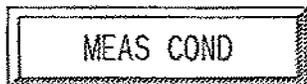
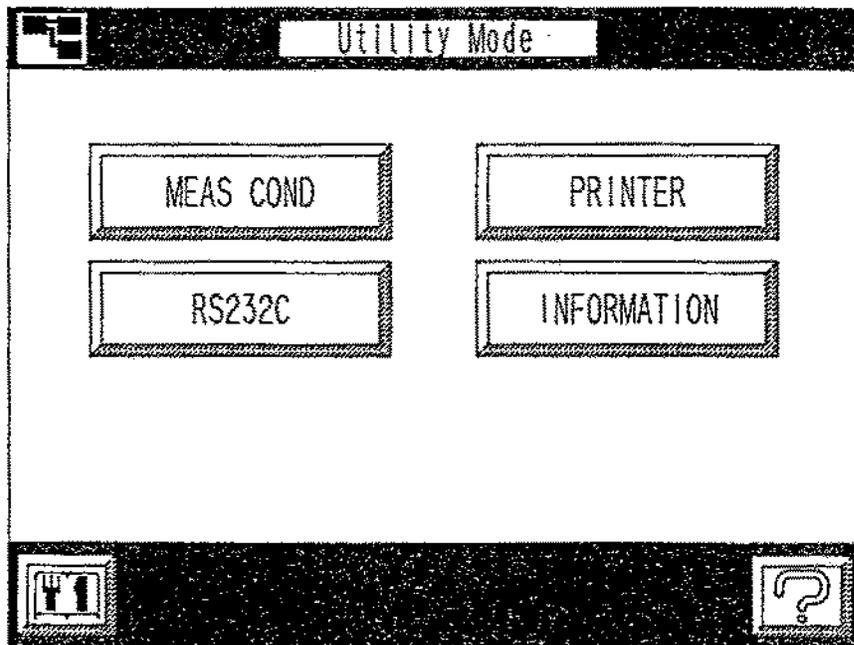
Advancing to other modes is performed by first changing to this screen:





Press the **OFF** key to clear LCD screen. This feature is used to save energy and extend component life, use it when taking breaks, etc. When resuming use, touch any part of the screen panel to restore the screen to as it was before.

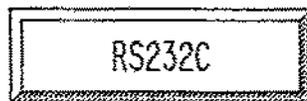
Utility Mode screen



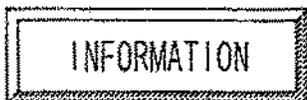
Advances to the **Measurement Condition** setting screen.



Advances to the **Select Printer** screen.



Advances to the **RS232C** setting screen.



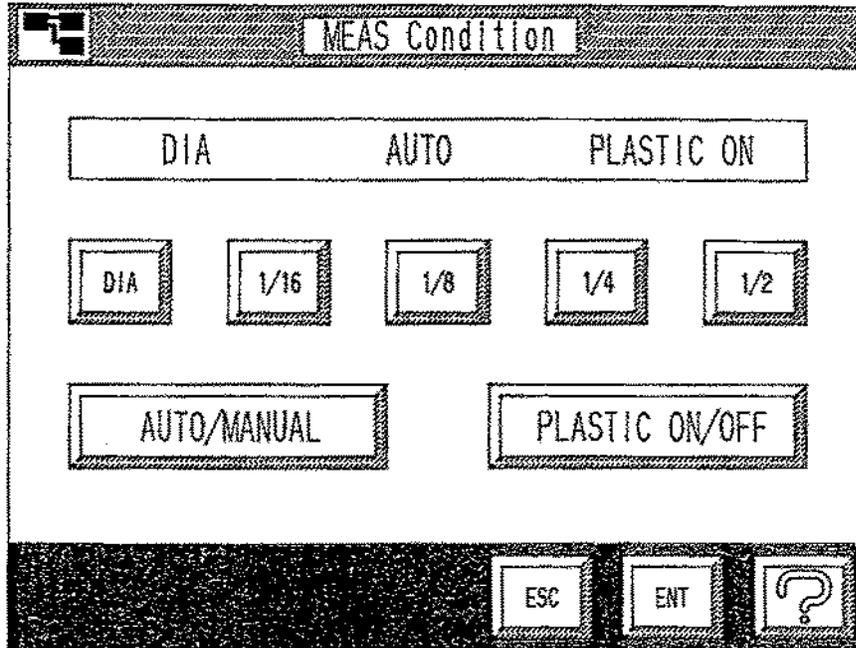
Advances to the **Information** screen.



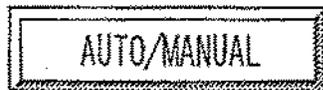
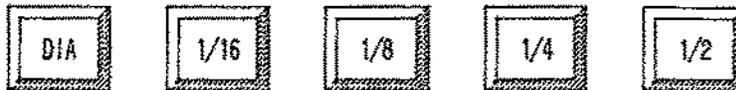
Returns to the **Main Menu** screen.

Measurement Condition screen

Sets various measurement conditions such as indenter type, automatic/manual mode, plastic measurement, etc.



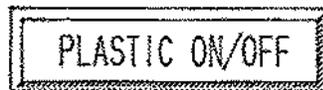
Select the indenter type from these five keys:



Selects Automatic or Manual measurement.

If Automatic is selected, the test load loading operation starts automatically after loading the datum load.

If Manual is selected, the test load is loaded by pressing the **START** key after loading the datum load.



Selects the Plastic Measurement timer **ON** or **OFF**.

If **ON** is selected, the plastic measurement timer (timer until reading in after unloading the test load) operates.



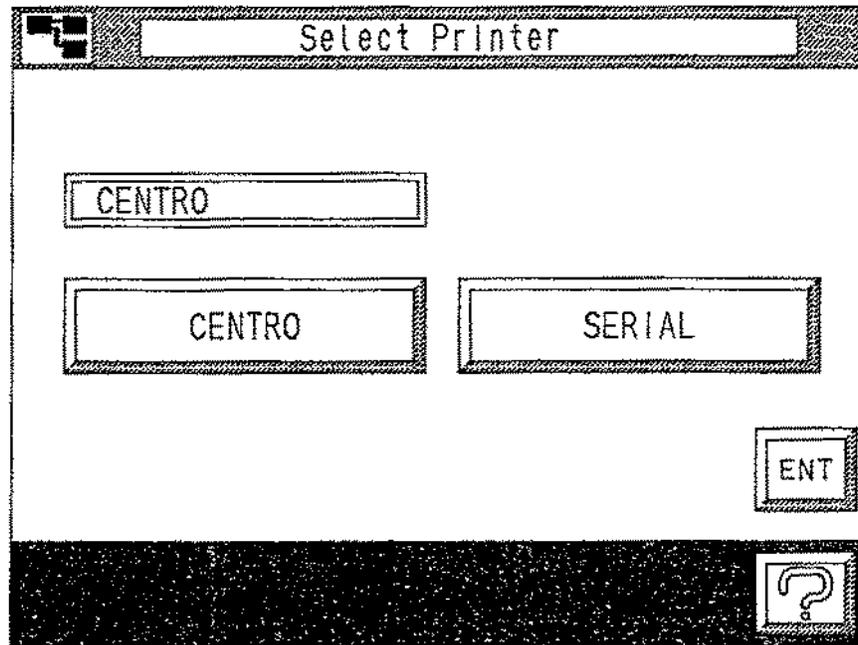
Press to confirm the Measurement Condition settings.



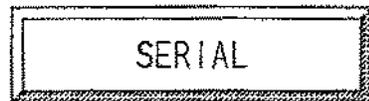
Returns to the **Utility Mode** screen.

Select Printer screen

Selects the printer connected to the hardness tester for printing out data.



The **CENTRO** key selects a centronics (parallel port) printer.



The **SERIAL** key selects a serial printer.



Press the **ENT** key to confirm the printer type and to return to the **Utility Mode** screen.

Transmission Rate screen

Is for setting the RS232C transmission.

RS232C

9600bps + PARITY NONE

BAUD RATE

9600 4800 2400 1200

PARITY

EVEN NONE ENT

?

9600

9600 BPS

4800

4800 BPS

2400

2400 BPS

1200

1200 BPS

EVEN

Even parity

NONE

No parity

ENT

Press the **ENT** key to return to the **Utility Mode** screen.

Select the BAUD RATE from these four types.

Select the PARITY from these two types.

Information screen.

Records the manufacturer (BUEHLER LTD.) or sales agent that provides after-sales service. Displays the company name, address and telephone number.

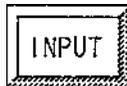
The screenshot shows a terminal window titled "INFORMATION". The window contains the following text:

```
SUPPORT OFFICE  
  
Address  
  
Phone
```

At the bottom of the window, there are three buttons: "INPUT" on the left, "ESC" on the right, and a question mark icon in the bottom right corner.



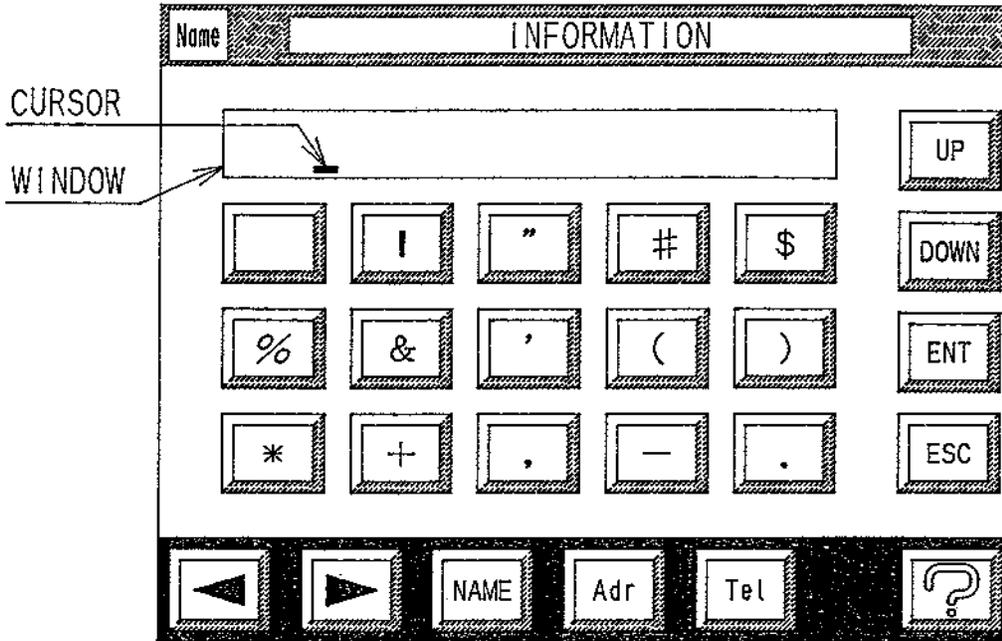
Returns to the **Utility Mode** screen.



Advances to the **Information** screen to add information on support resources.

This screen may also be used for other purposes.
It may be considered convenient to record the internal phone number of persons involved, or the names of supervisors.
The headings *SUPPORT OFFICE*, *Address* and *Telephone* number cannot be deleted.

Information (Support Office) - explanation of screen

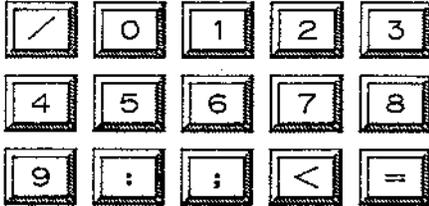


94 different letters, numerals, and symbols can be entered and are displayed over 7 screens. Enter the required characters by selecting from each screen.

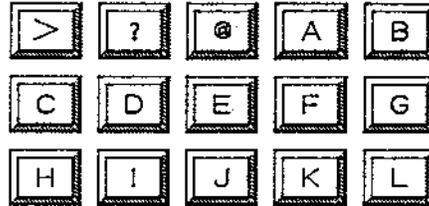
The character entered is displayed at the cursor position (see above) and the cursor will move to the right with each character input.

The characters that can be entered are displayed below:

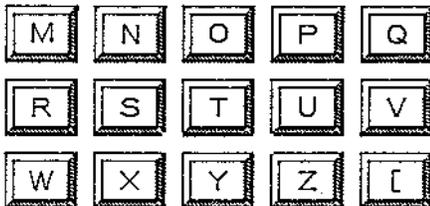
2nd screen



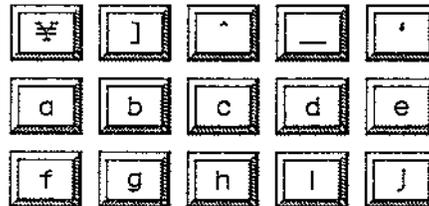
3rd screen



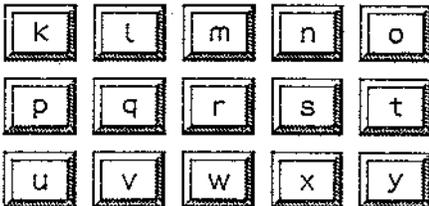
4th screen



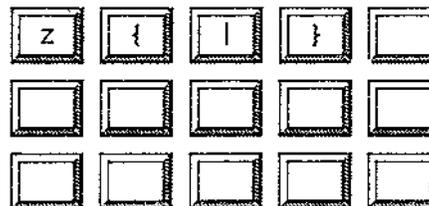
5th screen



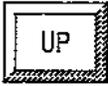
6th screen



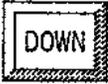
7th screen



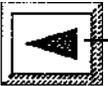
Information (SUPPORT OFFICE) screen - explanation of keys



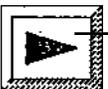
Moves to the next screen and the characters that are displayed change.



Returns to the previous screen.



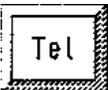
Used to move the cursor to the desired position when entering a character.



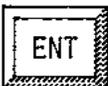
The **NAME** key is used to enter the SUPPORT OFFICE information. **Name** will display at the top-left of the screen and up to 25 characters can be entered.



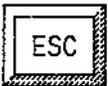
The **Adr** key is used to enter in the Address information. **Adr** will display at the top-left of the screen and up to 90 characters can be entered.



The **Tel** key is used to enter in the Telephone information. **Tel** will display at the top-left of the screen and up to 20 characters can be entered.

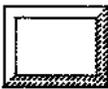


Press **ENT** to confirmed SUPPORT OFFICE, Address, and Telephone Number.



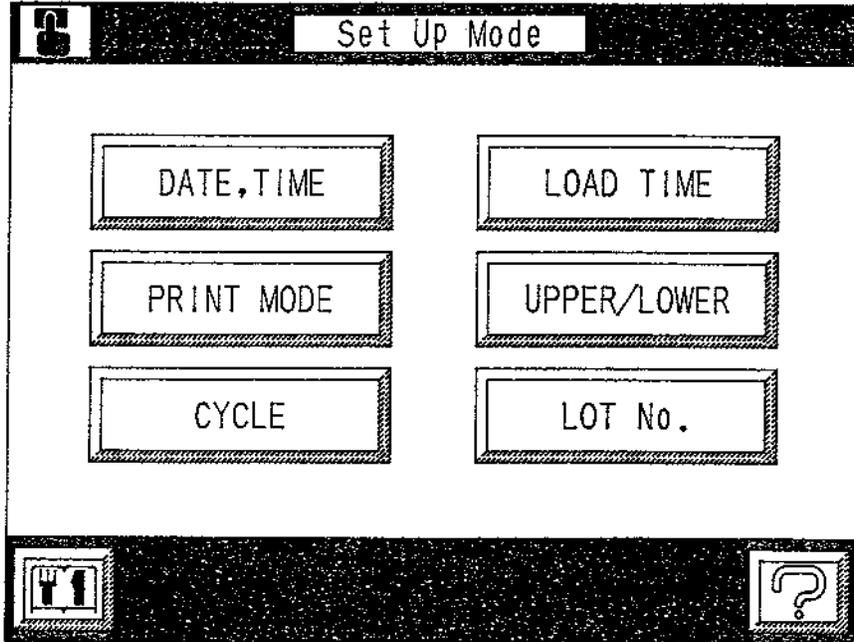
Returns to **Information** screen.

To correct a character already entered, move the cursor to the position of the character to be changed and overwrite it with the correct character.

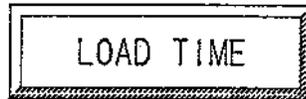


The **Space Key** overwrites or deletes any unwanted characters.

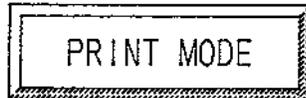
Set Up Mode screen



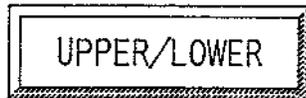
Advances to the **Date/Time** setting screen.



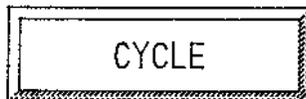
Advances to the **Load Holding Time** setting screen.



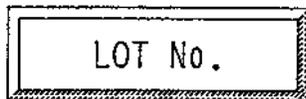
Advances to the **Print Mode** setting screen.



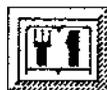
Advances to the **Measurement Range** setting screen.



Advances to the **Set Up Measuring (Stored Data)** setting screen.



Advances to the **Batch Number** setting data screen.



Returns to **the Main Menu** screen.

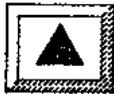
Time/Date Setting screen

Sets the Time, Day, Month and Year when sending data to the printer.

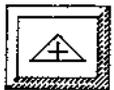
DAY	MONTH	YEAR
1	1	1980

HOUR	MINUTE
0	30

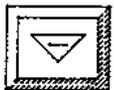
Buttons: [Up Arrow], [Down Arrow], [ENT], [ESC], [Help Icon]



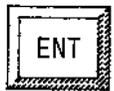
Press this key below the selected field. The cursor will appear below the field to enable a change in data.



Increases the number.



Decreases the number.



Confirms each item and starts the calendar and clock.

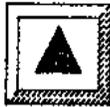
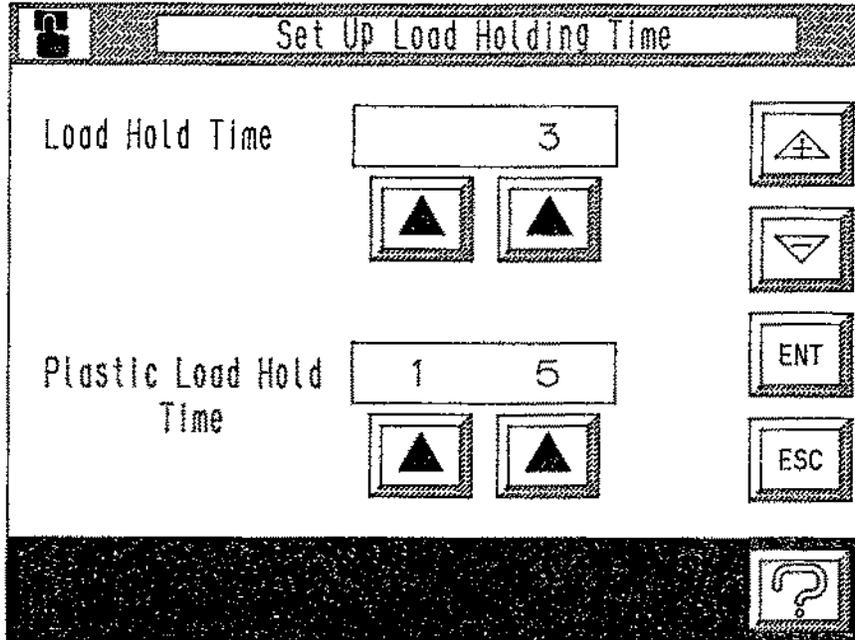


Returns to the **Setup Mode** screen.

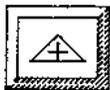
If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place.

Load Holding Time Setting screen

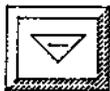
Sets the Test Load Holding Time for normal measurements and the reading-in time after releasing the load for plastic measurements.



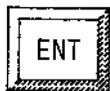
Press this key below the selected field. The cursor will appear below the field to enable a change in data. The **Load Hold Time** can be set in a range of 3 to 99 seconds and the **Plastic Load Hold Time** can be set in a range of 0 to 99 seconds.



Increases the number.



Decreases the number.



Confirms the settings.

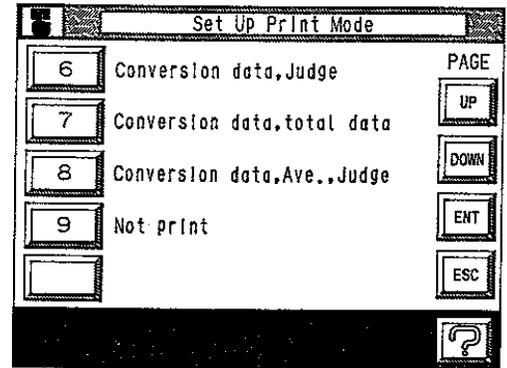
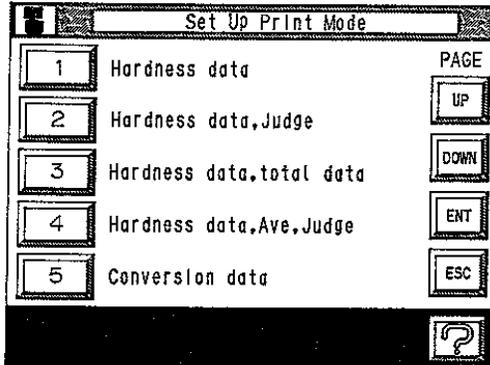


Returns to the **Setup Mode** screen.

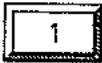
If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place

Print Mode Setting screen

Selects the print format sent to the printer.

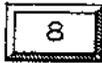


There are 8 different print data formats.

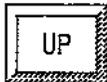


Select a key 1 through 8 to determine the type of data to be printed.

(See the following page for all the printing formats)



Press Key 9 when printing is not required.



Advances to the next screen.



Returns to the previous screen.



Confirms the selection.



Returns to the **Setup Mode** screen.

If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place

Printing Formats

1 Measurement data only

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 HRC=  60. 3
002 HRC=  61. 4
003 HRC=  62. 6
```

2 Measurement data,
acceptance evaluation

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 HRC=  60. 3   LO
002 HRC=  61. 4   OK
003 HRC=  62. 6   HI
```

3 Measurement data, general data

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 HRC=  60. 3
002 HRC=  61. 4
003 HRC=  62. 6
      MAX=  62. 6
      MIN=  60. 3
      RNG=   2. 3
      AV =  61. 4
      DEV=   1. 1
```

4 Measurement data, mean value,
acceptance evaluation

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 HRC=  60. 3
002 HRC=  61. 4
003 HRC=  62. 6
      AV =  61. 4   OK
```

5 Converted data only

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 P=150kgf HV = 703. 9
002 P=150kgf HV = 730. 4
003 P=150kgf HV = 761. 6
```

6 Converted data,
acceptance evaluation

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 P=150kgf HV = 703. 9
                        LO
002 P=150kgf HV = 730. 4
                        OK
003 P=150kgf HV = 761. 6
                        HI
```

7 Converted data, general data

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

001 P=150kgf HV = 703. 9
002 P=150kgf HV = 730. 4
003 P=150kgf HV = 761. 6
      MAX=  761. 6
      MIN=  703. 9
      RNG=   57. 7
      AV =  731. 9
      DEV=   28. 8
```

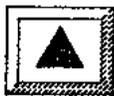
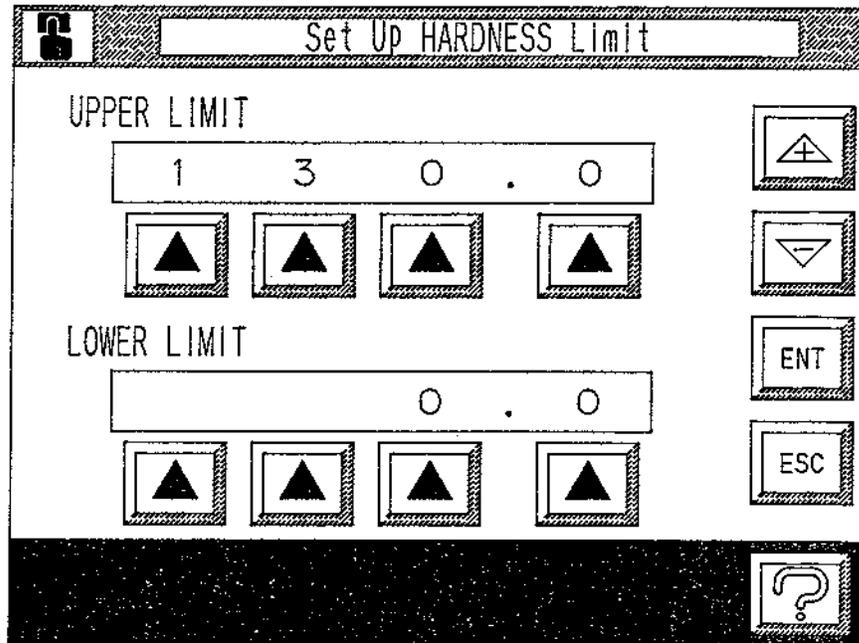
8 Converted data, mean value,
acceptance evaluation

```
DATE      1997.  1.  1
LOT NO.   ABCDEFGHIJ

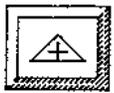
001 P=150kgf HV = 703. 9
002 P=150kgf HV = 730. 4
003 P=150kgf HV = 761. 6
      AV =  731. 9   OK
```

Measurement Range Setting screen

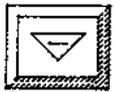
Sets the upper and lower limits for the hardness value. The acceptance evaluation is displayed on the **Measurement Mode** screen or an external output device (based on what settings have been selected).



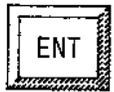
Press this key below the selected field. The cursor will appear below the field to enable a change in data. Enter permissible hardness values in the Upper and Lower Limits. A Lower Limit greater than the Upper Limit cannot be entered.



Increases the number.



Decreases the number.



Confirms the settings.

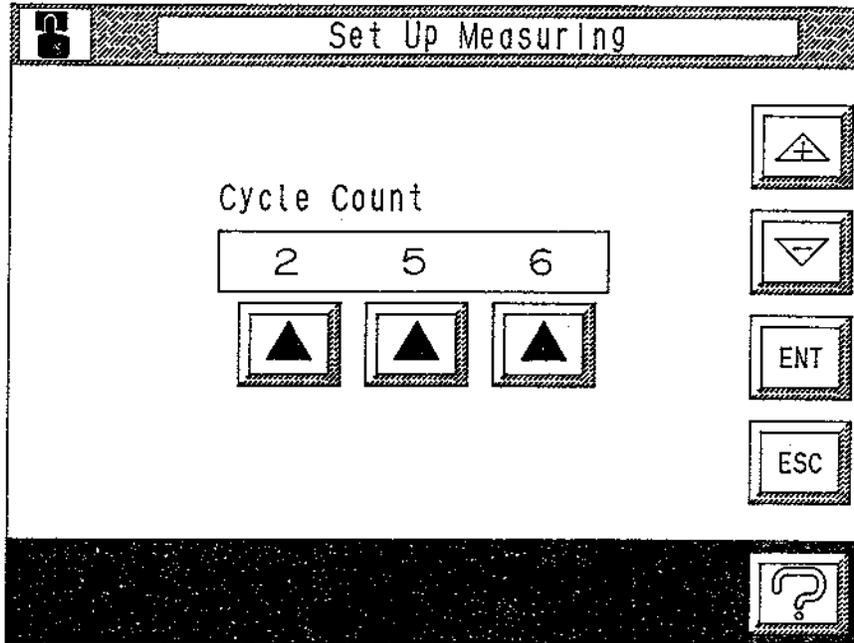


Returns to the **Setup Mode** screen.

If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place.

Set Up Measuring (Stored Data) screen

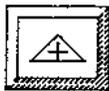
The Macromet 3100 is capable of temporarily storing measured data. The **Set Up Measuring** screen is used to set the number of stored data items.



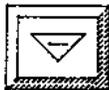
- Data is stored sequentially for each measurement.
- Data cannot be stored for measurements once the Set Number has been reached.



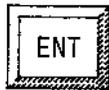
Press this key below the selected field. The cursor will appear below the field to enable a change in data.



Increases the number.



Decreases the number.



Confirms the settings.

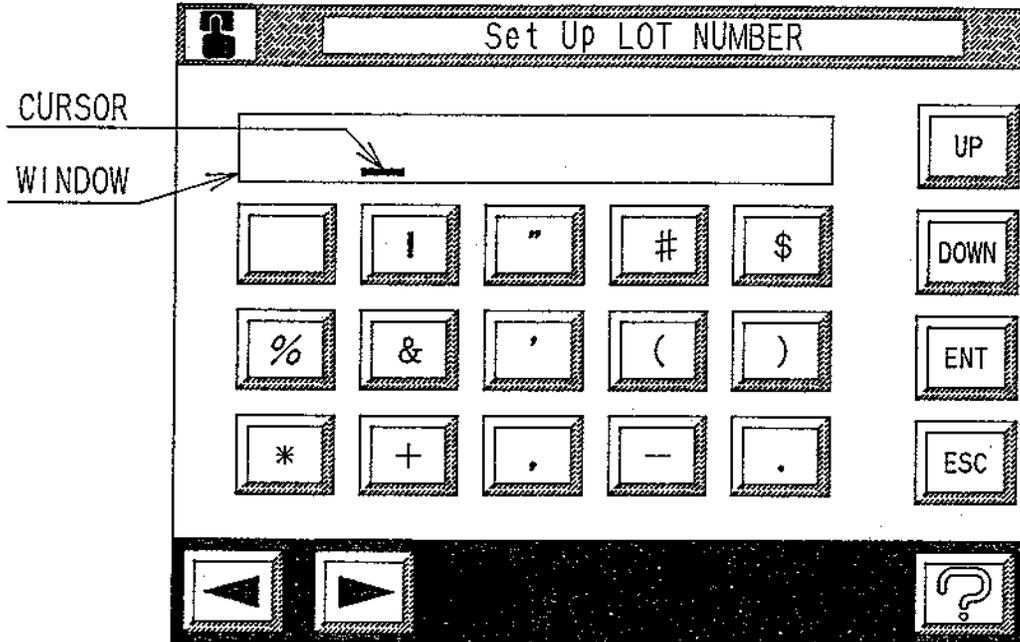


Switches to the **Setup Mode** screen.

If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place.

Batch Number Setting screen

Sets a batch number when outputting data to an external device.

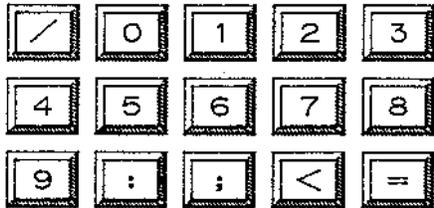


94 different letters, numerals, and symbols can be entered and are displayed over 7 screens. Enter the required characters by selecting from each screen.

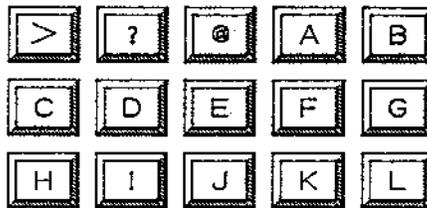
The character entered is displayed at the cursor position (see above) and the cursor will move to the right with each character input.

The characters that can be entered are displayed below:

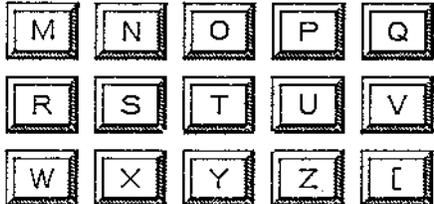
2nd screen



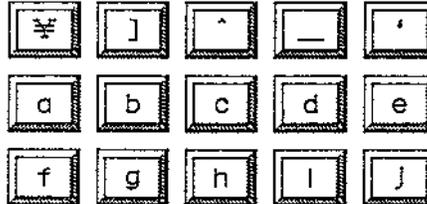
3rd screen



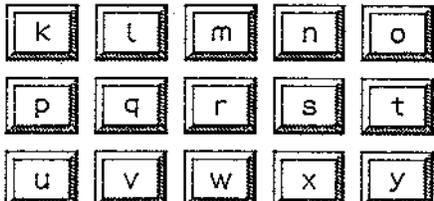
4th screen



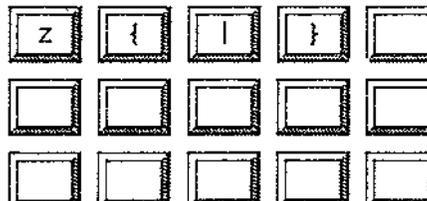
5th screen



6th screen



7th screen



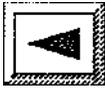
Batch Number Setting screen - explanation of keys



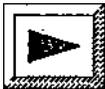
Moves to the next screen and the characters that are displayed change.



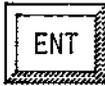
Returns to the previous screen.



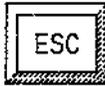
a



Used to move the cursor to the desired position when entering character. Up to 10 characters can be entered.

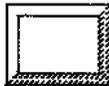


Confirms the record of the batch number.



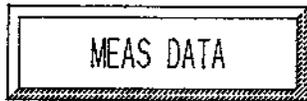
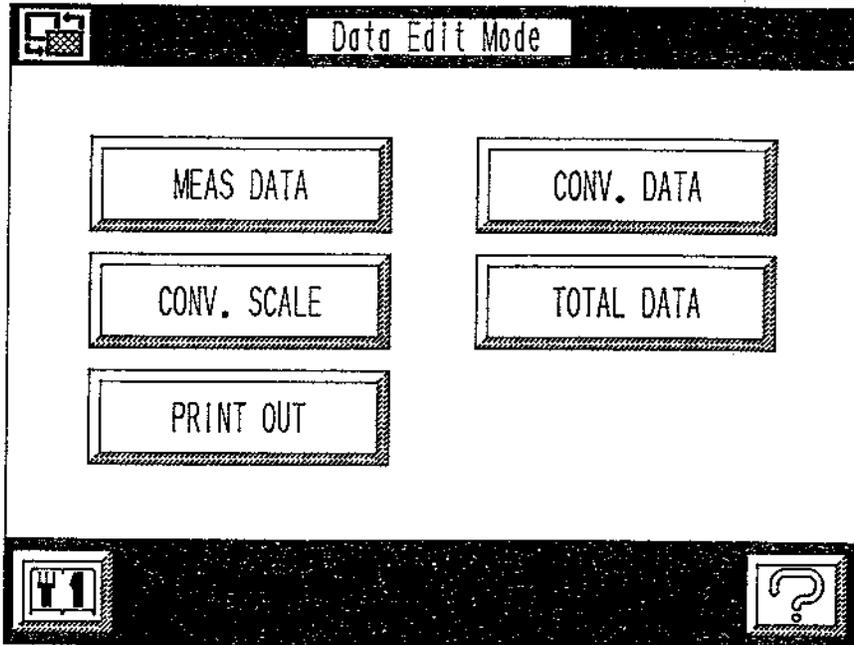
Returns to the **Set Up Mode** screen.

If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place.

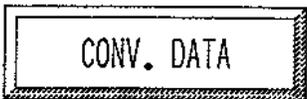


The **Space Key** overwrites or deletes any unwanted characters. To correct a character already entered, move the cursor to the position of the character to be changes and overwrite it.

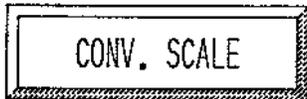
Data Edit Mode screen



Advances to the **Edit Measuring Data** screen.



Advances to the **Display Conversion Data** screen.



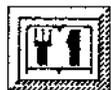
Advances to the **Select Conversion Scale** screen.



Advances to the **Display Total Data** screen.



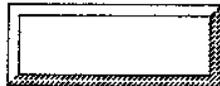
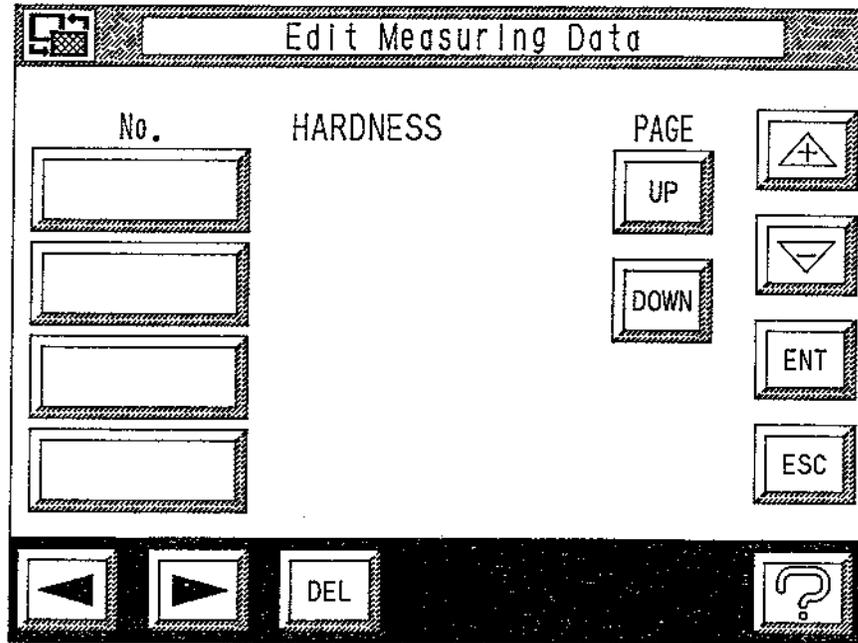
Advances to the **Print Out Mode** screen.



Returns to the **Main Menu** screen.

Edit Measuring Data screen

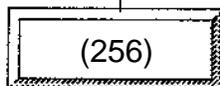
Is used for displaying and editing data stored in the hardness tester.



The keys are allocated in sequential numbers starting with 1 when data is entered. Hardness values can be viewed on this screen.



Press the key with the number of the data item to be edited to activate the cursor below the *Hardness Value*, enabling editing. Only the data items of the number set on the **Set Up Measuring** screen can be displayed and edited.



(A maximum of 256 data items can be displayed.)



Advances to the next screen. If data is not entered, the next screen is not accessible.

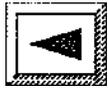


Returns to the previous screen.

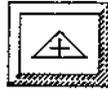
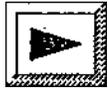


Deletes data, The **DEL** key changes the hardness value display to 0.0.

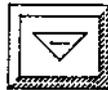
Measuring Data screen continued:



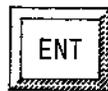
Used to move the cursor to the desired position when entering a character.



Increases the number.



Decreases the number.



Confirms the settings.



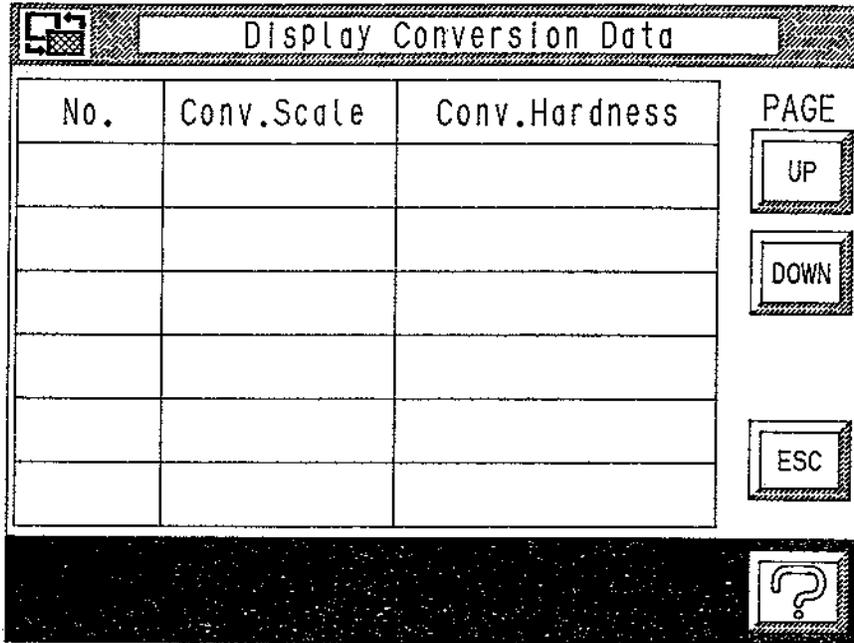
Returns to the *Data Edit Mode* screen.

If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place.

Display Conversion Data screen

The Macromet 31000 has a feature which converts Rockwell hardness or Rockwell superficial hardness values measured into Vickers hardness values or other hardness scales.

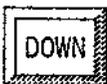
The **Display Conversion Data** screen below displays the preset conversion scales and conversion data.



No.	Conv.Scale	Conv.Hardness	PAGE
			UP
			DOWN
			ESC



Advances to the data on the next screen. If data is not available on other screens, this key will not be active.



Returns to the previous page.



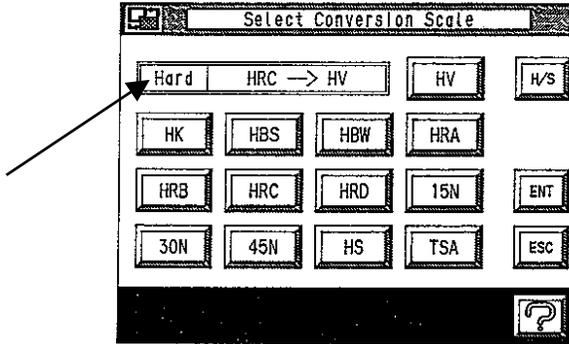
Returns to the **Data Edit Mode** screen.

Select Conversion Scale screen

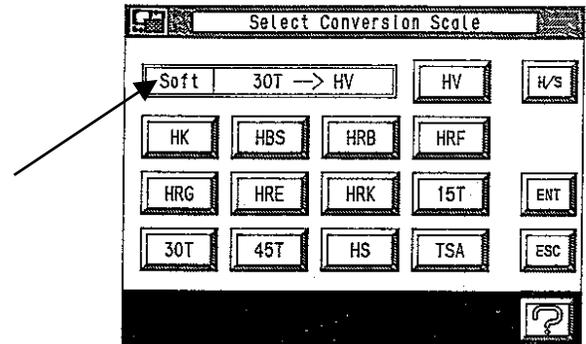
Is used for selecting a conversion scale between the Hardened steel and Soft steel conversion tables.

Hard or Soft is indicated in the left-hand box in the Display Window.

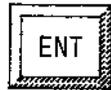
Hard screen



Soft screen



Keys used for selecting the required scale:



Confirms the selected scale.

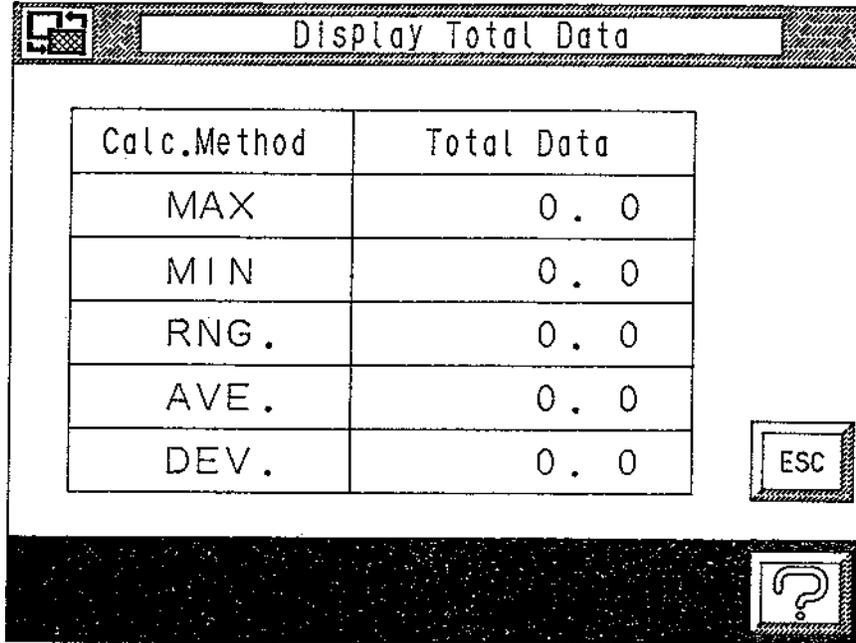


Returns to the **Data Edit Mode** screen.

If the **ESC** key is pressed without pressing the **ENT** key to confirm the settings, each item will remain at their original settings and no change will take place.

Display Total Data screen

Displays the Maximum Value, Minimum Value, Variance, Mean, and Standard Deviation of the measured and stored data.



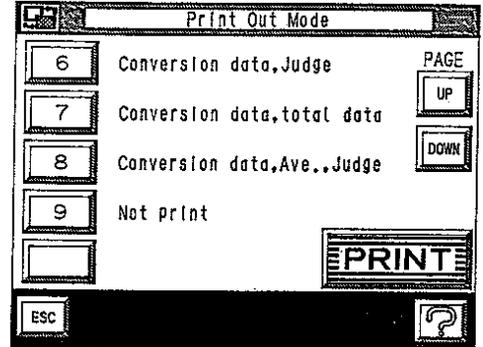
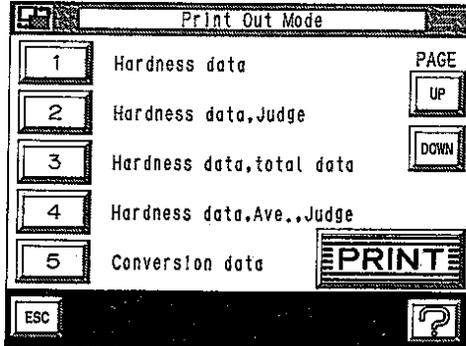
Calc.Method	Total Data
MAX	0 . 0
MIN	0 . 0
RNG .	0 . 0
AVE .	0 . 0
DEV .	0 . 0



Returns to the *Data Edit Mode* screen.

Print Out Mode screen

Select the print format when sending stored measurement data to the printer.



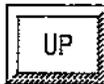
There are 8 different print data formats.



Select a key 1 through 8 to determine the type of data to be printed.



Press Key 9 when printing is not required.



Advances to the next screen.



Returns to the previous screen.



Sends data to the printer.



Returns to the *Data Edit Mode* screen.

Printer Connection

1) Centronics type

Centronics type printers can be connected in a normal manner and output is possible.

Connection procedure

- a. Turn off the power supply to the Macromet 31000 and to the printer.
- b. Connect the printer connector cable to the PRINTER terminal on the rear panel of the Macromet 3100 and connect the other end to the printer.
- c. Turn on the power to the Macromet 3100 and to the printer.
- d. Select Centronics on the **Printer Selection** screen.
- e. Set the calendar and clock on the **Time/Date Setting** screen.
(* The time/date are backed up once they have been set, so they do not have to be set again.)
- f. Enter the batch number on the **Batch Number Setting** screen.
The batch number column will be left blank if this is not entered.
- g. Perform measurements as normal.
Data will be printed out for each measurement.
Stored data can also be printed all at once from the *Print Output Mode* screen.

Connector cable

Use an Amphenol 36-pin (DDK 57-30360 or equivalent) 1:1.

2) Serial type

The output for serial printers is via the D-sub25P on the rear panel and is interchangeable with RS232C transmission.

Users who specified a serial printer at the time of purchase should follow the procedure below.

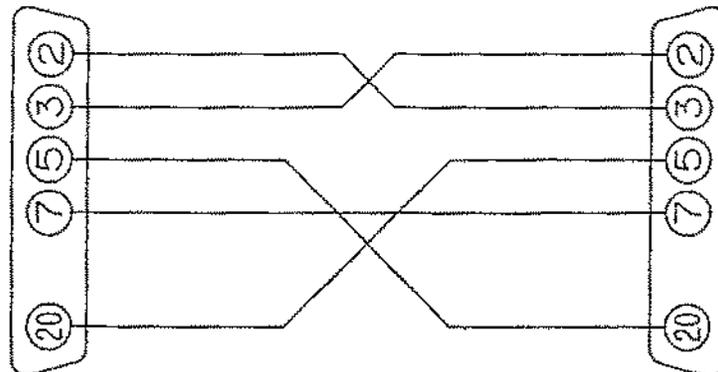
Users who wish to convert to a serial printer after purchase should contact their sales agent.

Connection procedure

- a. Turn off the power supply to the Macromet 3100 and to the printer.
- b. Connect the printer connector cable to the RS232C terminal on the rear panel of the Macromet 3100 and connect the other end to the printer.
- c. Turn on the power to the Macromet 3100 and to the printer.
- d. Select serial on the **Printer Selection** screen.
- e. Set the calendar and clock on the **Time/Date Setting** screen.
(* The time/date are backed up once they have been set, so they do not have to be set again.)
- f. Enter the batch number on the Batch Number Setting screen.
The batch number column will be left blank if this is not entered.
- g. Perform measurements as normal.
Data will be printed out for each measurement.
Stored data can also be printed all at once from the **Print Output Mode** screen.

Connector Cable

Connect as displayed below:



HDBB-25P (Hirose) or equivalent.

Transmission Format

1) RS232C specifications

Synchronous system	Start-stop system	Start bit 1 bit Data bit 8 bits Stop bit 1 bit
Transmission rate	1,200/2,400/4,800/9,600 BPS	selectable
Error detection code	even parity/no parity JIS 8-bit	selectable

2) Connection

RS232C transmission is connected via the D-sub25P on the rear panel and this is interchangeable with serial printers.

The setting is for RS232C, if specifications were not made at the time of purchase.

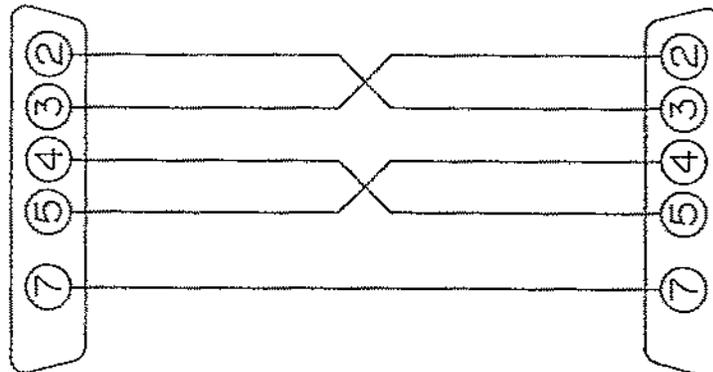
Users who specified serial printers but who wish to convert to RS232C use after purchase should contact their sales agent.

A. Connection procedure

- a. Turn off the power supply to the Macromet 3100 and to the interconnect equipment such as computer etc.
- b. Connect the printer connector cable securely to both units.
- c. Turn on the power to the Macromet 3100 and the interconnect equipment.
- d. Set the calendar and clock on the **Time/Date Setting** screen.
(* The time/date are backed up once they have been set, so they do not have to be set again.)
- e. Enter the batch number on the **Batch Number Setting** screen.
The batch number column will be left blank if this is not entered.

B. Connector cable

Connect as displayed below:

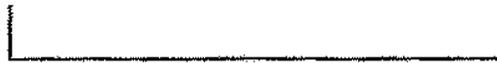
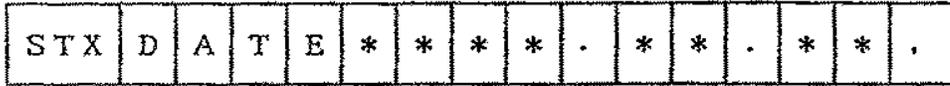


HDBB-25P (Hirose) or equivalent.

3) Data format

A. Date, Batch Number

The Date and Batch Number set in the **Set Up Mode** screen are set when outputting data.



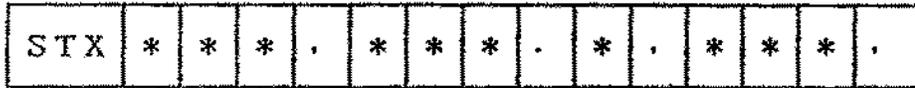
Date (10 characters)



Batch number (10 characters)

4) Measurement data

How the data output is sent once the Hardness Calculations are complete.



Measurement scale



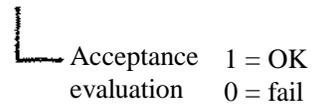
Measured hardness value



Conversion scale



Converted hardness value



5) Max. value, min. value, variance, mean value, standard deviation

Data output in print modes 3 or 6 after setting measurement data.

S	X	M	A	X	*	*	*	*	.	*	,	M	I	N	*	*	*	*	.	*
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Max. value
(0000.1 to 9999.9)

Min. value
(0000.1 to 9999.9)

,	R	N	G	*	*	*	*	.	*	,	A	V	*	*	*	*	.	*
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Variance
(0000.1 to 9999.9)

Mean value
(0000.1 to 9999.9)

,	D	E	V	*	*	*	*	.	*	C	R
---	---	---	---	---	---	---	---	---	---	---	---

Standard deviation
(0000.1 to 9999.9)

6) Mean value and acceptance evaluation on mean value

Data output in print mode 4 or 8 after setting measurement data.

S	X	A	V	*	*	*	*	.	*	,	*	C	R
---	---	---	---	---	---	---	---	---	---	---	---	---	---

Mean value
(0000.1 to 9999.9)

Acceptance evaluation
on mean value
1 = OK
0 = fail

Test Precautions

- 1) At least two preliminary tests should be performed before beginning any measuring, in order to acclimatize the indenter, raising/lowering screw, and specimen platform.

This is necessary at the start of work each day and after the raising/lowering screw has been substantially moved.

Preliminary tests are performed with the same procedures as normal tests.

- 2) Ensure that contact surfaces such as the indenter attachment face, between the specimen and specimen platform, and between the specimen platform and raising/lowering screw are continually maintained in a clean state.

Accurate hardness values may not be obtained if foreign matter such as dust, rust, or oil is included on contact surfaces.

Wipe all contact surfaces thoroughly with a clean cloth before performing tests.

- 3) The specimen measurement location must be spaced at least $4d$ (where d is the indentation diameter) from the center of indentations already present.

The measurement location must also be separated at least $2d$ from the edge of the specimen.

- 4) The surface (test face) and reverse face of the specimen must be kept as horizontal as possible.

When measuring specimens which are not horizontal, maintain the test face perpendicular to the indenter axis using special jigs.

Care is also needed in providing a satisfactory finish to the reverse face of the specimen, and not just the test face.

Correct hardness values will not be obtained if the specimen surface is concave, as deformation will occur under the load.

- 5) If a minus is indicated on the data display, the hardness value of the specimen is less than 0.

- 6) The specimen thickness or hardened layer thickness must be at least 8 times the indenter penetration depth.

Correct hardness values will not be obtained if below this and so either the test load must be reduced or else measurements must be performed using a different type of hardness tester.

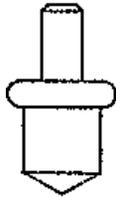
Otherwise, try measuring with a different scale having a large steel ball indenter.

Test Precautions continued:

- 7) The condition of the indenter greatly affects the hardness value.

Caution is recommended as long-term use or impacting the indenter due to operating errors may cause cracking, scratching, or defects.

Problems such as indenter damage can be relatively easily detected using a 20 to 25 magnifying glass.



Tip damage



Side face damage

Tip damage will normally gives higher hardness values.

Side face damage will normally gives lower hardness values.

Getting Started

Test Method

Determine an average hardness, hardenability profile or verifying that the tester is in calibration with a standardized block. All are accomplished in the same manner.

It is necessary to adjust the tester for the application before starting a test,

- First decide which scale is appropriate. In many cases, this has been predetermined for the operator by an engineering specification. Otherwise refer to Table 3-1 for a general guideline.

Some of the limitations to consider are:

1. Size and depth of the indent in comparison to the feature of interest.
 2. Spacing between indentations should be a minimum of 3 times the diameter of the indentation.
- Select the proper test force with the load selector dial. If it is a twin tester, verify that the correct preliminary load has been selected by turning the collar to either the R-Rockwell position or S-Superficial position.

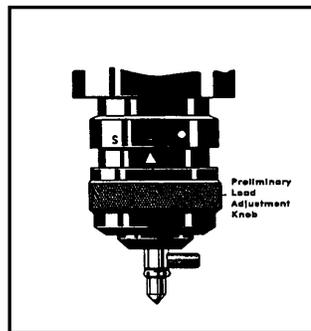


Figure 3-5. The position of the collar (R-Rockwell or S-Superficial) determines the preliminary test force.

- Verify that the correct indenter is in place. If necessary replace it with the appropriate indenter. The indenter neck surface is flat on one side, which faces the spring-lock screw.

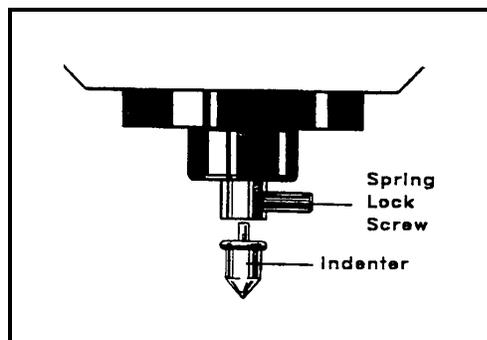


Fig 3-6. Indenter replacement.

Test Method continued:

- Verify that the correct indenter is selected in the **Measurement Condition** screen. *Dia* corresponds to the diamond or brale indenter. The diameter measurements are listed for the selection of the ball indenters. The selected indenter will be displayed in the top row of the **Measurement Condition** screen. This screen can be accessed from the test screen by selecting the **Main Menu** screen, followed by **Utility** and then **Measurement Condition** screens.
- Select the correct anvil. Typically the shape of the test piece will determine which anvil to use. Figure 3-7 illustrates some of the options. The most important aspect is that the test piece is secured and can not shift during the course of the test and that it is perpendicular to the indenter.

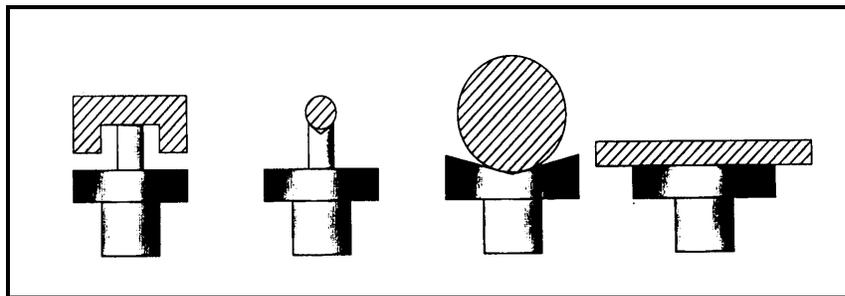


Figure 3-7. Anvils typically used for conducting tests, from left to right: a spot anvil, a small v-anvil, a large v-anvil, and a standard flat anvil.

- Set the dwell time on the **Load Time Setting** screen located within the **Set Up Mode** screen. If a dwell time of longer than 3 seconds is required due to the material having excessive creep, the time should be recorded after the result.

Below is an example of the routine typically followed by the operator.

- The test piece or test block is placed on the anvil.
- The preliminary test force is applied by bringing the test piece into contact with the indenter until the SET point is reached. If too much force has been applied, the OVER light will be on. Should the OVER light appear it is necessary to start the test on a new position of the test piece.
- At this point, if the tester is semi-automated, the remainder of the test force will be applied. Otherwise it will be necessary to press START. The level of automation can be selected within the **Utility** and then **Measurement Condition** screens. Either Auto or Manual will appear in the top line of the touch screen depending on your selection.
- The result is displayed by the testing machine. The larger the *e*-value (displacement), the smaller the HR value observed. In other words the hardness value will decrease as the specimen is more easily penetrated.

Test Method continued:

The values are based on depth measurements and are derived from the formulas listed below.

1) Rockwell test with brale indenter

$$\text{Hardness} = 100 - e$$

Where e = Permanent increase in depth of penetration under preliminary test force after removal of the additional force. The increase is expressed in units of 0.002 mm.

2) Rockwell test with ball indenter

$$\text{Hardness} = 130 - e$$

Where e = Permanent increase in depth of penetration under preliminary test force after removal of the additional force. The increase is expressed in units of 0.002 mm.

3) Superficial Rockwell test

$$\text{Hardness} = 100 - e$$

Where e = Permanent increase in depth of penetration under preliminary test force after removal of the additional force. The increase is expressed in units of 0.001 mm.

- Report the hardness value, the scale used, and any unusual conditions encountered during the test.
- Record the result.

Note: If the indenter and/or anvil were recently inserted, it is good practice to ignore the first two readings and start recording with the third result.

Calibration Verification

It is important to verify your tester on a routine basis to ensure that it is in good working order and that your methodology is correct. When a tester is first manufactured, the test force, indenter(s), and depth indicator are all verified independently. However, on a day-to-day basis all of the components are examined at once with an indirect verification. The criteria for such an evaluation is outlined in ASTM E18, Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials. A full verification checks the complete capabilities of a tester. In most cases this is more time and effort than required for a daily check, so a separate guideline has been developed.

Periodic Check by the User:

- Make at least one routine check each day that the testing machine is used.
- Before making the check, make at least two preliminary indentations to ensure that the machine is working freely and that the standardized block, the indenter, and the anvil are seated correctly. The results of these preliminary indentations should be ignored.
- Make at least three hardness readings on a standardized block on the scale and at the hardness level at which the machine is being used. If the mean of these values falls within the tolerances marked on the standardized hardness block, the machine may be regarded as satisfactory.

Table 3-1. Rockwell test parameters and applications

Test	Abbreviation	Indenter	Test Force (kg)	Application
Rockwell A	HRA	brale	60	very hard materials, cemented carbides
Rockwell B	HRB	1/16 in. ball	100	low strength steel, copper alloys, aluminum alloys, malleable iron
Rockwell C	HRC	brale	150	high strength steel, titanium, pearlitic malleable iron
Rockwell D	HRD	brale	100	high strength steel, thin steel
Rockwell E	HRE	1/8 in. ball	100	cast iron, aluminum, and magnesium alloys
Rockwell F	HRF	1/16 in. ball	60	annealed copper alloys, thin soft metals
Rockwell G	HRG	1/16 in. ball	150	malleable irons, copper-nickel-zinc alloys
Rockwell H	HRH	1/8 in. ball	60	Bearing metals and other very soft or thin materials
Rockwell K	HRK	1/8 in. ball	150	Bearing metals and other very soft or thin materials
Rockwell L	HRL	1/4 in. ball	60	Bearing metals and other very soft or thin materials
Rockwell M	HRM	1/4 in. ball	100	Bearing metals and other very soft or thin materials
Rockwell P	HRP	1/4 in. ball	150	Bearing metals and other very soft or thin materials
Rockwell R	HRR	1/2 in. ball	60	Bearing metals and other very soft or thin materials
Rockwell S	HRS	1/2 in. ball	100	Bearing metals and other very soft or thin materials
Rockwell V	HRV	1/2 in. ball	150	Bearing metals and other very soft or thin materials
Superficial Rockwell N	15N, 30N, 45N	brale	15, 30, 45	materials similar to Rockwell A, C, and D, but of thinner gauge
Superficial Rockwell T	15T, 30T, 45T	1/16 in. ball	15, 30, 45	materials similar to Rockwell B, F, and G, but of thinner gauge
Superficial Rockwell W	15W, 30W, 45W	1/8 in. ball	15, 30, 45	materials similar to Rockwell E, H, and K, but of thinner gauge
Superficial Rockwell X	15X, 30X, 45X	1/4 in. ball	15, 30, 45	materials similar to Rockwell L, M, and P, but of thinner gauge
Superficial Rockwell Y	15Y, 30Y, 45Y	1/2 in. ball	15, 30, 45	materials similar to Rockwell R, S, and V, but of thinner gauge

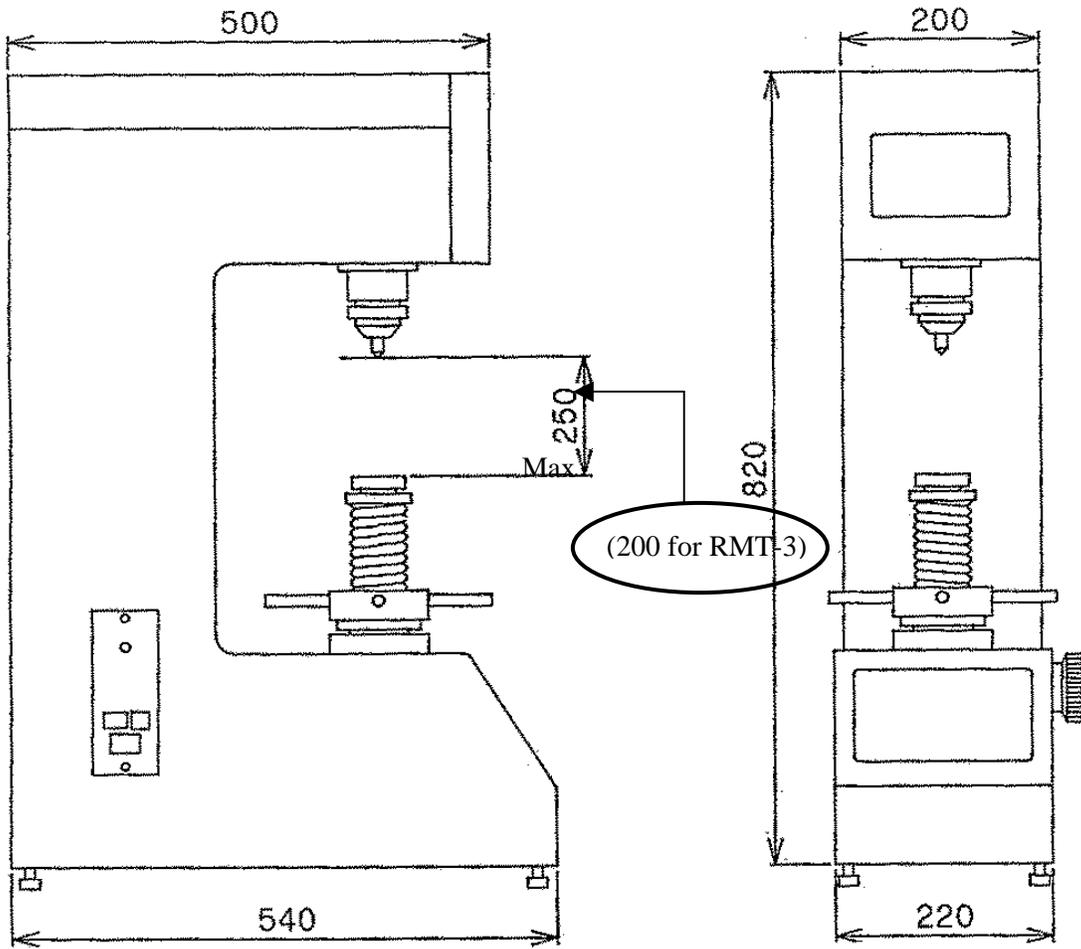
Appendix A

Standard Accessories

Name		Quantity	
		RMT-1	RMT-3
Standard test block	HRC	1	1
	HRB	1	1
	30T	-	1
	30T	-	1
Diamond indenter (fitted to main unit)		1	1
Steel ball indenter (1/16)		1	1
Spare steel balls (1/16)		10	10
Anvil	Flat type 60φ	1	1
	V-type (large)	1	1
Spare fuses			
100 to 120V	3A	2	2
200 to 240V	2A		
Power cable (3 pin and earthed, 2.5m)		1	1
Level adjusting feet		4	4
Anti-toppling fittings set		1	1
Accessory tools set		1	1
Machine unit cover		1	1
Operating instruction manual set		1	1
Accessory box		1	1

The details and quantity of standard accessories described in this table or in brochures may be changed without notice, following changes due to improvements.

Main Dimensions in millimeters



Appendix B

Reference Data

1) Cylindrical correction

The hardness values will normally be lowered if the test surface is curved (cylindrical surface).

The table below is the correction value table in accordance with ASTM E18-61.

A value approximating to the true value will be obtained if the correction value is added to the measured hardness value.

Correction values for HRC, HRA, HRD

Indicated value	Specimen diameter (inches)								
	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2
20	6.0	4.5	3.5	2.5	2.0	1.5	1.5	1.0	1.0
25	5.5	4.0	3.0	2.5	2.0	1.5	1.0	1.0	1.0
30	5.0	3.5	2.5	2.0	1.5	1.5	1.0	1.0	0.5
35	4.0	3.0	2.0	1.5	1.5	1.0	1.0	0.5	0.5
40	3.5	2.5	2.0	1.5	1.0	1.0	1.0	0.5	0.5
45	3.0	2.0	1.5	1.0	1.0	1.0	0.5	0.5	0.5
50	2.5	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5
55	2.0	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0
60	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
65	1.5	1.0	1.0	0.5	0.5	0.5	0.5	0	0
70	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0	0
75	1.0	0.5	0.5	0.5	0.5	0.5	0	0	0
80	0.5	0.5	0.5	0.5	0.5	0	0	0	0
85	0.5	0.5	0.5	0	0	0	0	0	0
90	0.5	0	0	0	0	0	0	0	0

Cylindrical correction continued:

Correction values for HRB, HRF, HRG

Indicated value	Specimen diameter (inches)						
	1/4	3/8	1/2	5/8	3/4	7/8	1
0	12.5	8.5	6.5	5.5	4.5	3.5	3.0
10	12.0	8.0	6.0	5.0	4.0	3.5	3.0
20	11.0	7.5	5.5	4.5	4.0	3.5	3.0
30	10.0	6.5	5.0	4.5	3.5	3.0	2.5
40	9.0	6.0	4.5	4.0	3.0	2.5	2.5
50	8.0	5.5	4.0	3.5	3.0	2.5	2.0
60	7.0	5.0	3.5	3.0	2.5	2.0	2.0
70	6.0	4.0	3.0	2.5	2.0	2.0	1.5
80	5.0	3.5	2.5	2.0	1.5	1.5	1.5
90	4.0	3.0	2.0	1.5	1.5	1.5	1.0
100	3.5	2.5	1.5	1.5	1.0	1.0	0.5

2) Test machine control

Test machine control is normally carried out using hardness standard pieces.

When necessary, take measurements at multiple locations on a standard piece in an appropriate hardness range and check the stability of the indicated values.

The permissible deviations for general accuracy stipulated in ASTM E18 (1999) are displayed in the table below:

Nominal Hardness of Standardized Test Block	Tolerance
HRA ≥60.5 and <80	±0.5
≥80	±1.0
HRB ≥1.5 and <45	±1.0
≥45	±1.5
HRC <60	±0.5
≥60	±1.0
HRF ≥57 and ≤99.6	±1.0
HR15N ≥69.4 and <90	±0.7
≥90	±1.0
HR30N ≥41.5 and <77.5	±0.7
≥77.5	±1.0
HR45N ≥19.6 and <66.5	±0.7
≥66.5	±1.0
HR15T ≥60.5 and <75.3	±1.0
≥75.3	±1.5
HR30T ≥15.0 and <46.2	±1.0
≥46.2	±1.5
HR45T ≥1.0 and <17.6	±1.0
≥17.6	±1.5

(2) A Conversion Table - Hardened Steel

HRC	HV	HK	HBS (3000)	HBW (3000)	HRA	HRB	HRD	HR 15N	HR 30N	HR 45N	HS	TENSILE STRENGTH (APPROX)
80	1865				92.1		86.5	96.5	92.0	87.0		
79	1787				91.6		85.7	96.3	91.5	86.2		
78	1710				91.1		84.9	96.1	90.9	85.4		
77	1633				90.6		84.2	95.9	90.3	84.6		
76	1556				90.1		83.4	95.7	89.7	83.8		
												kg/mm ²
75	1478				89.6		82.6	95.5	89.1	83.0		
74	1400				89.1		81.8	95.3	88.6	82.2		
73	1323				88.6		81.0	95.1	88.1	81.4		
72	1245				88.1		80.2	94.9	87.6	80.6		
71	1168				87.6		79.4	94.7	87.1	79.8		
70	1090	972			87.1		78.6	94.5	86.6	79.0		
69	1014	946			86.6		77.8	94.3	86.1	78.2		
68	938	920			86.1		77.0	94.1	85.6	77.4		
67	862	894			85.6		76.2	93.9	85.1	76.6		
66	786	868			85.1		75.4	93.7	84.6	75.8		
65	710	842			84.6		74.6	93.5	84.1	75.0		
64	634	816		733	84.1		73.8	93.3	83.6	74.2		
63	558	790		706	83.6		73.0	93.1	83.1	73.4		
62	482	764		688	83.1		72.2	92.9	82.6	72.6		
61	406	738		670	82.6		71.4	92.7	82.1	71.8		
60	330	712		654	82.1		70.6	92.5	81.6	71.0		
59	254	686		636	81.6		69.8	92.3	81.1	70.2		
58	178	660		618	81.1		69.0	92.1	80.6	69.4		
57	102	634		600	80.6		68.2	91.9	80.1	68.6		
56	26	608		582	80.1		67.4	91.7	79.6	67.8		
55	50	582		564	79.6		66.6	91.5	79.1	67.0		
54	74	556		546	79.1		65.8	91.3	78.6	66.2		
53	98	530		528	78.6		65.0	91.1	78.1	65.4		
52	122	504		510	78.1		64.2	90.9	77.6	64.6		
51	146	478	500	492	77.6		63.4	90.7	77.1	63.8		
			487	476	77.1		62.6	90.5	76.6	63.0		
50	170	452		475	76.6		61.8	90.3	76.1	62.2		
49	194	426		457	76.1		61.0	90.1	75.6	61.4		
48	218	400		439	75.6		60.2	89.9	75.1	60.6		
47	242	374		421	75.1		59.4	89.7	74.6	59.8		
46	266	348		403	74.6		58.6	89.5	74.1	59.0		
												212
												125
												179
												172
												167
												161
												156
												151
												146
												141
												136
												132
												127
												124
												120
												118
												114
												110
												108
												105
												102
												100
												97
												95
												93
												90
												88
												86
												84
												82
												80
												79
												77
												75
												72
												69
												66
												63
												61
												59
												56
												54
												53

(2) B Conversion Table - Soft Steel

HRB	HV	HK	HBS (3000)	HBW (3000)	HRF	HRG	HRE	HRK	HR 15T	HR 30T	HR 45T	HS	TENSILE STRENGTH (APPROX)
100 99 98 97 96	240 234 228 222 216	251 246 241 236 231	240 234 228 222 216	240 234 228 222 216		82.5 81.0 79.5 77.5			93.1 92.5 91.8	83.1 82.2 81.1 80.0	72.1 71.0 69.9 68.8	33.0 32.4 31.8 31.2 30.6	82.0 80.0 77.5 75.3
95 94 93 92 91	210 205 200 195 190	226 221 216 211 206	210 205 200 195 190	210 205 200 195 190		74.0 72.5 71.0 69.5 67.5		100 99.5	91.5 91.0 90.5 90.0	79.8 78.8 77.7 77.1	67.9 66.5 64.8 63.3	31.7 31.0 30.2 29.5 28.8	71.0 69.7 66.7 64.4
90 89 88 87 86	185 180 175 170 165	201 196 191 186 181	185 180 175 170 165	185 180 175 170 165		66.0 64.5 63.0 61.5 59.0		99.5 99.0 98.5 98.0 97.5	89.5 89.0 88.5 88.0 87.5	76.4 75.4 74.4 73.8	62.8 61.0 59.8 58.8	28.2 27.7 27.0 26.4 25.9	63.0 61.4 58.8 57.5
85 84 83 82 81	165 160 155 150 145	180 175 170 165 160	165 160 155 150 145	165 160 155 150 145		57.5 56.0 54.5 53.0 51.5		94.5 94.0 93.5 93.0 92.5	88.2 87.7 87.2 86.7 86.2	73.1 72.2 71.1 70.4	57.7 56.6 55.4 54.3	25.4 24.8 24.2 23.6 23.0	56.4 55.6 53.3 51.1
80 79 78 77 76	150 147 144 141 139	164 161 158 155 152	150 147 144 141 139	150 147 144 141 139		49.0 47.5 46.0 44.5 42.5		90.5 90.0 89.5 89.0 88.5	86.6 86.0 85.5 85.0 84.5	69.7 68.7 67.7 67.1	52.8 51.1 49.9 48.8	23.0 22.4 21.8 21.1	50.0 49.0 47.7 46.6
75 74 73 72 71	137 135 132 130 127	150 147 145 143 141	137 135 132 130 127	137 135 132 130 127	99.6 99.5 99.4 99.3 99.2	41.0 39.5 38.0 36.5 34.5	100	86.0 85.5 85.0 84.5 84.0	85.0 84.5 84.0 83.5 83.0	66.4 65.7 64.4 63.7	47.8 46.8 45.8 44.8	21.0 20.0 19.0 18.0	45.4 44.7 43.3 42.2
70 69 68 67 66	125 123 121 119 117	133 132 131 130 129	125 123 121 119 117	125 123 121 119 117	99.6 99.5 99.4 99.3 99.2	33.0 31.5 30.0 28.5 26.5		81.5 81.0 80.5 80.0 79.5	83.4 82.9 82.4 81.9 81.4	63.1 62.2 61.1 60.4	42.8 41.0 39.8		41.5 40.0 kg/mm ²
65 64 63 62 61	116 114 112 110 108	129 128 127 126 125	116 114 112 110 108	116 114 112 110 108	99.3 99.2 99.1 99.0 98.9	25.0 23.5 22.0 20.5 19.0		77.5 77.0 76.5 76.0 75.5	81.8 81.1 80.4 79.7 79.0	59.7 58.9 58.0 57.7	37.7 36.6 35.4 34.3		
60 59 58 57 56	107 106 104 102 101	120 118 117 115 114	107 106 104 103 101	107 106 104 103 101	99.1 99.0 98.9 98.8 98.7	17.5 16.0 14.5 13.0 11.5		73.0 72.5 72.0 71.5 71.0	80.1 79.5 78.8 78.2 77.6	56.4 55.5 54.4 53.7	32.7 32.0 30.9 29.8		
55 54 53 52 51	100 99 98 96 95	112 111 110 109 108	100 100 100 100 100	100 100 100 100 100	88.2 87.7 87.1 86.5 86.0	10.0 8.5 7.0 5.5 4.0		68.5 68.0 67.5 67.0 66.5	78.5 77.7 77.2 76.7 76.2	53.0 52.4 51.7 51.0 50.3	27.7 26.6 25.5 24.3		
50 49 48 47 46	94 93 92 91 90	107 106 105 104 103			85.4 84.8 84.3 83.7 83.1	2.5		87.0 86.5 86.0 85.5 85.0	64.5 63.8 63.2 62.6 62.0	76.9 76.2 75.5 74.8 74.1	49.7 48.8 47.7 46.6		
45 44 43 42 41	89 88 87 86 85	102 101 100 99 98			82.6 81.4 80.3			84.0 83.5 83.0 82.5 82.0	60.0 59.5 59.0 58.5 58.0	75.3 74.6 74.0 73.4	46.3 45.0 44.3		
40 39 38 37 36	84 83 82 81 80	97 96 95 94 93			79.7 79.1 78.5 77.9 77.4			81.0 80.5 80.0 79.5 79.0	55.5 54.8 54.2 53.6 53.0	73.6 73.3 72.7 72.2	43.0 42.6 41.9 41.0		
35 34 33 32 31 30	80 78 77 76 75 74	92 91 90 89 88 87			76.9 76.3 75.7 75.1 74.5			78.0 77.5 77.0 76.5 76.0	51.5 51.0 50.5 50.0 49.5	72.0 71.4 70.7 70.0	39.6 38.8 37.7 36.6		