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# **User Manual: JCI 155v5 Charge Decay Test Unit**

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**Declaration of CE conformance**

John Chubb Instrumentation Ltd of Unit 30, Lansdown Industrial Estate, Gloucester Road, Cheltenham, GL51 8PL, declares as designer and manufacturer of the JCI 155v5 Charge Decay Test Unit that the design and construction of these instruments conform to the requirements of the EC Directive on Electromagnetic Compatibility (EMC) 89/336/EEC to Standards EN 50081-1:1992 and EN 50082-1: 1992. These instruments also conform to the requirements of the Electrical Equipment (Safety) Regulations 1994 (S.I. 1994/3260).



John N. Chubb for and on behalf of John Chubb Instrumentation Ltd

# User Manual:

## JCI 155v5 Charge Decay Test Unit

*The JCI 155v5 is a compact instrument for quick, easy and direct measurement of the ability of materials to dissipate static electricity and to assess whether significant voltages will arise from practical amounts of charge transferred to the surface.*

### 1. INTRODUCTION

Many materials, in particular plastics, easily become electrostatically charged when rubbed against other materials. Such 'triboelectric' charging can be used constructively - for example, in photocopying, electrostatic clamping and the retention of powder in electrostatic precipitation and paint spraying. Retained electrostatic charge however can also create risks and can cause problems in many areas of industry. It can cause ignition of flammable gases and give shocks to personnel. It can make thin films and light fabrics cling, attract airborne dust and debris, damage semiconductor devices and upset the operation of microelectronic equipment.

Most of the uses and problems of static electricity relate to the influence of charge retained on surfaces. The 'suitability' of materials thus needs to be judged in relation to the influence of retained charge – not just the quantity of charge as such. The way to assess the charge retention performance of materials is to measure the 'charge decay time' - how quickly any charge put on the material dissipates over and through the material and away to earth [1]. (Note: we are talking about 'decay time' - not 'resistivity!'). To avoid risks and problems it is necessary to ensure that static charge can dissipate more quickly than charge is generated. For normal manual handling and body motion activities this means the charge decay time needs to be ¼ second or less. A new concept, relevant to risk control, is that if static charge experiences a high capacitance on a material then only low surface voltages will be observed - and many problems and risks will not arise [3,4].

The simplest way to test the charge retention capability of materials is to put some charge on the material and see how quickly this charge disappears. In the JCI 155 Charge Decay Test Unit a high voltage corona discharge is used to deposit a patch of charge on the surface of the material to be tested. A fast response electrostatic fieldmeter observes the voltage generated by this charge on the material and measurement is made of how quickly this voltage falls as the charge migrates away [1]. The general arrangement is shown in Figure 1.

Corona charge deposition is a simple way to simulate practical charging events. It allows control of initial surface voltage and charge polarity and is applicable for all types of surfaces - whether uniform or with localised conducting features. It can also be used with liquids and powders. Studies have shown that corona charge decay matches well the practical situation of the decay of charge generated by rubbing surfaces together [2,3,4] and provides consistent, reproducible results that are not affected by corona exposure.

Recent studies have shown that measurement of the 'capacitance loading' offered to surface charge by materials is a useful additional feature for assessing risks from static electricity [3,4,8,9]. A high capacitance loading means that only a low surface voltage arises per unit of charge. When the JCI 155v5 is operated in conjunction with the JCI 176 Charge Measuring Sample Support Unit the software recognises the presence of this unit and stores measured values of charge. These values are then used automatically in JCI-Graph to calculate values of 'capacitance loading'.

Version 5 of the JCI 155 Charge Decay Test Unit is a development of previous version JCI 155 instruments for laboratory based studies of the suitability of materials. The special feature of this new version instrument is that it includes an integral microprocessor so that all basic analysis, display and storage of charge decay curves are carried out by software within

the instrument. The aim is to make normal use very easy, but to have a wide range of options available for adjustment of test and analysis conditions where these are judged appropriate.

Observations, and information on test conditions, are stored to a PCMCIA memory card slotted directly into the instrument. The stored data can be transferred into a microcomputer running Windows 95/98, 2000, NT, XP or Vista using software JCI-Graph v2.2 or later. This software provides for the display of charge decay graphs, for alternative analysis and display of results and for long term secure data storage. It calculates values of 'capacitance loading', generates a Spreadsheet table summarising test conditions and results obtained and provides a route to predict decay times to  $1/e$  and 10% where it is not practical to continue observations for such long times – for example over say 10,000s. This prediction approach [11] is described in the JCI-Graph user manual.

The integral software in the JCI 155v5 provides full versatility in setting instrument operation and the measurement arrangements. All parameters for instrument operation have default values that are set as generally appropriate values at manufacture. Alternative values can be set and held for testing and analysis using the key buttons in the top cover. Parameters available for setting include corona voltage and duration, the criteria for ending a run (by maximum time or by reaching an end voltage at a set fraction of the initial peak) and whether the moving plate, that carries the cluster of corona discharge points, is retracted quickly, for fast decay time measurements (20ms), or slowly for measurements on light powders with minimum sample disturbance.

The charge decay and capacitance loading characteristics of materials usually vary with temperature and humidity. For good consistent and reliable measurements it is necessary that materials are conditioned for an adequate time (for example 24 hours) and tested in stable and defined conditions of temperature and humidity. This is particularly important where materials have an 'antistat' treatment, as the performance of this relies upon absorption of atmospheric moisture. Provision is made in the JCI 155v5 for measuring and automatically recording temperature and humidity conditions within the test region of the instrument. To minimise differences between local ambient conditions and those within the JCI 155v5 it is important to keep power dissipation within the instrument to a low level. This is best achieved by making measurements with the instrument running on battery power alone. To minimise heating during battery charging and long term operation from the mains the switched mode power supply has been separated from the JCI 155v5 for instruments with serial numbers over 02112030. In these more recent instruments a modest ventilation has been provided through the instrument during operation from the external mains power supply.

## 2. INSTRUMENT OPERATIONAL FEATURES

**2.1 Test Area:** The JCI 155 has a 45x54mm test aperture in the instrument baseplate. This can rest directly on the test surface. Contact with the surface around the test aperture provides a return route for outwardly migrating charge and high local capacitance to trap such charge. With short duration corona charging (e.g.20ms) the presence and position of the outer earth boundary is not important. Measurements can be made on surfaces smaller than the test aperture area.

**2.2 Charging:** The surface is charged by a high voltage corona discharge (3-10kV) from the tips of a small conical cluster of fine wires mounted on the underside of a light moveable plate. This plate is moved between the fieldmeter sensing aperture and the material surface exposed through the instrument baseplate. Corona is usually generated as a brief pulse (20ms) immediately before the plate is moved away. The plate moves fully away within 20ms.

The moving plate and instrument construction shield the fieldmeter from high voltage connections so reliable measurements can be made down to even quite low surface voltages. An 'air dam' is included on the trailing edge of the moving plate. This sweeps away residual air ionisation at the end of the corona period so this gives little influence on surface voltage measurements (no more than about 10V). However to avoid residual air ionization affecting measurements it is wise, where possible, to work with initial peak voltages of at least 100V.

The moving plate is advanced against return tension springs by a snail cam. For instruments made after June 2003 (serial numbers above 0306\*\*\*\*) the plate is held in the fully forward position on a small spring latch. The tension is provided by coil springs for long operational life. At the end of corona charge deposition the latch is released (within 3ms) by the action of a magnetic solenoid and the plate moves to the fully retracted (open) position within 20ms.

**2.3 Fieldmeter:** A proprietary fast response 'field mill' electrostatic fieldmeter [5,6] gives fast, sensitive and stable measurement of surface potential. The response time is below 10ms and charge decay times can be measured from below 50ms to many days.

Instrument software provides for automatic zero setting of the fieldmeter just before each test. In very long charge decay studies arrangements are made to check the fieldmeter zero from time to time.

It is not easy to measure decay times with signals where noise is significant in comparison to the signals or the signal differences to be measured. This may apply for materials that dissipate charge either so quickly that the initial peak voltage is very low, only 10-50V, or with materials that dissipate charge very slowly, so that small differences in signal levels need to be measured to get results within modest periods of observation. A special feature of the JCI 155v5 is that it uses a new 'stutter timing' approach for decay timing. This provides an excellent way to identify average values of a noisy signal without slowing down time response.

**2.4 Sample support:** Measurements are normally made both with the material freely supported with an open backing and also resting against an earthed backing surface. These two arrangements represent the extremes of constraints of practical application. The longer of the two decay times is used for assessment of the suitability of the material. The JCI 166 Sample Support provides a simple arrangement for such measurements.

Simultaneous measurement of the quantity of charge received by the sample surface and the initial peak surface voltage achieved enables calculation of the capacitance loading experienced by charge on the sample surface [3,4,9]. The JCI 176 Charge Measuring Sample support provides the ability to measure the corona charge received by the sample. This unit can be directly connected to the JCI 155v5 (by an 8w-8w DIN cable) so that charge measurements are stored alongside the relevant charge decay observations. Measurements using the JCI 176 can be with both open and earthed backing.

Powder, and liquid, samples can be presented for testing using a JCI 173 Powder Sample Support Plate mounted between the plates of a JCI 176 unit. Alternatively, powder and liquid samples may be presented for testing using the JCI 170 Powder Sample Support with the JCI 155v5 supported by a JCI 172 Support Plate. The JCI 172 enables the JCI 170 to be easily put in place and removed without disturbing the JCI 155 and provides a few mm stand-off to reduce risk of powder dispersal into the air by action of the air dam.

**2.5 Test conditions:** Charge decay characteristics are usually susceptible to absorption of surface moisture from the atmosphere, so measurements are very likely to depend on humidity. It is hence desirable to carry out testing under defined, or at least known, conditions of temperature and humidity. This can be achieved by carrying out measurements in a controlled environment – as is provided, for example, in the JCI 191 Controlled Humidity Test Chamber, with adequate time allowed for acclimatisation.

The charge decay and capacitance loading characteristics of materials (for instance some cleanroom garment fabrics) can vary with the quantity of charge. It is hence desirable to make measurements with quantities of charge comparable to those applicable in the practical situation.

The JCI 155v5 includes facilities to measure both temperature and humidity within the test region of the instrument. These measurements are stored on the memory card along with all the other information on test conditions.

**2.6 Test criterion:** A simple acceptance test criterion is that the decay time (initial peak voltage to  $1/e$ , 37%, of this) should be less than half a second or less than 2s to 10%. A paper has been published describing formal arrangements for assessing the electrostatic suitability of materials [9].

Experience is that the form of charge decay curves is usually not an exponential [1]. The form of the curve however does not depend on the level of the initial peak voltage or hence on the level of charging. Thus a ‘decay time’ measurement as the time from the initial peak voltage to a set percentage of this is an appropriate basis to compare the performance of materials. A point immediately after the initial peak voltage is used as a starting point for timing. Timing from this point includes full influence of possibly fast initial voltage drops. The point is chosen to be immediately after completion of competition between opening of the moving plate and the decay of surface potential.

It is also useful to record how the rate of charge decay varies during decay to see whether significant levels of charge may be retained for long times. It is observed that charge decay curves may ‘plateau out’ after an initial perhaps fairly rapid fall of surface voltage. In this situation it may be argued that a better acceptance test criterion would be the time to 10% of the initial peak voltage – as this would better ensure that residual surface voltages were low. Measurements to both  $1/e$  and to 10% are recommended when practicable. Where this is not practical, for instance because decay times might be 10,000s or more, it is possible to predict decay times to  $1/e$  or to 10% using information on the variation of local decay time constant with time, as provided in JCI-Graph [11].

Measurement of the quantity of charge transferred to the sample and the initial peak voltage enables materials to also be assessed in terms of ‘capacitance loading’.

**2.7 Decay timing:** Decay times are measured using a proprietary technique called ‘stutter timing’. This approach very effectively overcomes problems with signal noise at low signal levels. It is helpful a) with very slow charge decay rates, and b) with very low initial peak voltages (for example 10-50V). Stutter timing works by running and stopping the timing clock according to whether the instantaneous fieldmeter signal is above or below the voltage level of interest. This approach is used both in the algorithm for finding an initial peak surface voltage,

from which timing will start, and for determining the end of timing. It is also used in calculation of local charge decay time constants during the progress of charge decay.

**2.8 JCI 155 Operation:** The JCI 155v5 operates from its own internal rechargeable batteries (NiMH, nominal 600mAh capacity). This provides some 4-5 hours of battery powered operation. When the instrument is connected to an external mains power supply unit (18V 15W) via the 2.5mm d.c. connector in the back panel the batteries are Smart recharged according to need. The presence of an external mains power supply and application of fast battery recharging are indicated by LEDs in the top cover.

For measurements under defined environmental conditions it is best to use the instrument on batteries, without the mains connected, to minimise heat dissipation within the instrument. To minimise heating during battery charging and long term operation, the mains switched mode power supply has been separated from the JCI 155v5 for instruments with serial numbers over 02112030. Modest ventilation has also been provided during operation from the external mains power supply.

To save battery power the instrument is automatically shut-down a short time (about 2 minutes) after set operations have been completed if none of the key buttons are operated and if a run is not in progress. Activity is restored by pressing the 'Power On' key.

The instrument operation is set up and controlled using the top panel keys. Operation may alternatively be controlled from an associated microcomputer connected via the serial communications 'RS232 port' or by connections to the 'Remote control' port.

**2.9 Integral microprocessor:** An integral microprocessor (TDS 2020) controls all aspects of instrument operation and enables charge decay curves to be stored, analysed and displayed in real time by the instrument itself. Observations are stored in a removable PCMCIA memory card inserted into the instrument. Observations by the instrument can be passed to a microcomputer using a PCMCIA or CompactFlash memory card and Windows software JCI-Graph. Results displayed by JCI-Graph can be easily transferred into word processing and Spreadsheet operations.

**2.10 Calibration:** Where the results of measurements may be used with contractual or legal implications then it is necessary for the JCI 155v5 to be within formal calibration [7,10] and for measurements to be made using appropriate test procedures [8,9].

Instrument performance can be formally calibrated to British Standard BS 7506: Part 2: 1996 [7] using measurements whose accuracy is traceable to National Standards. The JCI 255 Calibrator Unit provides a convenient basis for such formal calibration.

In performing calibrations it is important to note that sufficient corona charge needs to be used to achieve initial test voltages well over 100V. The reason for this is that with lower quantities of charge the form of the charge decay curve can be affected by residual air ionization from the corona discharge. This has a decay time in the range 50-100ms.



### 3. USE OF INSTRUMENT

#### 3.1 Getting started

##### 3.1.1 Introduction

The JCI 155v5 instrument is designed to make operation very easy for normal charge decay studies.

- ‘Normal’ charge decay studies involve depositing some corona charge on to the surface to be tested and measuring how the surface voltage falls with time from its initial peak value to set ‘result’ point criteria. These ‘result’ points are a set percentage of the initial peak voltage, a set time after the start of decay and a set voltage level. These may be reached in any order. A wide range of options is available for adjustment of test and analysis conditions where these are judged appropriate. A set of ‘Default’ values is included in the software which will suit most normal test requirements.
- Figure 2 shows a top view of the JCI 155v5 instrument. Figure 3 shows an underside view with the test aperture and the sensing aperture of the fieldmeter.
- The liquid crystal display (LCD) in the instrument top cover shows information about the status and progress of instrument operation, about test results, about values of test parameters used and menus for changing test and analysis parameters.
- The 8 keys around the liquid crystal display give opportunity to:
  - a) control instrument operation
  - b) inspect and edit test condition values
  - c) examine results from present and previous tests.
- Only the keys that are illuminated are active – except the ‘Power on’ key. The ‘Power on’ key is only illuminated in a flashing mode to indicate the battery is nearly fully discharged and that a mains supply should be connected to continue measurements.
- Keys are used individually and as pairs. When keys are used in combination (for example ‘Data’ + ‘Run’ or ‘Setting’ + ‘Revert’) then the first key mentioned is used as a shift key on the second – that is the first key is held down while the second key is operated momentarily.
- The small red LED near the middle of the top cover indicates when a mains supply is connected. The nearby green LED indicates the batteries are in fast charge. The small red LED in the top left hand corner indicates when corona is being applied.

The following sections start with descriptions of basic normal operation using instrument keys and then outline the additional facilities available. Additional notes are included in *italics*.

##### 3.1.2 Making a test run:

###### *Start-up:*

The instrument is switched on by pressing the ‘Power On’ key – located towards the lower right hand corner of the instrument top cover. Instrument operation will start and the liquid crystal display (LCD) will show the progress of the initial set-up and testing.

JCI 155v5-01 Charge Decay Test Unit
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Following switch-on the instrument will carry out internal tests and checks over a few seconds before becoming available for use. The plate carrying the cluster of corona discharge points will be heard to advance and then retreat. This is associated with initial checking and zeroing of the fieldmeter used for surface voltage measurement. Up to 3 fieldmeter zeroing tests may be done. If a satisfactory zero is not found the user may either consider what action is appropriate (see Section 5 below) or proceed anyway.

A check is made for the presence of a memory card and the space remaining available on it. If no card is in place then either a card can be inserted or operation can proceed with no card. **Note:** The card or the adaptor with a CompactFlash card is put in upside down.

#### Ready to run:

When the instrument is ready to run the red 'Run' key is illuminated and the display will show next run number (top left hand side), the date and time (top right hand side, alternating), 'Ready to run' (lower left hand side) and the present surface voltage (lower right hand side).

Run#00000001	22/01/01
Ready to go..	Vs +0.25 V

In this mode the test parameters and conditions may be inspected and edited (see Annex 2). If no changes are made then default or the previous settings will be used.

To prepare for a test, place the instrument either on the test material or on to a JCI 176 Charge Measuring Sample Support with the material between the measurement plates.

In the 'Ready to run' state the instrument will turn off after 2 minutes if the operators does not initiate any action.

#### Run:

Press the red 'Run' key. The moving plate carrying the cluster of corona discharge points will be heard to be advanced (in about 2s).

After a short pause the corona LED will be briefly illuminated as charge is deposited and the plate will be released - and will be heard to flip back. The display will give guidance on the progress of preparation for testing.

*In case of problems see Section 5 'Problems: What if..?'*

#### Run display:

After plate release operation is in the 'Run display' mode.

Peak value found:
0.0ms      100%      ****V

For a few seconds the display shows the initial peak surface voltage achieved. This is followed by a display of the progressive decrease in surface voltage with time until the first end point test condition is achieved. There are 3 end conditions and these can be reset by the user while the instrument is in the 'Ready to run' state. The three conditions are a set time, a set % of the initial peak voltage and a set surface voltage.

The display shows, on the lower line, the time since the initial voltage peak, the % of initial peak voltage and the present surface voltage.

```
Reading Decay Data..
***_s  **.*%  ****_V
```

When an end point result is achieved the display pauses to show the values that apply. To continue towards the next result press the 'Up (Next)' key.

```
Run end % peak found @:
***ms  36.8%  *****V
```

'Results' are shown as the set 'result conditions' are met. Three conditions are used: when the surface voltage reaches a set % of the initial peak voltage, when a set overall decay time has elapsed and when the surface voltage has fallen to a set level.

In this mode all earlier 'Result' values are available for inspection using the Up/Next and Down/Previous arrow keys.

Charge decay observations are continuing in the background while results are displayed. Pressing the 'Up' arrow key each time a results is found will enable the display to catch up with present time observations.

*Ready to save:*

If the display is left for 20 seconds after reaching a set end point criterion (surface voltage, % of initial peak voltage or time) then the instrument moves into the 'Ready to save' mode. The red 'Run' key is illuminated and the display shows on the top line the run number and the date and time. The left hand side of the lower line shows 'Ready to save'. Data collection is continuing in the background.

```
Run#00000001  22/01/01
Ready to save Vs *****V
```

There are three options available at this time:

- 1) To inspect results achieved so far without stopping data collection
- 2) To stop recording data and save all data to this point.

*This is appropriate if it is desired to move the instrument to a new sample or sample area or to change any test conditions.*

- 3) To proceed directly to a follow on run with no change of sample or position or test conditions.

*If there is no memory card in place it is not possible to save the present observations. However, a memory card may be inserted at this time and will be able to be used.*

*Re 1) Inspect results achieved with run continuing:*

This is achieved using the Up and Down arrow keys by themselves. After the most recent results with the Down arrow key the display will show present observations until the next end criterion is reached.

*Note that when moving forwards through recorded observations the time steps increase progressively. Thus moving away from zero time will seem slow to start with, but progress accelerates rapidly.*

*Re 2) Save data:*

Observations and test data can be stored to the memory card by pressing 'Data' + 'Run'. When the data has been saved the display will show 'Ready to run' and operations may proceed as from 'Ready to run:' above.

*Remember that the 'Data' key acts like a 'shift key' - so this is pressed and held down briefly while the 'Run' key is pressed.*

Saving data in this way stops collection of data. This allows the instrument to be moved to another test material without recording disturbed data.

*Re 3) Immediate next run:*

If a further test run is to be made on the same sample then the 'Run' key may be pressed directly. Data collection from the previous test will be stopped and will be saved, and a new test will be started as from 'Run:' above.

3.1.3 Additional operational features*Examination of earlier test results:*

When the instrument is in the 'Ready to run' mode there is opportunity to examine results from earlier tests stored on the memory card. Earlier runs are accessed using the Data + Right(Next) / Left(Previous) arrow keys.

S/N 01010000	22/01/01
Run#00000001	Review

Results within each run are accessed using the Up(Next) and Down(Previous) arrow keys.

*Changing test conditions:*

When, and only when, the instrument is in the 'Ready to run' mode there is opportunity to edit test condition parameters. (They may be inspected, but not changed, in the 'Ready to save' state).

Test condition information is accessed via the menu facilities described below in Section 3.3. The ranges of values and default setting values are listed in Annex 1.

The 'Test Conditions' menu system is entered by pressing 'Setting' and an 'Up' or 'Down' arrow key. The first menu via the 'Up' arrow key is the corona conditions menu. Items within this menu (corona voltage, corona duration and corona 'on/off') are accessed using the 'Setting' key with the 'Left'/'Right' arrow key. This moves the identification blocks to select the item to be edited. Selection of the character to be edited and editing actions are then implemented using just the 'Left'/'Right' and 'Up'/'Down' arrow keys as described in detail in Annex 2. Edited selections are confirmed and preparation made for a new Run by pressing 'Setting' with 'Revert' twice.

The second menu accessed with the down arrow gives the parameters set for pausing display during a test run. The third menu shows the test environment conditions – temperature and humidity within the instrument.

*Note that when the menu system is entered the fieldmeter motor is turned off to conserve battery power. It restarts automatically at exit from the menus.*

*Abort:*

A test may be stopped immediately after the 'Run' key has been pressed using the 'Revert' key - so long as the plate has not been released. While the moving plate is being advanced and checks made on surface voltage zero and other relevant start up parameters, the 'Revert' key will be illuminated and the words 'Key to Abort ->' will appear at the right of the second line of the display. If the 'Revert' key is pressed during this time the test will be stopped and no run data saved.

*This 'Abort' may be useful if it is found, when a run is started, that the instrument or sample is not properly positioned.*

*Sample support:*

It may be convenient to present sheet and layer type samples for testing using either the basic JCI 166 Sample Support Unit or, better, the JCI 176 Charge Measuring Sample Support. In both cases the sample support unit should be earth bonded to the JCI 155v5 via the Durable Dot/4mm bayonet connections provided.

The JCI 176 allows measurements to be made of the quantity of corona charge transferred to the test surface. This applies with both open and earthed backing. This may be used in conjunction with the initial peak surface voltage value observed to estimate the capacitance loading provided by the sample.

Powder samples, and small volumes of liquids, may conveniently be tested using the JCI 173 Powder Sample Support Plate mounted between the support plates of a JCI 176. Alternatively, the JCI 170 Powder Sample Support, perhaps in combination with the JCI 172 Support Plate may be used.

For light powders it is recommended that the JCI 155v5 be operated with 'Slow' plate release. This will minimise risks of ingesting powder particles into the fieldmeter and instrument mechanisms. Slow plate release can be selected via the test condition menus.

*Operation with 'remote' facilities:*

The instrument may be set to run as a slave to a remote control push button unit or remote sample changing equipment. Alternatively it may be set to operate as a master to control remote sample changing equipment. In all cases if remote equipment is not connected operation reverts to normal instrument operational control. Operation with remote facilities is described in Section 6.3.

*Operation via RS232 serial communications link:*

JCI 155v5 instruments (with installed software 4.00 and higher) may be operated via a direct serial link to a remote computer running JCI-Graph software version 2 or higher. This facility provides both for extraction of data stored on the memory card within the instrument and also for remote operation of the instrument with quasi real-time display of observations and results.

*Restart of integral microcomputer:*

Although great care has been taken in the design and testing of the microcomputer software used in the instrument it is always possible that a problem may occur. If a problem is experienced it will be useful to record the apparent causes and information displayed. All critical software is held in Read Only Memory (ROM), so a microcomputer 'restart' should clear the problem. The microcomputer may be reset via the 1mm hole towards the top right hand corner of the instrument back plate – just above the earthing connector. If a suitably small rod is pushed gently into this hole

(about 6mm) the computer will be reset. At such a reset the instrument will restart automatically if mains powered, but on battery power may be restarted in the normal way using the 'Power on' key. Restarting the computer will not affect any of the data saved to the memory card, sequencing of run numbers, default values or date and time settings.

*See also 'Problems: What if...' Section 5.*

### 3.2 Switching off:

The instrument can be switched off manually if, and only if, the instrument is in the 'Ready to run' state.

'Switch off' is achieved by ending any run in progress and saving the data. This will enable the instrument to enter the 'Ready to run' state (red 'run' key illuminated). The menu system is then entered by holding down the 'Setting' key and pressing the 'down' arrow key twice. With the 'setting' key still held down use the left arrow key to move the cursor blocks across to the left hand 'On' displayed word; release the 'Setting' and the left arrow key, press the 'down' arrow key to cause the 'On' to toggle to 'Off'. Then while holding down the 'Setting' key press the 'Revert' key twice – the instrument will switch off.

*Note: The menu is a circular list so if the 'Up' arrow key is pressed with the 'Setting' instead of the 'Down' then the same situation can be achieved by working down through the menu list.*

*Note: If all else fails then the instrument can be turned off by resetting the computer using a thin wire about 1mm diameter (a paper clip end is appropriate) and pushing this gently into the small hole in the back plate just above the earth bonding connector.*

If the instrument is left in the 'Ready to run' mode, or is reviewing results of earlier runs ('Review' mode), with no activity then it will switch itself off after about 2 minutes. The instrument may be restarted as from where it was by pressing the 'Power on' key.

If the instrument is running from the battery and the battery charge falls too low then the instrument will also turn itself off after giving the user several minutes warning of the need to connect to the mains. All data is saved automatically at shutdown.

### 3.3 Checking instrument operation

A long satisfactory operating life can be expected from JCI 155v5 instruments if the instrument is treated with sensible care. A list of possible problems and appropriate remedial actions is given in Section 5: 'Problems: What if...'. If operation of the instrument may have suffered from poor handling or internal exposure to powders or liquids then it is useful to keep an eye on the displayed values of surface voltage when the instrument rests on a fairly conducting surface. If the 'zero' reading on a good conducting surface is more than a few volts from zero or the reading is drifting or unstable or if the instrument is not able to achieve a good zero during its start up procedure then it will be wise to check operation of the fieldmeter and possibly clean it – as described in Section 11.

### 3.4 Observational data storage

#### 3.4.1 Introduction

Data is stored to a PCMCIA memory card (or preferably a CompactFlash card in a PCMCIA adaptor) with a maximum capacity of 512MB. For each test run the data includes:

- a) observations of the surface voltage versus time
- b) test condition data
- c) charge measurements, when a JCI 176 Charge |measuring Sample Support is linked to the JCI 155v5

This data is stored on the memory card in a single large binary data file. Stored data can be accessed off-line using the proprietary software JCI-Graph to transfer and extract the data from the memory card into files relating to individual test runs. This is described in Section 8 and in the JCI-Graph User Manual

Where a JCI 155v5 is operated in a controlled humidity chamber (for example a JCI 191) it may be convenient to mount a CompactFlash card reader (for instance a Sandisk 'Imagemate') within the chamber so that card data can be extracted to an external PC without need to upset environmental conditions. Alternatively the instrument can be operated directly in conjunction with an external PC with JCI-Graph 2-2-0, or later versions. Test and observational data is stored to the memory card whether the instrument is operated from a linked PC or from the instrument itself.

#### 3.4.2 Observations of charge decay

Observations of surface voltage versus time are made at an initial frequency of 512 readings a second. After recording 512 observations the recording frequency batches of 256 readings are made with the recording frequency halved for each batch. While the recording frequency decreases the actual frequency at which measurements of surface voltage are made is kept constant and opportunity taken to average observations to improve the signal to noise ratio of recorded values. The numbers of observations averaged per reading increases to 256 and is then kept constant. The progressive halving of the recording frequency as time progresses provides a good way to store observations from long test runs in a compact way.

#### 3.4.3 Associated test condition and result information

Observations of charge decay are stored to the memory card with associated information concerning the test conditions. The recorded data includes observations of the fieldmeter zero before the start of test, the corona voltage and current during the 20ms preceding plate release, the temperature and humidity values and measurements of 'conduction' and 'induction' charge measurements made when a JCI 176 Charge Measuring Sample Support is connected. (See also notes in Section 4.10).



## 4. MAKING CHARGE DECAY MEASUREMENTS

### 4.1 Introduction

The following procedure is suggested as likely to be suitable for general testing the ability of materials and surfaces to dissipate electrostatic static charge and for measurement of capacitance loading effects [8]. Alternative procedures may prove to be more appropriate for particular materials or items. Where the results of measurements may be used with contractual or legal implications then it is necessary for the JCI 155v5 to be within formal calibration [7] and for measurements to be made using appropriate test procedures [8].

The charge decay performance of materials is conveniently represented by the time from the initial peak voltage to 36.8% (1/e) and/or to 10% of this. Display and inspection of the actual decay curve data provides a better insight into the character of the material performance. Display of the variation of surface voltage during the progress of charge decay is provided using software JCI-Graph. This also displays associated test condition data, creates a .csv summary file for Spreadsheet processing of results and allows decay graphs and test data to be copied into wordprocessed documents.

### 4.2 Equipment:

- JCI 155v5 Charge Decay Test Unit
- JCI 176 Charge Measuring Sample Support (or JCI 166 Sample Support).  
- for powder samples also a JCI 173 with the JCI 176 or a JCI 170 and JCI 172
- Software JCI-Graph (for presentation of up to 4 graphs and results together in a Windows 95/98/2000/XP computer operating environment)
- Humidity controlled test chamber (e.g. JCI 191 with JCI 192 Dry Air Supply)

### 4.3 Test Samples:

The easiest materials to test are in sheet, film or layer form. These should lie flat under the test aperture without rucks, bulges or bits that might project into the test aperture. Other surface forms can be studied whether larger than the area of the test aperture (45x54mm) or smaller. It is necessary of course to note

- a) that the surface area tested is that close to the middle of the test aperture (about 15mm diameter)
- b) that material projecting into the test aperture or it may interfere with movement of the air dam on the moving plate and may lead to damage of the instrument

Care must be taken when testing powders or testing materials that may have loose surface fibres to avoid these being ingested into the test aperture. These materials are likely to adversely affect instrument operation. In particular, insulating powder particles or fibres on surfaces in and near the fieldmeter sensing aperture are likely to cause appreciable zero offsets and zero drift.

Powders and liquids may be tested by placing these in an earthed cup under the instrument test aperture (e.g. a JCI 173 or JCI 170).

For measurements on light powders it is wise to use the 'Slow' plate release option and perhaps also to increase the separation between the powder surface and the instrument baseplate (e.g. using a JCI 172 Support Plate with a JCI 170 Powder Sample Support. Under-filling of the JCI 173 cup between the support plates of a JCI 176 may be appropriate).

### 4.4 Test Environmental Conditions:

The charge decay properties of materials vary with temperature and the absorption of moisture. It is hence very important that the values of these parameters in the test environment are known, and that they are controlled to agreed values for standardised measurements. The JCI 155v5 includes sensors to measure temperature and humidity within

the instrument and to record these values along with the other test condition data. Temperature and humidity values may be examined in between test runs via the menu system.

To ensure environmental conditions within the instrument match those of the surroundings in which samples have been conditioned it is best that the JCI 155v5 is operated by its batteries to minimise internal heat dissipation. It is also wise to leave the JCI 155v5 with its test aperture exposed to the test chamber atmosphere when the instrument is not in immediate use. Fan assisted ventilation within the instrument during operation with power input from the external mains power supply unit maintains internal humidity within about 2% of local external ambient.

*Note. For critical measurements (see also Section 10) it is recommended that*

- a) Batteries are fully recharged before a period of measurements with the instrument not resting in position on any sample or in position on a JCI 176
- b) A period of 2 hours is left before the start of measurements with the instrument disconnected from the external mains power supply unit
- c) measurements are made with the instrument operating from its batteries.

Handle samples only well away from the area of the surface to be tested. Use tweezers for small samples. Avoid breathing in the direction of the sample.

For measurements in practical situations the ambient temperature and relative humidity shall be recorded. This is provided by measurements within the JCI 155v5 instrument.

For laboratory measurements the materials and samples should be conditioned in the selected environmental conditions for at least 24 h before testing and measurements made with the following conditions in the listed sequence, or as otherwise agreed [7,8].

	Temperature (°C)	Relative humidity (%)
High relative humidity	23 ± 2	50 ± 3
Low relative humidity	23 ± 2	12 ± 3

The surface of the material tested should be clean and free of loose dust. Remove any loose dust by gentle brushing or blowing with clean, dry air. If the surface is obviously contaminated either an alternative area or sample should be tested or measurements made with the contamination present and the condition of testing reported to be ‘as received’.

Solvent or chemical cleaning is not recommended as this may change surface conditions or characteristics.

For measurements in practical or installed applications, the materials shall be tested without any “special” cleaning. If cleaning is part of the process, for example washing of garments, measurements should be taken before and after cleaning where practical. The materials and the method used to clean shall be reported.

## 4.5 Placement of instrument

### 4.5.1 Introduction

The instrument is placed on the sample in a way that ensures it will remain stable and steady in position throughout the period of charge decay measurement.

*Note - Movement of the test equipment relative to the surface can cause tribocharging that may affect observations. With fabrics that include conductive threads it is usually necessary to avoid touching or disturbing the material overhanging the support plates of a JCI 176. An earthed external environment is desirable.*

#### 4.5.2 Precharged sample surfaces

When a sample is presented for testing the initial surface voltage on the material shall be observed before the moving plate carrying the corona discharge points is advanced to shield the fieldmeter sensing aperture. If this surface voltage is more than 50V the sample shall be left in place under the instrument until the surface voltage has fallen to below 20V.

*Note – Sample surfaces may become pre-charged by handling when placed ready for testing. It is recommended that when samples are placed in position the moving plate is back, in the ‘Ready to run’ state so the fieldmeter can respond to any charge on the sample surface and show these observations. This initial surface potential on relatively insulating samples may be minimised by careful handling with minimum sliding actions.*

*Two main options are available if there is appreciable pre-charge:*

- a) to wait until the pre-charge has dissipated. This means waiting for the initial surface voltage to fall to say 10-50V, depending on the quality of observations required.*
- b) to make a study on the self-decay of this pre-charge without adding any corona charge. This means making a measurement with the corona voltage turned off (via the test condition menus). It is to be noted that the decay of such pre-charge may be rather slower than the decay of the local patch of corona charge – because at least it relates to decay behaviour well down a normal corona charge decay curve. It is, none the less, a useful observation.*

*For quality measurements it is recommended that no measurements are attempted by putting corona charge on to an already well charged surface or material.*

*It is also recommended that pre-charged material is not neutralised by any other means than waiting. Deposition of neutralising charge may only give the appearance of neutrality but give close coupled regions of charge.*

*There are two other possible artefacts are worth noting:*

- a) that if the air dam, on the trailing edge of the moving plate, touches the sample surface then tribocharging may occur during plate movement. This may arise when testing light fabrics. The fabric surface should be stretched flat under the test aperture, but it may still rise by induced air movement. This effect may be checked by making measurements with no corona charging. It may be avoided by slightly raising the baseplate of the instrument off the sample.*
- b) that with some materials a very short (1-2ms) transient peak voltage is observed before the real charge decay curve. It is thought this is due to vertical charge separation between front and back surfaces of the sample at sample flexing. The polarity is usually positive. Precautions have been taken to prevent such events upsetting operation of software timing*

#### **4.6 Sample mounting – open/earthed backing**

With an installed material the test aperture in the base plate of the instrument shall be rested directly on its surface.

Sheet or flexible materials shall be tested as supported against the test aperture with both ‘open backing’ and ‘earthed backing’. These two arrangements represent the extreme conditions of practical application. For both arrangements the longer of the two decay times shall be taken for comparison with general acceptance criteria.

*Note - In practical terms, ‘earthed backing’ represents a material in intimate contact with an earthed surface, for example a garment fitted close to the body of the wearer, or a work surface on top of a metal bench. ‘Open backing’ measurements represent the other practical extreme where materials are separated from earthed surfaces, for example the bottom edge of a coat or smock which hangs away from the body of the wearer.*

For testing of material with ‘open backing’ the material shall be supported against the base plate of the instrument by an earthed metal aperture aligned with the instrument test aperture and with at least 5mm width outside the test aperture area. . The shield over the reverse side of the test area shall be earthed and at least 25 mm away over the whole test area.

For testing of materials against an ‘earthed backing’ the material shall be mounted between the base plate and a flat earthed metal plate.

*Note - If charge moves more readily through the bulk test material than across its surface, then placing an earthed metal plate immediately behind the test area may decrease the charge decay time. On the other hand, if charge moves more readily across the surface of the test material, then charge decay time may be increased due to increased capacitive loading.*

Powders and liquids may be tested while supported in an earthed metal cup beneath the test aperture (for instance a JCI 173 or a JCI 170). An insulating cup is not appropriate.

#### **4.7 Corona charge deposition**

Corona charging provides a rapid and repeatable non-contact means of depositing charge with controllable magnitude and polarity.

Corona charging is achieved using a number of discharge points on a 10 mm diameter circle 10 mm above the middle of the test area. The exact size and distribution of charge deposited on the material is not well defined, particularly with the more conductive surfaces, but the arrangement provides a consistent pattern of deposited charge for decay time measurement.

The corona charge deposition time is most conveniently 20ms  $\pm$ 10ms. Longer times may be used if needed to achieve an adequate initial peak voltage for good quality charge decay measurements. Materials should preferably be tested with both positive and negative polarity, although very similar results can be expected.

*Typical voltages for corona charging are between 3.5kV and 10kV with 5kV for 20ms as a useful level for general test work. Corona deposition times longer than 100ms should be avoided. They will not provide any enhancement of charging and may damage sensitive surfaces. High initial surface voltages are not needed for good quality measurements – initial peak voltages 50-1000V are quite adequate.*

Charge decay and capacitance loading characteristics of materials can vary with the quantity of charge deposited. It is therefore wise to make tests with quantities of charge comparable to those likely to arise in the practical situation or, if this is not known, over a range of quantities of charge. Tribocharging by rubbing may involve quantities of charge in the range 10-20nC. For layer, fabric and film materials the JCI 176 Charge Measuring Sample Support provides an appropriate way to measure the quantity of charge transferred.

It is desirable that some measurements are repeated at the same location to check consistency of behaviour for particular positions on a fabric. However, it is also necessary to check that characteristics have not been affected by corona exposure. The best way to check this is to start and finish at low corona charge levels and to include changes in test position.

The equipment for charge deposition moves fully away from the region of field meter observation in less than 20 ms.

*For corona voltages around 10 kV the initial peak surface voltage with relatively insulating materials may be up to about 3 kV. For materials with fast charge decay rates, and/or high capacitance loading, the initial voltage may be much lower - for example only 50V to 100V. Reliable measurements may be made with surface voltages in this low range.*

#### **4.8 Measurement of surface voltage**

A ‘field mill’ type of electrostatic fieldmeter is used to measure the surface voltage of the sample. The proprietary design of the fieldmeter used has been described in published papers [4,5]. These should be consulted to gain understanding of instrument principles and

operation. The dynamic noise level corresponds to surface voltage variation within 2V p-p. The influence of noise on surface voltage measurement is decreased progressively during the progress of studies by averaging an increasing number of observations.

The sensitivity of the fieldmeter is set, as described in Section 10.5, in relation to a defined potential on a conducting surface covering the whole of the instrument test aperture.

During corona charge deposition and decay time measurement the sensing aperture of the fieldmeter is well shielded from any connections or surfaces associated with corona high voltage supplies. There are no insulating materials in or around the region of the instrument between the fieldmeter and the test aperture that can retain charge and able to contribute signals to fieldmeter observations.

The upper surface of the moving plate carrying the corona discharge points is gold plated. When this surface is moved forward in front of the fieldmeter it is used as a zero reference. This zero check is made at the start of each test run.

For measurements with materials having initial peak surface voltages less than 200V it is necessary to remove residual air ionisation created by the corona discharge when the moving plate carrying the corona discharge points is moved away. An air dam is mounted on the trailing edge of the moving plate mounting the corona discharge points. This removes the air ionisation from the region between the moving plate and the test aperture in the baseplate and this greatly reduces the influence at the fieldmeter sensing aperture. Residual ionisation shall contribute less than 10V to measurement of surface voltage. This may be tested by measurements on a fully conducting test surface

#### **4.9 Measurements of charge decay times**

Experience has shown that charge decay curves usually do not follow an exponential form. With some materials the curve may plateau out appreciably as the decay progresses. It is also observed that this form is little affected by the level of the initial peak voltage. It is thus appropriate to normalise decay time measurements in relation to the initial peak voltage observed. The time from the initial peak voltage,  $V_i$ , to a lower end voltage,  $V_e$ , at 36.8% ( $1/e$ ) of this is a convenient decrement for a quick comparison between materials. In addition, measurement of the decay time to 10% is desirable as this better includes any plateauing out tendency in the form of the decay curve.

Signal noise makes decay time measurements difficult with low level signals. This problem has been overcome by the use of the proprietary 'stutter timing' approach that has recently been developed. In this approach the timing clock is started and stopped as the surface voltage fluctuates in falling across the target voltage level.

The start of timing and associated initial peak voltage are determined by comparing the median of the most recent four surface voltage measurements with the maximum median value. This occurs just after the physical voltage maximum. This is appropriate, as selection of an initial voltage and the start of timing need to relate to the beginning of the falling part of the decay curve rather than the instant at which the signal increase due to plate movement matches the rate of signal decay. 'Time zero' is determined by stutter timing from this start point.

Experience from manual tribocharging studies [2,3] indicates that it takes about 100ms after the end of charging for the rubbing surfaces to separate and for the surface voltage to reach a peak value and hence be available to influence items nearby. In the light of this it is appropriate to use a similar time after the end of corona charging for selecting the initial voltage on which analysis of decay curves is based. The form of decay curves before this time may well still be of interest but is not directly relevant to using corona studies to predict the performance of materials in practice

#### 4.10 Measurement of quantity of charge transferred to test surface

Measurement of the quantity of corona charge transferred to a sample is conveniently made using a JCI 176 Charge Measuring Sample Support. The mounting of a JCI 155v5 on a JCI 176 is shown in Figure 4. The charge transferred is observed as a combination of the conduction and induction signals [8]. The conduction charge signal relates directly to the conduction charge but the induction signal is subject to the sensing electrode geometry. The total charge may hence be expressed as:

$$Q_{\text{tot}} = Q_c + f Q_i$$

With a simple dissipative sample material, such as paper or cling film, it is observed that nearly all the initial observations are associated with ‘induction’ charge effects and that as this decreases the conduction signal increases. The total corona charge deposited is of course constant, hence the fall of the induction signal,  $Q_i$ , must match the increase in the conduction signal  $Q_c$ . A factor,  $f$ , may be found that gives a good match between the fall of induction signal to the rise of the conduction signal. The geometry of the JCI 176 was designed to give  $f \sim 2$ . Experience shows values close to 2.2. This value may be checked by matching observed variations of conduction and induction signals after charge deposition.

*The JCI 176 provides two ranges of charge measuring sensitivity on both ‘Induction’ and ‘Conduction’ charge signals. The JCI 155v5 software chooses the most sensitive of each that is within measurement range. For materials with high capacitance loading and with long corona charging times at high corona voltages it is possible to transfer more ‘Conduction’ charge signal than is within the measurement range. If the ADC for the least sensitive range saturates then the recorded charge signal is zero. If one may be operating in this regime it will be useful to also connect a digital multimeter to the second 8w mini DIN analogue output socket of the JCI 176 to directly measure the charge received. If saturation is likely (signals over 4V) then the corona charging time or the corona voltage should be reduced.*

The quantity of charge transferred to the sample is most conveniently varied by changing the corona voltage. Experience shows that charge decay measurements may be made with corona voltages down to between 2.5 and 3kV. Corona times may be adjusted down to 5ms.

#### 4.11 Measurements of ‘Capacitance loading’

The influence of electrostatic charge on materials depends both on how long it is there and to the associated surface voltage created. The quantity of charge per unit of initial peak surface voltage is effectively a ‘capacitance’. If this capacitance is large then only low surface voltages will arise from the quantities of charge likely to arise in practical tribocharging events. Many materials, notably cleanroom garment fabrics that include conductive threads, show high values of ‘capacitance’ so although their charge decay times may be long they may be they present little risk of causing problems [3,4,8]. Note that both charge decay time and capacitance loading can vary with the quantity of charge so (as noted in 4.7) it is important to make measurements at charge levels appropriate to the application.

Measurement of the quantity of corona charge transferred to a sample is conveniently made using a JCI 176 Charge Measuring Sample Support directly linked to the JCI 155v5 – as shown in Figure 4.

Surface voltages measured by the JCI 155 are calibrated in terms of a voltage applied to a conducting plane across the whole test aperture area. The area over which corona charge is deposited is much smaller than the area of the test aperture, so the local ‘initial peak voltage’ will be rather higher than the value interpreted from the fieldmeter measurements. Rather than guess an area for the deposited charge, in order to calculate a real ‘capacitance’ it is more practical to assess materials in terms of their

'capacitance loading' [3,4,8]. This is the 'capacitance' value observed for the test material divided by the 'capacitance' value observed for a very thin dielectric layer, such as cling film. It is assumed that there are similar distributions of surface charge for the two materials.

*Note: It is wise to check the 'capacitance loading' value for a thin dielectric layer such as cling film from time to time to ensure that values close to unity are achieved for particular combinations of JCI 155v5 and JCI 176 instruments.*

#### 4.12 Results

At least 3 decay time measurements should be made in testing any material under any set of test conditions. These measurements should be made at different positions on the material and/or with different samples of the same material. Such measurements should be made, where practicable, both with 'open' backing and 'earthed' backing.

Experience is that very similar results are obtained with positive and negative corona polarity, however it is considered wise to check this with new materials.

*Note: Where decay times are less than 100s it may be useful to demonstrate repeatability of measurements and observe any variation over the sample area. This may be done by making say 4 measurements at one location (with adequate time for the surface voltage to fall to below 5% of the initial peak value before the next test) and then moving on to say 3 further measurement positions over the sample followed by repeat sets of measurements on the first 2 areas. This will show the repeatability of the measurement method, consistency of performance over the sample and also show if the sample performance is changed by repeated measurements. This approach is also useful with capacitance loading measurements.*

#### 4.13 Test Report:

The following information shall be recorded:

- a) date of measurements
- b) description and identification of test material and location of test area
- c) history of test sample (e.g. number of washes of fabrics)
- d) temperature and relative humidity
- e) test conditions of corona charging voltage, duration, polarity, sample support arrangement and whether open or earthed backing
- f) individual values of initial peak sample surface voltage and of the initial voltage for the start of decay timing where timing is started a set time after the end of corona charging.
- g) associated individual values of the time from initial decay timing voltage to  $1/e$  of this.
- h) (For computer stored data the file reference of the test).
- i) where measurements are made of the charge received by the sample these values should be recorded and the results of calculations made of 'capacitance loading'.
- j) graph of the variation of surface voltage and of the local charge decay time constant during charge decay
- k) serial number of instrument used and date of most recent calibration



## 5. PROBLEMS: WHAT IF...?

### 5.1 Initial fieldmeter zeroing

At start up of the instrument the software checks instrument operation and zeros the fieldmeter. This proceeds in 3 basic stages:

- 1) checking operation of the electronic circuits without any signals from the sensing surfaces of the fieldmeter
- 2) checking the circuits with phase sensitive detection operating from the fieldmeter operating but no signals from the sensing surfaces
- 3) checking the output when the fieldmeter is operating normally but looking at just the upper gold plated surface of the moving plate.

If there is a problem the results of these tests can be inspected by restarting the instrument and pressing the Revert key as soon as it is illuminated. With the left hand item toggled with the illuminated key below to 'Off/Sig' the voltage  $V_s$  reading should be less than  $\pm 1V$ . With 'On/Sig' (signals connected from the fieldmeter), 'On/MII' (fieldmeter on) and 'In/Plt' (plate forwards) the voltage  $V_s$  will be a few volts. This is what should be seen.

If a 'Bad static zero' is reported at start up this indicates some offset problem in the signal processing circuits. This may not be a show stopper because the zeroing action before each test run will compensate. However, it does show a need to return the instrument to JCI for attention.

A 'Bad detector zero' can be checked with 'Off/Sig' (signals connected from the fieldmeter), 'On/MII' (fieldmeter on) and 'In/Plt' (plate forwards) the voltage  $V_s$  should be less than 1V. This may not be a show stopper because the zeroing action before each test run will compensate. However, it does show a need to return the instrument to JCI for attention.

A 'Bad fieldmeter zero' reported at start up indicates contamination in or around the fieldmeter. A high but fairly steady zero offset probably indicates particulate contamination, whereas a fluctuating voltage is likely to arise if fibres are present. It may be feasible to remove particulate contamination by sluicing out the inside of the fieldmeter thorough the sensing aperture with a small jet of good solvent – and then letting the instrument dry out for 10-20 minutes. Fibre contamination is more difficult to remove. It is worth trying a jet of air at not too high pressure. If these approaches fail the fieldmeter module needs to be cleaned. This is best done by returning the instrument to JCI.

If the displayed surface voltage, in the 'Ready to run' mode, fluctuates more than  $\pm 2V$  the sensing region of the fieldmeter probably needs cleaning as described above. This may be carried out with some care, as described in Section 11, or the instrument is returned to JCI.

### 5.2 Inadequate initial peak surface voltage

If the initial peak voltage is very different from that expected from experience at set levels of corona voltage it is useful the check that the corona points have not been flattened and then to check the level of corona voltage applied and the duration of corona charge transfer.

JCI-Graph provides opportunity to make a .csv file with all the heading and observational data recorded for each test run. When this file is loaded into a Spreadsheet (such as Excel) the variations of corona voltage and current with time can be studied. The duration of the corona can be judged from the time when the corona current increases sharply to the time when it falls below a few microamps. This time should sensibly correspond to the set corona duration. If there is much difference it will be useful to adjust the 'plate advance' time – the time taken from initiation of plate release to interruption of current flow by motion of the moving plate.

### 5.3 Plate Overshoot (Premature plate release)

If the plate carrying the corona discharge points flips back as soon as it has been advanced there is a mechanical problem which needs to be resolved. Instruments from Serial N $\geq$ 0306\*\*\*\* onward (software version 505) differ mechanically from previous instruments

(versions 504.x). The two types are considered separately.

### 5.3.1 *Earlier instruments serial numbers up to N0306\*\*\*\*, software version 504*

In these instruments, the cam that advances the plate is supposed to be stopped by the cam stop position sensor just before the drop off point of the cam follower at the back of the moving plate on the cam. The normal stopping position can be seen by looking obliquely into the test aperture towards the back of the instrument. The cam follower will be seen on the back edge of the moving plate and the tip of the cam.

If the cam stops just after the plate has flipped back then there needs to be a slight adjustment to the cam stop position sensor. ("Plate overshoot" will also be signalled on the display with 'no peak found'). The backplate of the instrument may be removed by undoing the two M3 screws at either side of the back plate as well as the front screw holding the left hand side extrusion (be careful not to lose the metal strip held in the extrusion that helped support the PCB). The back plate can now be swung round to the left. A small PCB will be noted in the middle of the instrument below the position of the PCMCIA card holder. There are two M2 screws, that hold either side of this board. If these two screws are loosened the PCB may be moved slightly to the right (about ½ mm should do) and then the screws retightened. The instrument can be operated to check satisfactory operation. The side extrusion and back plate may now be replaced, and normal operation resumed. When replacing the backplate make sure that the leads will not be trapped and will not be in the track of the cam or main gear.

If the above is not successful it may be useful to remove the left-hand side extrusion and check that the small black magnetic sensor unit mounted from the middle of the above PCB is close down near the top surface of the large gear.

### 5.3.2 *In later instruments (serial numbers from 0306\*\*\*\*, software version 505)*

As the moving plate is fully advanced by the cam it is caught by a solenoid operated latch on its topside. When a fast release of the plate is required the cam stops just clear of the cam follower to allow plate release by the latch release solenoid. A premature release ('Plate Overshoot') is then due a malfunction of the latch. If this occurs infrequently it is best just to note the occurrence and repeat the test. If this occurs during a test sequence, it is worth trying to repeat the test at the same location, as there will have been no corona charging taking place when the error was detected. If this problem persists the instrument must be returned to JCI for servicing.

When a slow plate release is required, the cam stops short of the drop off point. After corona deposition the latch is released and the cam rotates to allow the plate to retract slowly. If there is a 'Plate Overshoot' error in this case because the cam rotated too far the cam stop sensor can be adjusted as described above.

## 5.4 Plate movement

If the movement of the plate jams there will be a 'Advance motor overload' error shown on the display. Check whether movement jam was due to material getting into the test aperture. If so carefully remove the obstruction – and, if necessary, straighten the brass 'air dam' if this was bent. If the mechanism itself has jammed with the plate part way back then try pushing the plate forwards by finger pressure near the base of the brass sheet 'air dam' and check if the drive motor runs freely with the plate held forwards. If the plate does not move easily in its guide slots it may be useful to try wiping these with a piece of link free tissue or cloth with a little light solvent. Do NOT lubricate the slides with oil. If the plate is jammed fully forwards and the motor runs freely then carefully try to prize the 'air dam' away from the front edge of the aperture - but take care as the plate may fly back fast. If the motor does not run freely it maybe that there is some obstruction in the gear train. It may be that this can be

spotted by removing the back plate of the instrument and very carefully incrementing the gear train by hand - if not the instrument must be returned to JCI for servicing.

If the motor cannot drive the plate forwards the display will show 'Advance Motor Overload' or 'Plate Advance TimeOut'. If the plate fails to flip back as expected the display will show 'Plate Return TimeOut', 'Plate Release Stuck' or 'Plate Release Timeout'.

### **5.5 Mains supply**

If the mains indicating LED in the top cover does not illuminate when the external mains power supply unit is connected then it is appropriate to check the fuses in the supply connection. It may also be appropriate to check that the output at the 2.5mm d.c. connector is close to 18V.

### **5.6 'LO BATT'**

The characteristics of rechargeable batteries is that if the instrument is being operated on the internal battery supply then when the battery charge falls to a level near the point where normal instrument operation will not be able to be maintained then the 'Power on' key LED starts to flash and the user is advised to connect the instrument to the mains to continue operation and to recharge the batteries. Several minutes warning are given of the need for connection to the mains. If connection is not made to the mains then when the battery voltage has fallen a bit further all data will be saved as part of the instrument shut down procedure.

### **5.7 Reverse polarity pre-pulse**

If a test is made with a zero corona volts immediately following one or more tests with high corona voltages on materials with several seconds charge decay times, it may be noticed on inspection with JCI-Graph that the main signal excursion is a small excursion of the opposite polarity to the last corona charging polarity. This can arise from corona charge trapped on the insulating under surface of the moving plate giving induction charging of the test surface to opposite polarity to the preceding corona potential. If this effect is a problem, it may be minimised by allowing a time for charge on the insulating surface of the moving plate to migrate away to the earthed parts of the plate.

### **5.8 Error messages**

#### **5.8.1 'Overshoot' error:**

This indicates that the signal from the fieldmeter has recorded more than 2 peaks and/or that there was a reversal in polarity between at least initial peaks. This might indicate a problem with 'flap' of a thin material – and inspection of associated graphical results will be helpful. Enhancements to JCI-Graph reduced the risk of problems in the analysis of observations. Changes to arrangements for stopping plate movement during 2008 reduced the chance of occurrence of multiple peaks by reducing impact induced vibration of the fieldmeter structure.

#### **5.8.2 Plate movement errors:**

'Advance Motor Overload', 'Return Motor Overload', 'Plate Release Stuck', 'Plate Release Timeout', 'Plate Advance TimeOut' and 'Plate Return TimeOut'. All these indicate problems with ease of movement of the plate or the motor drive system for advancing the moving plate.

If the plate is far enough forward to be able to hold the brass air dam then the ease of movement of the plate itself can be checked. It is best to pull the air dam near the plate surface to reduce risks of distorting the dam. If the plate does not slide easily against the return springs then it may be useful to try cleaning the guide slots with a clean lint free cloth with a light volatile solvent. Do NOT use any lubricant.

If the plate slides easily but the drive is still jammed or if the above action does not make sliding easy it will best to return the instrument to JCI for servicing.

‘Plate overshoot’: In instruments built with serial numbers above 0306\*\*\*\* this message means that the peg on the top side of the cam follower has not been held by the solenoid operated latch. No useful data will be stored in a test when such a failure occurs. If such failures only occur very infrequently it is best just to note the occurrence of the failure and to run the test again. As no corona charge will have been deposited on the sample it should be possible to run a repeat test directly. If failures become too frequent then it is necessary to return the instrument to JCI for servicing.

In instruments before 0306\*\*\*\* the advanced moving plate is held on the snail cam just before the drop off point and is released very soon after the plate motor is restarted for plate release. In these earlier instruments ‘plate overshoot’ means that the cam has rotated a bit too far in advancing the plate and gone beyond the drop off point. This can usually be remedied by taking the back plate off the instrument and loosening the two M2 screws holding the small circuit board in the middle of the mechanism plate and moving this slightly to the right before retightening the screws and replacing the back plate.

### 5.8.3 Charge measurement errors:

If the quantities of charge transferred to the sample, and measured by the JCI 176 Charge Measuring Sample Support are beyond the range then errors are shown. If the ‘conduction’ charge signal is too large the display shows Qc! And if the ‘induction’ charge signal is too large then Qi!

When observations are transferred into JCI-Graph the corresponding readings in the text details and in the .csv summary table will show \*\*\*\*.

Over-range charge measurement errors will arise if there is any earthing contact to the sample mounting plates of the JCI 176.

### **5.9 Computer errors and ‘Reset’**

If the display goes blank while the fieldmeter motor can still be heard running, or if all else fails, then it is useful to try resetting the computer. This can be done by inserting a 1mm rod (a paper clip will do nicely) into the ‘Reset’ hole in the instrument backplate (upper right hand side) and pushing it in lightly. The fieldmeter motor should be heard to slow down and stop. The instrument may be restarted by pressing the ‘Power on’ key in the usual way.

### **5.10 Non-smooth charge decay curves**

If charge decay curves show sudden steps at voltages of 800V or 200V this indicates that the gain of one of the fieldmeter signal processing channels has changed a bit. If the steps are larger than a couple of percent of the signal level it will be wise to return the instrument to JCI for servicing.

If oscillations or fluctuations are observed in the charge decay curves when testing thin film and fabric materials this probably arises from flexing of the charged surface. This may occur where the sample is mounted with open backing if the material is mounted too loosely. With an earthed backing this may arise if flexing of the material lifts it away from the earthy surface as the force of electrostatic attraction decreases during charge decay.

If the zero reading of the fieldmeter fluctuates or drifts or if the fieldmeter signal becomes noisy it is likely that the fieldmeter sensing region is contaminated – probably by fine fibres.

The influence of fibres in the fieldmeter sensing region is likely to be worse after an extended period of operation. If this problem occurs during a critical sequence of tests it may be worth trying switching off the JCI 155v5, allowing the fieldmeter rotor to stop rotating, gently earthing the rotor and then restarting operation. The fieldmeter needs to be cleaned (as suggested in 5.1 above) or the instrument returned to JCI.

## 6. EXTERNAL CONNECTIONS

### 6.1 Charge measurement port

The corona charge received by sheet and layer materials may be measured using the JCI 176 Charge Measuring Sample Support [6]. The JCI 155v5 is mounted directly on the JCI 176 and linked to it by a 8w-8w mini DIN connecting cable. Connection to the JCI 155v5 is made using the far left 8w DIN connector on the back plate of the JCI 155v5. Either of the two connectors in the back of a JCI 176 may be used - the other may be used for other direct measurements using a DMM or storage oscilloscope. (See also section 4.10).

The cable connection both links signals from the JCI 176 to the JCI 155v5 and gives automatic provision of power supply to the JCI 176 independent of its on/off switch. Zeroing of the charge measurement circuits is controlled by software in appropriate relation to the time of charge deposition. Charge measurements, using appropriate sensitivity levels, are stored to the memory card of the JCI 155v5 alongside related charge decay observations.

### 6.2 RS232 serial data communications port

Opportunity is provided for direct linking of the JCI 155v5 to a microcomputer via an RS 232 serial communications port. Connection is via the single 8w miniature DIN socket towards the middle of the back plate of the unit (as opposed to the 6w and 8w DIN sockets mounted together towards the left hand side). A cable is provided (8w DIN plug to 9w D type socket) to link the 8w DIN socket to a 9w D type plug as commonly used for computer serial data ports. The connections provided and used are:

	8w miniature DIN		9w D type	25 way D type
DTR	1	black	4	20
earth	2	white	5	7
DSR	3	red	6	6
TX	4	yellow	3	2
RX	7	green	2	3
			5	cable screen
				1

The direct serial communications link is used in conjunction with JCI-Graph v2-2-0 (or above) for downloading charge decay observations from the memory card while in the JCI 155v5 instrument. In addition JCI-Graph allows initiation of runs from the PC with opportunity to observe the progress of active charge decay tests in quasi-real time and to inspect results and test condition data.

Many new computers, notably Laptop computers, are not provided with RS232 serial data ports. On-line operation of JCI-Graph can be achieved on such computers by using a USB to serial adapter – e.g. Belkin Serial Adapter F5U103. This adapter is plugged into a USB port and connected to the JCI 155v5 with the 9w D type to 8w mini DIN cable supplied by JCI.

### 6.3 Remote control port

The port provides facilities for operating the instrument in conjunction with remote facilities. These may be a simple push button ‘Master’ control unit or a sample changer unit as ‘Slave’ or ‘Auto’.

These facilities are selected in the ‘Config settings’ menu (see A2.9). In all cases lack of connection to a remote unit leaves the instrument operating normally.

Remote master control of the instrument is useful when this is used within, for example, a controlled humidity chamber (for example JCI 191). Remote Slave / Auto are used to integrate operation of instrument operation with, for example, sample changing equipment.

The connections provided via the 6w mini DIN socket (second from far left hand side of back cover) are:

1	Remote signal to Instrument	black	Contact to ground
2	Instrument signal to Remote	white	Logic level
3	Instrument signal to Remote	red	Logic level
4			
5	V+	violet	~6V
6	GND	blue	0V

#### **6.4 External mains power supply input**

The batteries within the instrument may be recharged and the instrument operated using an external 18V 15W (or more) mains power supply unit connected via the 2.5mm d.c. connector in the back panel. The centre pin of the d.c. connector is positive relative the outer earth.

## 7. REMOVABLE MEMORY CARD

A flash memory card is used for storing results from charge decay studies with the JCI 155v5. It enables results to be re-examined at the instrument and enables results to be transferred to a PC for long term storage and for the inspection and display using proprietary software JCI-Graph.

The ‘memory card’ may be either a PCMCIA flash card or a CompactFlash card (as used for digital cameras) held in a PCMCIA card adaptor. Both are equally valid – but experience has been good using CompactFlash cards. It is advised that where PCMCIA cards are used these are Sandisk cards. Sandisk is also a suitable manufacturer of CompactFlash cards. It is advised that the capacity of the card should be no more than 512MB.

The memory card (as PCMCIA equivalent) is mounted into the Charge Decay Test Unit through the slot in the middle of the back plate. The card is introduced upside down – with the main label facing down. As the card is pushed firmly home the card ejection button on the right of the card slot will move out.

A preformatted memory card is supplied with the JCI 155v5 instrument. This card has sufficient capacity to hold results from a large number of charge decay tests. Larger and smaller capacity cards may equally well be used. When the storage space is full the oldest data will be overwritten progressively if permission is granted for this. In general, it will be wise to consider the card as used for temporary data storage and to transfer results to a hard disc or back up medium on a microcomputer when convenient.

If a new card is to be used then when this is put into the instrument a question will be asked if the card is to be formatted. The answer to this is ‘yes’. Similarly, when a memory card is full, a question will be asked whether this card is to be reformatted. Before answering ‘yes’ it is important to ensure all relevant stored data has been extracted, as this will be lost at formatting.

*If it is desired to use a memory card that has already been used for other purposes it is necessary to reformat the card. To do this it is important to delete all folders and files and then put the card into the JCI 155v5 for formatting by the JCI 155v5 software. At start up the question will be asked as to whether formatting is required – to which the answer is ‘yes’.*



## **8. COMPUTER DISPLAY AND ANALYSIS OF OBSERVATIONS**

### **8.1 Introduction**

Data from test runs with the JCI 155v5 is stored on the removable memory card (Section 7 above) that is mounted upside down into the back plate of the instrument. Observations may be displayed and analysed on a PC microcomputer using proprietary software JCI-Graph. This is Windows compatible software (Windows 95/98/2000, XP and Vista). It enables test run data to be transferred from the memory card and then extracted to make files in designated directories for display and analysis. Graphical and text information can then be transferred into other Windows applications such as Wordprocessing and Spreadsheet operations. For full details of off-line and online operation of JCI-Graph see the JCI-Graph user manual.

Where a JCI 155v5 is operated in a controlled humidity chamber (for example a JCI 191) it may be convenient to mount a CompactFlash card reader (for instance a Sandisk 'Imagemate') within the chamber so that card data can be extracted to an external PC without need to upset environmental conditions.

JCI-Graph includes an extensive 'Help' menu facility. This should be consulted to gain familiarity with software operation and facilities.

JCI 155v5 instruments may be operated via the serial link to an external PC operating JCI-Graph version 2-2-0 or higher (see JCI-Graph 2-2-0 user manual for details). With computers not supplied with a RS232 port on-line operation can be achieved using a USB to serial adapter – e.g. Belkin Serial Adapter F5U103. This adapter is plugged into a USB port and connected to the JCI 155v5 with the 9w D type to 8w mini DIN cable supplied by JCI.

When a JCI 155v5 is operated via the serial link data is both stored to the memory card and directly into files on the linked computer. It is necessary for a memory card to be present in the JCI 155v5 for communications to be established.

### **8.2 Data format**

Data from instrument operation is stored on the memory card as binary data within a large single file. This is done for convenience and efficiency of data storage. Stored data can be read back and displayed at the instrument by the integral microprocessor. This allows review of information from present or just completed run and information from earlier runs. File transfer and extraction into a PC microcomputer is achieved using software JCI-Graph v2.

### **8.3 Data transfer and file extraction**

Data on a memory card is transferred into a PC by inserting the PCMCIA memory card or the CompactFlash memory card into suitable card reader. With Notebook computers this may be one of the standard PCMCIA card ports provided. For CompactFlash memory cards this requires use of a PCMCIA card adaptor. For desktop computers an external PCMCIA card reader unit may be used. For both Notebook and desktop computers a CompactFlash card reader connected to a USB port is a convenient (and low cost) arrangement. Operation is direct 'Plug and Play' and this avoids the need to close down use of directly inserted PCMCIA cards. (Note that the Sandisk 'Imagemate' is a suitable USB reader for CompactFlash cards, but there may be problems with Windows 2000 compatibility).

Data is extracted from the memory card by running JCI proprietary Windows software JCI-Graph v2. File transfer and extraction causes observations to be stored as individual files by 'run number' within directories for each day of operation and within directories identified by the serial number of each instrument that has been used. Results from individual runs are hence uniquely stored.

It is convenient to allocate a general folder (directory) into which files are extracted. Individual run files will be stored into sub-folders according to instrument serial number and into sub-sub-folders according to date. Re-extraction into the same general folder will then

add or update sub-folders appropriately. Date and time values stored are derived from the instrument calendar clock that is maintained by a long life battery. The instrument serial number is incorporated into the microprocessor software data that is set up at time of manufacture. Instrument date and time values can be updated by the user – but not the instrument serial number.

At the time of file extraction from JCI 155v5 data a Spreadsheet compatible file, ‘summary.csv’, is generated with a summary of results and test conditions for each day of operation. Where only new runs are extracted then new information is appended to any existing summary file. This summary.csv file may be loaded into popular Spreadsheet software, such as Excel, and then edited or reformatted for pasting into a report or paper. This summary table will also prove useful in the selection of runs for more detailed inspection by graphical display.

When charge decay measurements with a JCI 155v5 are made in conjunction with a JCI 176 then the measurement of conduction and induction charge are stored to the memory card. These charge measurements are then used in the automatic preparation of the summary table to calculate the total quantity of charge received by the surface and the ‘capacitance loading’ values (see Section 4.10). Values are also included in the text details available with each graph. Fuller details will be found in the User Manual for JCI-Graph.

#### **8.4 JCI-Graph display of observations:**

Examples of charge decay curves made using a JCI 155v5 and processed using JCI-Graph are shown in Figure 5. The graph shows 4 charge decay curves for a heavy paper sample together with values calculated for the local charge decay time constant during the progress of charge decay. Textural information can be included, as shown, to give the test conditions and numerical values of the measurements made for each graph. The graph includes dashed line markers showing the decay timing initial voltage level, the end point voltage level and the time to the set end of timing point.

A description may be attributed to each test and introduced manually after clicking the key buttons just below the graphs. These descriptions are automatically introduced into the summary.csv file. Changes made to the analysis of results (e.g. the end point % time) can be transferred into the file using the ‘Update’ key.

Following the sheet showing the graphs and text information is an example of the Results Summary table created automatically by JCI-Graph. This is stored by JCI-Graph as a .csv file in the dated directory (Folder) of the test runs summarised. This file may be loaded into a Spreadsheet, such as Excel, for presentation or inclusion into a document. Towards the top of the results summary table are the factors used in measurement of the charge received by the sample surface and for interpretation of capacitance loading values.

Descriptions for individual runs may be added into the file for each run by clicking the relevant test number on the bar under a displayed graph and filling in the ‘description’ box. This description is included in the text list of information that can be printed alongside graphs and is also included in the summary file.

## 9. INSTRUMENT POWER SUPPLY

The JCI 155v5 is powered directly from integral 600mAh rechargeable NiMH batteries. These provide over 4 hours of intensive instrument operation. The batteries may be recharged at any time by connecting the instrument to an external mains power supply via the 2.5mm d.c. connector (centre positive) in the back plate. An 18V switched mode power supply unit of more than 15W rating will be suitable (a unit such as used for operating many laptop computers). The presence of an external mains supply and fast battery recharging are indicated by LEDs in the top cover. Full recharging of the batteries is achieved in about 2 hours. While the instrument is connected to the mains, it is to be noted that every 6 hours the batteries are topped up by a fast recharge. This will probably last 5 to 10 minutes.

To save battery power when the instrument is not in the middle of a run and data is 'ready to be saved', the instrument is shut-down after a couple of minutes of inactivity if none of the key buttons are operated. Activity is restored by pressing the Power ON key.

As the batteries approach a LO BATT level the LED in the Power ON key is flashed and the user is advised on the display to make connection to a mains power supply. If any key is pressed the display returns to show its normal functions but the Power ON key continues to flash. If connection to the mains supply is not made then after several minutes the instrument shuts itself down after saving information from any test run in progress or just completed.

If the instrument has shut down due to passing the LO BATT level then if an attempt is made to switch the instrument on with the Power ON key, but without connection to the mains, then this key will flash and the display advise connection to a mains supply as above.

If the instrument has been left with the batteries in a discharged state for a long time then it is possible that when connected to a mains supply the batteries will go through a relatively short period of fast battery charging – only a few minutes. This will be indicated by the short time for which the fast charge LED is illuminated or by the short period of instrument operation before battery charging is required. Reconnection to the mains after a brief disconnection will ensure that charging proceeds for the normal time of about 2 hours. The batteries will then be restored to their full charge retention capacity.

It is worth noting (as in Section 4) that dissipation of heat within the instrument will raise the internal temperature and depress the internal humidity a little. To minimise differences between local ambient conditions and those within the JCI 155v5 it is important to keep power dissipation within the instrument to a low level. This is best achieved by making measurements with the instrument running on battery power alone. To minimise heating during battery charging and long term operation from the mains the switched mode power supply has been separated from the JCI 155v5 for instruments with serial numbers over 02112030. Modest ventilation has also been provided between the front and back during operation from the external mains power supply. This maintains the internal humidity within about 2% of the surroundings. Internal conditions can be inspected via the menu system.

When measurement conditions are thought to be critical it is recommended:

- 1) that when measurements can be expected to be completed within a battery charge operating time (about 4 hours):
  - a) batteries are checked to be well charged before starting measurements
  - b) the instrument is disconnected from the external mains power supply unit at completion of charging
  - c) measurements are made with the instrument operating only from its batteries and not started until at least an hour after recharging of the batteries
- 2) that when measurements are likely to take longer than a battery charge time:
  - a) batteries are charged to completion at least an hour before starting measurements
  - b) the instrument remains connected to the external power supply at completion of charging and throughout the period of measurements

The batteries are protected by an internal 1A fuse. There should be no reason for this to fail. If it becomes clear that the batteries are not charging, after being connected to the external mains 18V power supply for a time, then this indicates some significant internal fault. If the instrument continues to operate satisfactorily with the external supply then it can continue to be used in this mode, otherwise it needs to be returned to JCI for servicing.

It is recommended that the batteries should not be left in a fully run down and uncharged state for long periods. This is likely to reduce battery life.

## **10. SAFETY**

### **10.1 Introduction**

The JCI 155v5 Charge Decay Test Unit has been designed and built to provide full safety for the operator. Safety in instrument operation concerns 3 aspects:

- mains power supply
- high voltage power supply
- mechanical aspects

### **10.2 External mains power supply**

Battery recharging and long term instrument operation use an external mains switched mode power supply providing 18V 15W via a 2.5mm d.c. connector. The mains supply to the external switched mode power unit should be suitably fused and take account of initial pulse surges at switch on. The JCI 155v5 is not directly linked to power supply earth via the d.c. connector, so separate earth bonding should be made via the combination Durable Dot/4mm bayonet pin connector on the instrument back plate.

### **10.3 High voltage power supply**

The high voltage power supply can be set to provide voltages up to 10kV. The supply circuitry is totally contained within the case of the JCI 155v5. Connection to the cluster of corona discharge points on the moveable plate is via a 10M high voltage resistor that limits the maximum current available to below 1mA. Access to touch the corona discharge points is only available when the moveable plate is in the forward position. In normal, default, operation the high voltage is only applied to the discharge points for 20ms.

If the instrument were used in such a way as to charge the body of a person while isolated from earth then the highest body voltage that could be achieved would be rather under 10kV. The worst shock that could be experienced would be by touching earth at this body voltage. This will give a definite feeling of shock – but less than frequently experienced on getting out of a car and touching the car bodywork, and is no risk to life.

### **10.4 Mechanical aspects**

The only mechanical feature of the JCI 155v5 relevant to safety is the possibility of trapping a finger by the air dam on the moveable plate. When the plate is advanced any obstruction, such as a finger, will stall the drive motor and after several seconds the plate will be retracted. There is no way to prevent nipping a finger by the return of the air dam if the finger is put into the test aperture behind the air dam while the plate is advanced. Internal springs will give a nipping force around 1kg when the plate flips back. To avoid such risks no fingers, or other material, should be allowed to enter the test aperture while the instrument is switched on.



## **11. RoHS and WEEE Directives**

JCI electrostatic measuring instruments are not required to conform to the RoHS Directive because they come within Category 9 exemption.

To comply with the requirements of the EC WEEE (Waste Electrical & Electronic Equipment) Directive all JCI instruments at the end of their useful life should be returned to JCI so they can be disposed of or recycled in an environmentally appropriate manner. JCI WEEE registration number is: WEE/GA0697TX.



## 12. CHECKING INSTRUMENT OPERATIONAL PERFORMANCE

### 12.1 Introduction

There are four basic steps in setting up instrument operation.

- a) Adjusting the internal fieldmeter offset
- b) Checking alignment of phase sensitive detection
- c) Checking and possibly adjusting charge compensation
- d) Checking and possibly adjusting surface voltage sensitivity

The first two steps are not likely to be needed by normal users as they should remain as set in instrument manufacture. The later two may be carried out at any time to check, and if necessary adjust, instrument performance.

The above actions are best carried out in conjunction with a special function control menu that can be accessed shortly after instrument power on. A short time after the 'Power on' key has been pressed the 'Revert' key is illuminated for a couple of seconds. If this is pressed while it is illuminated then the following control menu is shown and normal instrument start-up is bypassed.

On	On	In	Vs :
Sig	Mll	Plt	xxxx_V

Below this menu 3 Keys are illuminated below the 'Sig' (signal), below the 'Mll' ('field mill' fieldmeter motor) and below the 'Plt' (plate) legends. These keys provide independent opportunity to link/break the signal from the front end of the fieldmeter to the back end circuits, to turn the fieldmeter motor on and off and to advance or retreat the plate carrying the corona discharge points. Pressing the keys will toggle the corresponding functions On/Off for the signal link, On/Off for the fieldmeter motor and In/Out for the moving plate. The function control menu is exited by pressing the 'Revert' key.

If working with fibrous materials or with fine powders, it may be necessary, to clean the fieldmeter from time to time. The fieldmeter module may be removed and replaced through the test aperture.

Access to the potentiometers to set charge compensation and sensitivity of the fieldmeter can be gained through the test aperture and the two cutouts at the front of the fieldmeter mounting plate on either side of the gold plated fieldmeter housing. Charge compensation is set via the hole on the side of the instrument towards the corona polarity setting rotary switch and the sensitivity via the hole on the side away from the corona polarity setting.

### 12.2 Removal of instrument covers – if necessary

Unscrew the two M3x8 screws at either side of the back cover of the instrument (mounting the IEC mains connector) and ease off the back cover. It may be helpful to tap the front of each side with the finger in the recess region of the side extrusions.

Unscrew the two M3x8 screws at either side of the front cover of the instrument. Leave the front cover in place and ease back the two side extrusions of the compression pins in the front cover. The top cover can now be lifted off and out of the groove in the front cover.

If necessary the front end cover plate can be removed by unscrewing the two M2x5 screws holding the cover at the front end of the baseplate.

### 12.3 Checking and adjusting the internal fieldmeter offset

Press the 'Power on' key. After a few seconds the 'Revert' key is illuminated. Press this immediately to enter the function control menu. This menu provides opportunity to manually control running of the fieldmeter motor, linkage of the fieldmeter front end circuits to the main fieldmeter signal processing circuits and advance and retraction of the moving plate.

When the 'Sig' key is toggled 'Off' and the 'Mll' is 'On' the surface voltage, Vs, reading

at the right hand side of the display should show a value close to zero, and preferably below  $\pm 0.5V$ . If the reading is outside this range then the instrument top cover and front end plate need to be removed (as 10.2 above) and adjustment made to the forward facing potentiometer (RV5) second in from the right hand edge of the main circuit board, looking down on to the top of the instrument.

If the above offset reading is larger than a few volts operation of the fieldmeter is inhibited in the normal start up sequence. This means the fieldmeter motor does not start and the fieldmeter cannot be 'zeroed' as normal.

#### **12.4 Checking and adjusting alignment of phase sensitive detection**

Adjustment of the alignment of the fieldmeter sensing aperture plate is normally only necessary during instrument set-up in manufacture or if it has been necessary to take the fieldmeter fully apart. If it is found that the sensitivity of the fieldmeter has become significantly reduced, then it may be sensible to check this alignment.

The instrument top cover (but not necessarily the front end plate) needs to be removed (as 10.2 above). Rest the instrument on its side so there is access to the test aperture and opportunity to read the display.

Press the 'Power on' key and when the 'Revert' key is illuminated after a few seconds press this to enter the function control menu.

There is a row of three test connection holes on the top right hand side of the main PCB – about 45mm back from the front edge and 30mm in from the right hand edge. An oscilloscope probe needs to be used to examine the form of signals at these test points. The left hand test point is the most sensitive.

The signal pattern observed on the test points should be symmetrical half cycle sinewaves of the same polarity as the potential of a charged surface brought up to the test aperture. If the pattern is not symmetrical then it is necessary to loosen the five M1.6 screws nipping the sensing aperture plate. With these screws loosened, turn off the fieldmeter motor via 'MII' in the function control menu. Rotate the aperture plate a little, turn the fieldmeter back on and re-examine the signal pattern. When a symmetrical pattern is established lightly tighten the M1.6 screws and re-check the pattern before fully tightening the screws.

#### **12.5 Checking charge compensation**

The surface voltage reading when looking at a fairly conducting earthed surface should be independent of the presence of charge on the rotating chopper. The procedure to check and set the compensation is as follows:

- With the fieldmeter signal connected through, 'Sig' on, and the fieldmeter motor turned off, 'MII' off, (via the function control menu), carefully earth the chopper to the front aperture of the fieldmeter through the instrument sensing aperture using a small section clean metal rod (for example a small clean screwdriver)
- Turn the fieldmeter on by pressing the 'MII' key to 'on' in the function control menu
- Support the instrument on its side so that the sensing aperture of the fieldmeter can be seen through the test aperture. Note the surface voltage reading.
- Turn the fieldmeter motor off, 'MII' off, via the function control menu, while leaving all circuits fully active ('Sig' on).
- allow the rotating chopper to come to a stop.
- Apply charge to the chopper – for example by touching the rotor with the end of a lead to a 9V PP3 battery with the other pole earthed to the instrument. (A voltage above 20V is not suitable).
- switch on the fieldmeter motor, 'MII' on, via the function control menu. Note the surface voltage reading after a few moments operation. If this differs from the initial reading at start up after the rotor was earthed then adjust the multiturn potentiometer accessible

through the test aperture and the hole in the fieldmeter mounting plate on the side near the corona polarity selection switch. Adjust the potentiometer to give a reading close to the reading after the chopper was earthed.

- switch off the fieldmeter motor via the function control menu and allow the rotating chopper to come to a stop.
- carefully earth the chopper to the front aperture of the fieldmeter
- the above sequence may need to be repeated a few times to achieve full independence of reading from charge on the rotor. The readings with and without charge on the rotor should match within about a volt.
- finally, turn off the instrument (after exiting the function control menu system using the Revert key) and restart instrument operation. The surface voltage shown while in the 'Ready to run' state should be close to zero – with a volt or so.

## 12.6 Checking sensitivity for surface voltage measurement

The fieldmeter is carefully set up and calibrated during manufacture. No adjustments should be attempted unless suitable instruments and facilities are available. The following notes describe appropriate set up and calibration procedures.

The fieldmeter is most simply checked and calibrated in position in the Charge Decay Test Unit in terms of a uniform potential across a surface covering the whole area of the test aperture and just below ( $\frac{1}{2}$  mm) the plane of the test area aperture. Surface voltage measurements are shown on the instrument display while the instrument is in the 'Ready to run' state. The sensitivity is best set with a voltage of 1000V applied to this plate. Adjustment of sensitivity is by the potentiometer accessible through the instrument test aperture on the side away from the corona polarity selection switch.

There is interaction between adjustment of sensitivity and adjustment of compensation and it is important that compensation is set first.

Procedures for formal calibration are described in British Standard BS 7506: Part 2: 1996 [7].

## 12.7 Cleaning and resetting fieldmeter operation

Noisy and variable surface voltage values shown while the instrument is in the 'Ready to run' state indicate that the inside of the fieldmeter sensing region is probably contaminated - for example by insulating particles or fibres. In this situation it is necessary to take out the fieldmeter module, partially dismantle the sensing system, clean it, reassemble and then reset operation - including setting charge compensation and sensitivity as above.

The fieldmeter sensing section can be taken out through the test aperture by unscrewing the 3 M2x16 screws around the edge of the gold plated body outside the sectored sensing aperture. It is important NOT to disturb the 5 M1.6 screws in a ring nearer the sensing aperture. With the 3 M2 screws removed the cylindrical brass body can be carefully pulled out - with care to pull it straight down and not at an angle. Removal of the 3 M1.6 screws around the edge of the PCB holding the motor will allow the motor and rotor assembly to be removed from the cylindrical body. The chopper assembly and the inside of the cylindrical housing can now be inspected in good side illumination for the presence of any dust, contamination or fibres and this removed. It may also be useful to sluice out the sensing region and the rotor assembly with a brief spray of aerosol solvent.

The sensor assembly should be reassembled with care taken to ensure the original angular alignment is maintained of the PCB to the housing. When the sensor assembly is remounted through the JCI 155 test aperture care is needed to ensure that both sets of 3 contacts align and mate correctly with the corresponding sockets mounted on the main circuit board within the body of the JCI 155. Secure the fieldmeter sensor unit with the 3 M2x16 screws.

Switch on the instrument and check a) the fieldmeter motor rotates, and b) the fieldmeter

is sensitive to nearby charge. Before using the JCI 155 the charge compensation should be checked as in 12.5. It may also be useful to check the sensitivity of the fieldmeter, if suitable facilities are available (as in 12.6). If the problem persists it may well be best to return the instrument to JCI.

If significant errors are noticed when checking charge compensation it will be wise to check if the rotor is loose on the motor shaft by lightly pulling it. If it is loose then it is necessary to pull it as clear towards the end of the shaft as is easy, to put a small drop of anaerobic glue on to the shaft and then carefully slide the rotor back until the front chopper is 0.7mm from the front of the sensing surface.

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## 14. SPECIFICATION FEATURES

<b>Controls:</b>	<ul style="list-style-type: none"><li>- 'Power on' key at lower right hand corner of instrument top cover.</li><li>- 8 push buttons: left, right and below liquid crystal display, with LED illumination to show those available for active use. The four push buttons below the LCD are concerned with selection of result information and with selection and editing of setting values. The two push buttons on the left of the LCD are concerned with selection of data and settings for display. The two on the right hand of the LCD are concerned with initiation of test runs and with reverting to previously displayed or set values.</li><li>- corona voltage polarity change-over rotary switch</li><li>- microcomputer reset via 1mm hole at top right of backplate</li></ul>
<b>Displays:</b>	<ul style="list-style-type: none"><li>- liquid crystal display with two rows of 24 character (150x25mm)</li><li>- red LED indication of connection to external mains power supply unit</li><li>- green LED indication that batteries are in 'fast charge' mode</li><li>- red LED indication while corona charging is active</li></ul>
<b>Test area:</b>	<ul style="list-style-type: none"><li>- 45x54mm aperture in instrument baseplate</li></ul>
<b>Sample:</b>	<ul style="list-style-type: none"><li>- the unit may be placed directly on a surface or area of sample.</li><li>- the JCI 166 Sample Support Unit provides a simple support for open and earthed backing tests</li><li>- the JCI 176 Charge Measuring Sample Support provides open and earthed backing support for film and layer samples up to 5mm thick with measurement of the corona charge received by the sample surface</li><li>- powders and liquids may be studied by placing in an earthed cup (e.g. JCI 170)</li></ul>
<b>Fieldmeter:</b>	<ul style="list-style-type: none"><li>- fast response proprietary 'field mill' fieldmeter measures surface voltage with response time less than 10ms.</li><li>- surface voltage display automatically adjusts between V and kV of surface potential.</li><li>- automatic zero setting by software with plate advanced at start of each test. Zero stable within <math>\pm 5V</math> over long duration runs. Noise on displayed and stored values within <math>\pm 2V</math>.</li></ul>
<b>Operating times:</b>	<ul style="list-style-type: none"><li>- about 2 seconds to 'set for charging',</li><li>- 20ms 'Fast' opening. About 2s 'Slow opening' for measurements on light powders.</li></ul>
<b>HV supply:</b>	<ul style="list-style-type: none"><li>- internal feedback stabilised high voltage supply providing positive and negative potentials of 0kV (corona off) and from 2kV to 10kV.</li><li>- 10 Megohm personnel safety resistor is used in the link to the corona discharge points.</li><li>- direct measurement by software of corona voltage and current</li></ul>
<b>Surface voltage:</b>	<ul style="list-style-type: none"><li>- from below 50V to about 3kV, depending on rate of charge dissipation</li></ul>
<b>Timing range:</b>	<ul style="list-style-type: none"><li>- decay times from about 50ms to over 1,000,000 seconds.</li></ul>
<b>Operation:</b>	<ul style="list-style-type: none"><li>- direct operation by integral 600mAh nickel metal hydride (NiMH) rechargeable batteries providing over 6 hours continuous operation. Automatic shut down with data saving by software with display warning as LO BATT condition approached.</li><li>- operation is continuous when JCI 155v5 is connected to the mains supply (115V/ 240V 6VA 60/50Hz). Mains supply connection indicated by red LED.</li></ul>
<b>Battery charging:</b>	<ul style="list-style-type: none"><li>- the NiMH batteries (600mAh) are Smart recharged whenever the JCI 155 is connected to external mains power supply unit (18V 15W). Charging time is about 2 hours. Green LED indication of fast recharge operation</li></ul>
<b>Connections:</b>	<ul style="list-style-type: none"><li>- external mains power supply input via 2.5mm d.c. connector (centre positive).</li><li>- 8w mini DIN connector for linking to JCI 176 for sample charge measurement</li><li>- 6w mini DIN connector for linking to external operational control and indication</li><li>- 8w mini DIN for RS232 serial data communications</li><li>- combined Durable Dot and 4mm bayonet earth bonding point.</li></ul>

<b>Software:</b>	<ul style="list-style-type: none"><li>- proprietary software in ROM for operation of integral TDS2020 microcomputer for control of instrument operation , for setting operational parameters and for recording and analysis of charge decay curve data. Observations stored to PCMCIA memory card or to CompactFlash memory card in PCMCIA adaptor.</li><li>- Windows 95/98 &amp; 2000 compatible software, JCI-Graph v2.1, for transfer and extraction of data from memory card and for display and analysis of instrument observations.</li></ul>
<b>Data storage:</b>	Type II PCMCIA (ATA) removable memory card. 16M CompactFlash memory card in PCMCIA card adaptor supplied
<b>Dimensions:</b>	- 173x216x67 mm about 2½ kg
<b>Packaging:</b>	- in carrying case with external switched mode power supply unit, IEC mains cable, 8w mini DIN-9w D serial communications cable, 8w - 8w mini DIN cable for linking to JCI 176, JCI-Graph software disc, user manuals

## **Annex 1: Key functions**

### A1.1 Introduction

There are a total of 9 keys on the top cover of the instrument. Apart from the 'Power on' key only those illuminated will give any action.

The 8 main keys cover the three main modes of operation of the instrument: 'Ready to run', 'Running and ready to save' and 'Review'. In the 'Ready to run' mode a test run may be started, test conditions may be inspected and many of the test conditions may be edited or default values selected. In the 'Running and ready to save' mode charge decay observations are in progress and are being stored in the microprocessor memory. If a run is stopped these stored results may be recorded to the memory card.

The function of each key is described in the following sections:

### A1.2 Power on

Instrument operation will start when this key is pressed. This key is not normally illuminated.

When the battery charge reaches a low state this key will start to flash. At this point a few minutes of operation remain, after which the software will arrange to save all data and turn the instrument off in a controlled manner. If a mains supply is connected while the 'Power on' key is flashing then the key flashing will cease and normal instrument operation will continue. The battery will be Smart recharged.

### A1.3 Run

Pressing the red 'Run' key by itself, when it is illuminated, will start a new test. If there is unsaved data available this will be saved to the memory card before the new run starts. When ready for a new run a new run number is shown in the top left of the display.

In 'Ready to save' mode, pressing the 'Run' key with the 'Data' key used as a shift key (Data + Run), while both are illuminated, will cause any available data to be saved to the memory card. The mode will then change to 'Ready to run'.

*This is useful to store data at the end of a run before the instrument or sample are moved in preparation for a new run. This is because observations are upset by movement of the instrument or sample.*

### A1.4 Revert

Functions of the Revert key used by itself are:

- a) to revert to the initial peak result (at  $t = 0.0\text{ms}$ ) when in the 'Run display' mode
- b) to select in sequence available 'Default'/'New'/'As set' values of an individual setting selected within a group of settings displayed in the menu mode.
- c) to select in sequence available 'Default'/'New'/'As set' values for a group of settings displayed in the menu mode.

Functions of the Revert key used in combinations with the 'Setting' key (Setting + Revert)

- a) in 'Menu mode', 'Setting' + 'Revert' keys will deselect a group of settings, thus returning to the mode 'Ready to run', 'Ready to save' or 'Review' from which the menu was accessed. As each individual setting or group of

settings is deselected, the values displayed (which may have been altered) are saved with their appropriate status 'Default', 'As set' or 'New'.

Functions of the Revert key used in combinations with the 'Data' key (Data + Revert)

- a) 'Run display' mode changed to 'Ready to save' mode
- b) to escape from 'Review' mode to 'Ready to run' mode

#### A1.5 Right/Left arrow keys

Functions of the Right/Left arrow keys by themselves:

- a) In Menu mode when an individual setting is first selected within a group of settings displayed in the Menu mode, the Right/Left arrow keys select the first/last editable character of the displayed value. The selected character is identified by a flashing block cursor
- b) In Menu mode when a character has been selected by a) above then the Right/Left arrow keys select the next / previous editable character.

Functions of the Right/Left arrow keys in combination with the 'Setting' key ('Setting' + 'Right' / 'Setting' + 'Left'):

- a) In Menu mode when a group of settings in the menu has been selected 'Setting' + 'Right' / 'Setting' + 'Left' initially select the first / last individual setting within the group. The selected setting is shown bounded by cursor blocks.
- b) In Menu mode when an individual setting has been selected by a) above then 'Setting' + 'Right' / 'Setting' + 'Left' select the next / previous individual setting.

*Note that the values of an individual selected setting, that may have been changed, is saved along with its status ('Default'/'As set'/'New') when another setting is selected.*

Functions of the Right/Left arrow keys in combination with the 'Data' key ('Data' + 'Right' / 'Data' + 'Left'):

- a) When in the 'Ready to Run' mode, 'Data' + 'Right' / 'Data' + 'Left' enter 'Review mode and select initially the first / last Run data stored on the memory card
- b) When in the 'Review' mode, 'Data' + 'Right' / 'Data' + 'Left' select the next / previous Run data stored on the memory card

#### A1.6 Up/Down arrows

Functions of the Up/Down arrow keys by themselves:

- a) In Menu mode when an editable digit within an individual setting has been selected (as in A1.5 above) the Up / Down arrow keys increment/decrement the value of the setting by the unit value of that digit, within the allowable range for that setting
- b) |In Menu mode, when an individual character within an individual setting has been selected (as in A1.5 above), e.g. 'p', 'n', 'μ', ' ', 'k', 'M', etc), the Up/Down keys multiply / divide positive values of the setting by factors of 10. Negative values are divided / multiplied by factors of 10.
- c) In Menu mode when an individual setting has been selected, the Up/Down keys select the next / previous possibility of that setting

- d) In 'Ready to save' and 'Review' modes the Up / Down keys enter the 'Run display' mode at the first (peak) result / last result shown when previously in the 'Run display' mode.
- e) In 'Run display' mode the Up/Down keys move to the next / previous result.

Functions of the Up / Down arrow keys in combination with the 'Setting' key ('Setting' + 'Up' / 'Setting' + 'Down'):

- a) In 'Ready to run', 'Ready to save' and 'Review' modes, 'Setting' + 'Up' / 'Setting' + 'Down' enter the menu, causing the first / last group of setting to be displayed
- b) In Menu mode, 'Setting' + 'Up' / 'Setting' + 'Down' keys cause the display of the next / previous group of settings.

*Note that the values of a selected group of settings, that may have been changed, are saved along with their group status ('Default'/'As set'/'New') when another group of settings is selected.*

### A1.7 Setting

This key is use as a shift key in combination with the 'Up', 'Down', 'Left' and 'Right' arrow keys, and with the 'Revert' key

It is concerned with selecting settings for inspecting and editing test and analysis conditions. The available settings are presented in menus illustrated in Section 3.3 below. The range of values and their default settings are listed in Annex 2.

### A1.8 Data

This key is used as a shift key

- a) to save results while in the 'Ready to save' state used in combination with the 'Run' key (Data + Run). See A1.3 above.
- b) to find earlier test runs used in combination with the Left and Right arrow keys. See A1.5 above.



## Annex 2: Menus

### A2.1 Introduction

The Menu system consists of 9 groups of up to 3 operationally related settings. Access to groups and settings, and escape from the menus, is described in Annex A1.5 and A1.6 ('Setting' + 'Up/Down', 'Setting' + Right/Left, 'Setting' + Revert key combinations)

When settings can be edited, this is done as described in Annex 1, 1.5 and A1.6 (Right/Left and Up/Down keys). Relevant keys are illuminated when editing is available. Each menu group is shown in the following form:

Group name	Status
Value1 Value2 Value3	

Status applies to the whole group, 'Default', 'As set' or 'New'. The status may be selected using 'Revert' key – see Annex A1.4.

Individual settings may be selected for inspection or editing using the 'Setting' + Right/Left arrow keys – see Annex 1 A1.5. The selected setting is shown bounded by markers, its name replaces the group name, and the status shown applies to the individual setting:

Setting name	Status
■Value1■ Value2 Value3	

When an individual setting is editable, appropriate Arrow keys are available and are illuminated. If the value of the setting contains editable characters, one may be selected by Right/Left arrow keys – see Annex 1 A1.5. The selected character is identified by a flashing block cursor.

Setting name	Status
■Value1■ Value2 Value3	

↑

### A2.2 Corona setting (as set/default)

Corona	Setting	Default
9.00kV	20ms	On

The corona voltage may be set from 2 to 10kV with a display resolution of 10V. The actual voltage is generated with 40V steps over this range. The corona can be selected On/Off by editing the lower right hand end of the lower row. The polarity of the corona voltage applied is selected by the rotary switch at the top left hand corner of the instrument top cover.

*Note the minimum voltage setting is 2kV. Experience shows that voltages over about- 2.5kV are needed for generating corona discharges.*

The corona time may be set in increments of 10ms for times up to seconds. It is recommended that the duration is usually set at 20ms (the default value).

Editing of values is allowed only in the 'Ready to run' state. When an item has been selected and its value edited the new values may be set and preparation made for a run by pressing 'Setting' and 'Revert' twice. New values selected only become 'set' values once a run has been made – otherwise they remain as 'new' values.

### A2.3 Set End Limits

Set End Limits	Default
100s 36.8%	100 V

These limits are used to set the conditions at which a test run is considered as complete. The display will pause as each end point is reached but timing will continue in the background. These values may be edited when accessed from any mode.

### A2.4 Surface levels

Surface Levels	as set
+20.0 ° 50.0 % -0.50 V	

These measurements are made by sensors exposed to the atmospheric conditions in the test region of the JCI 155v5 instrument. They apply at the time at which the values were inspected. Fresh values are used at the time a run is started so they reflect the run start conditions. These values are recorded with the observations for each test run. Values cannot be edited.

*Note that temperature and humidity values measured within the instrument may be a bit different from those in the surrounding environment. Additional internal heating will occur during fast battery charging so critical measurements should be avoided at such times and for an hour or so after.*

### A2.5 Sample labels

Sample Labels	Default
0 # Unset	Unset

These numbers provide opportunity to attribute reference numbers to individual runs or groups of runs to identify a particular type of sample or treatment.

The second entry allows indication of whether the sample was tested with an open or an earthed backing. The third entry enables the area on a sample to be identified. Editing is only allowed in the 'Ready to run' state.

### A2.6 Plate setting

Plate Setting	Default
0ms Fast	0.0_s

#### *'Plate' release advance time:*

It is desirable to have minimum delay between the end of corona charge deposition and the start of surface voltage measurements.

In the latest instruments (serial numbers above 0307\*\*\*\*) when the moving plate advanced to its most forward position it is held on a small spring loaded latch. The latch release is triggered at the end of the corona period by impact of a small solenoid plunger. The delatching time is about 3ms. As the plate starts to move back it disconnects the high voltage supply. Total plate travel time from delatching to plate fully back is about 20ms.

In earlier JCI 155v5 instruments the moving plate was advanced by the snail cam to a stop just before the cliff edge of the cam. As it took about 30ms for the cam motor to start and

allow return of the spring loaded moving plate the tail end of the corona was delayed by the ‘pre-release’ time to get the end of corona as close as possible to the opening of the moving plate. A pre-release time of 0.030s was generally appropriate for these instruments.

Actual corona duration times can be obtained by inspection of detailed data records via JCI-Graph by making a .csv file of the data records. If the ‘Plate’ advance time is too large then the corona time will be less than expected.

#### *‘Fast’ plate movement:*

The ‘Fast’ plate movement option is appropriate for studies on most materials. The ‘Slow’ option is appropriate for studies on fine light powders that might be disturbed by air movement induced by rapid movement of the air dam on the moving plate.

#### *‘Plate’ hold time:*

The ‘Hold time’ may be useful with slow plate release to allow fine powders to settle after corona application before the plate is moved back.

### A2.7 Date and Time

Time	Default
22/01/01	12:00:00

These values may be edited only in the ‘Ready to run’ state. Editing will only be needed if the values displayed when the instrument is switched on do not match current date or time – for example for operation in a different time zone.

### A2.8 Ident.

Ident	Default
00000001	01010000

The first entry relates to the number of runs carried out. The second entry is the instrument serial number. Neither of these entries can be edited

### A2.9 Config. Setting

Config.	Setting	Default
	On	Off

Config.	Power	Default
■	On	Off

The instrument may be turned off using the left hand ‘On/off’ (as shown above). With the ‘On’ selected (as shown) release the Setting and left arrow key. Press the Up key. This will change ‘On’ to ‘Off’. Then press Setting + Revert twice – and the instrument will turn off.

The instrument will turn itself off after 2 minutes of inactivity while in the ‘Ready to run’ state. If this does not happen the instrument may be turned off by gently pushing a 1mm diameter rod into the small hole in the back plate of the instrument. This will reset the internal computer software and turn the instrument off.

Config.	Remote	Default
On	Off	

The second entry is concerned with remote operation of the instrument either in conjunction with a manual push button unit or with a sample changer unit. (*Note:* this facility is not yet available)

- Remote Off is used for normal, manual operation
- Remote Master is for use with an external manual control unit, e.g. to control an instrument whose panel buttons are inaccessible to the operator.
- Remote Slave is for use with an automatic sample changer which feeds a new sample for each run
- Remote Auto is for use with a remote sample changer, where the completion of a run initiates a sample change, which in turn initiates a run, until the sample supply runs out.

The 'Remote' is set according to whether instrument operation is controlled manually, when the remote controller is treated as the master, or is operating in conjunction when the with a sample changer when the remote operates in slave or auto mode to the instrument.

#### A2.10 Analysis setting (This feature is not yet available)

Analysis Setting	Default
-5.0%	

#### A2.11 Menu parameters

Parameter	Minimum	Maximum	Default
Corona voltage (V)	0	10000	9000
Corona time (s)	0.010	100	0.020
Run end voltage (V)	5	10000	100
Run end time (s)	1	33554431	100
Run end %	5	99	36.8
Deg C			
Relative humidity (%RH)			
Surface voltage (V)			
Sample #	0	999	0
Sample backing – Unset/Open/Earth	Unset	Earth	Unset
Sample area – Unset/Old/New	Unset	New	Unset
Plate pre-release (s)	0.0	0.050	0.000s
Plate speed – Fast/Slow	Slow	Fast	Fast
Plate hold time (s)	0	10s	0
Date			
Time			
Run #	0	99999999	
Serial #			
Power on/off	Off	On	On
Remote stop	Go only	Go stop	Go only
Analysis % step	50%	1%	5%

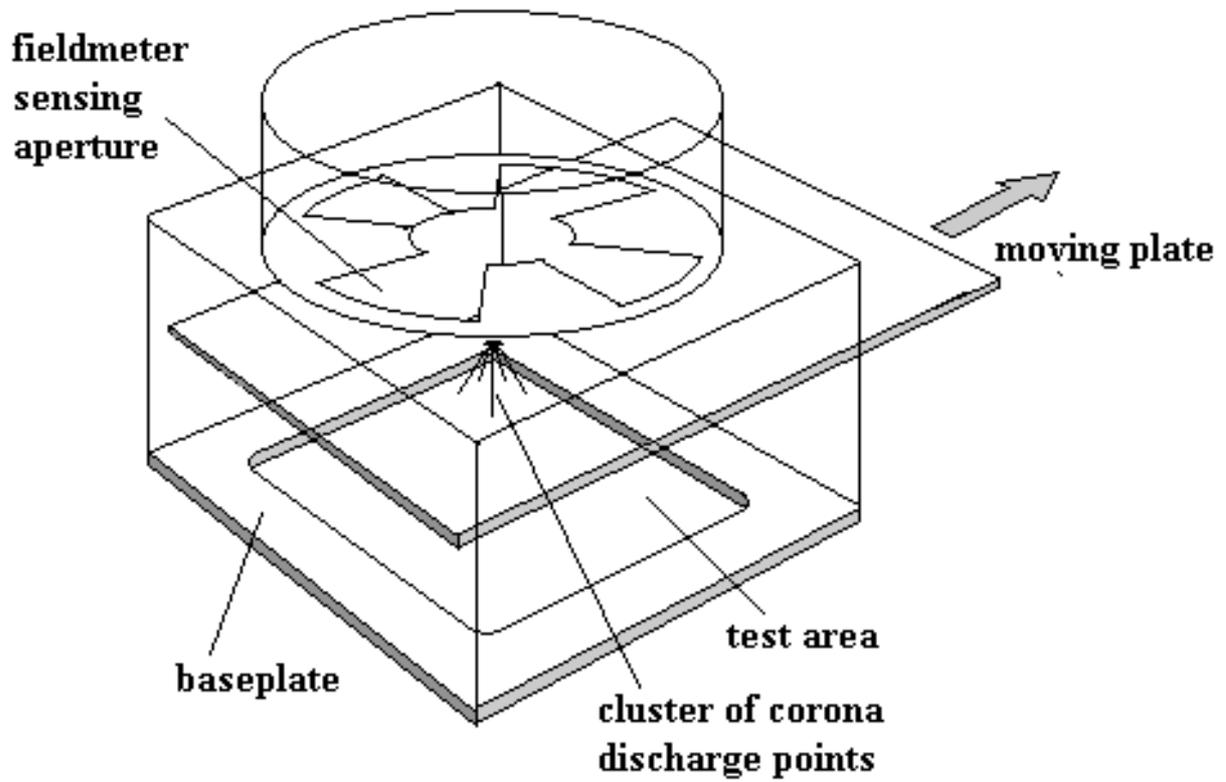


Figure 1: General arrangement for charge decay measurements



Figure 2: View of JCI 155v5 Charge Decay Test Unit

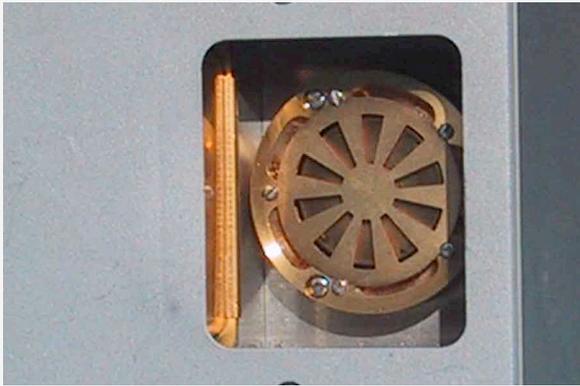
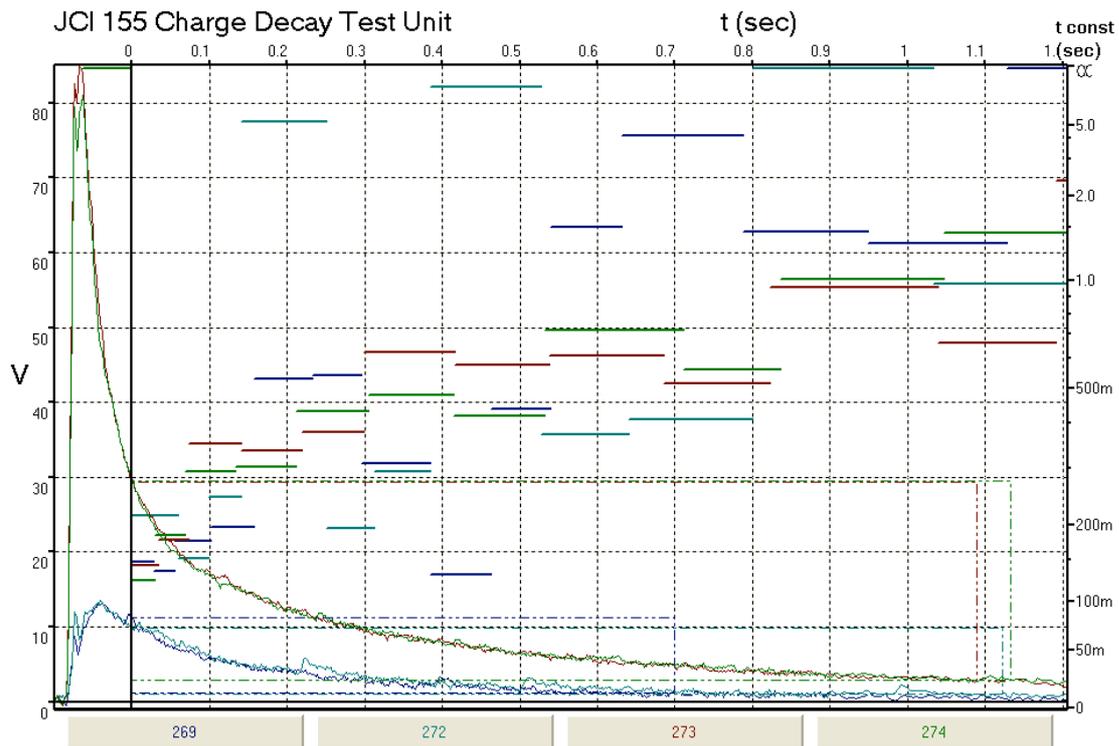


Figure 3: View through test aperture in baseplate of JCI 155v5 showing fieldmeter



Figure 4: JCI 155v5 mounted on JCI 176 Charge Measuring Sample Support

Figure 5: Example of charge decay results



1 : MyDocuments\JCI-Graph Data\04092193\2004-10-14\00000269.jc5

Copy paper  
 Serial: 04092193, run: 00000269  
 Date: 14.10.2004 at 14:35:31  
 Corona (Voltage): -3000  
 Corona (Time): 0.01  
 Surface (Temp. °C): 22.78  
 Surface (% R.H.): 58.56  
 Pretest (Voltage): 0.45  
 Peak at 13.06 volts  
 Analysis start 0.1 secs after charging  
 at 11.253 volts  
 1/e reached after 0.19785 sec  
 10% reached after 0.6998 sec  
 Received charge = 1.05673 nC  
 Capacitance loading = 34.7462

3 : MyDocuments\JCI-Graph Data\04092193\2004-10-14\00000273.jc5

Copy paper  
 Serial: 04092193, run: 00000273  
 Date: 14.10.2004 at 14:39:22  
 Corona (Voltage): -10000  
 Corona (Time): 0.01  
 Surface (Temp. °C): 22.8  
 Surface (% R.H.): 58.38  
 Pretest (Voltage): 0.89  
 Peak at 83.99 volts  
 Analysis start 0.1 secs after charging  
 at 29.406 volts  
 1/e reached after 0.25254 sec  
 10% reached after 1.0895 sec  
 Received charge = 150.218 nC  
 Capacitance loading = 768.006

2 : MyDocuments\JCI-Graph Data\04092193\2004-10-14\00000272.jc5

Copy paper  
 Serial: 04092193, run: 00000272  
 Date: 14.10.2004 at 14:37:15  
 Corona (Voltage): -3000  
 Corona (Time): 0.01  
 Surface (Temp. °C): 22.8  
 Surface (% R.H.): 58.35  
 Pretest (Voltage): 0.81  
 Peak at 13.273 volts  
 Analysis start 0.1 secs after charging  
 at 9.9037 volts  
 1/e reached after 0.28965 sec  
 10% reached after 1.1227 sec  
 Received charge = 1.14171 nC  
 Capacitance loading = 36.9372

4 : MyDocuments\JCI-Graph Data\04092193\2004-10-14\00000274.jc5

Copy paper  
 Serial: 04092193, run: 00000274  
 Date: 14.10.2004 at 14:40:06  
 Corona (Voltage): -10000  
 Corona (Time): 0.01  
 Surface (Temp. °C): 22.8  
 Surface (% R.H.): 58.08  
 Pretest (Voltage): 0.45  
 Peak at 79.846 volts  
 Analysis start 0.1 secs after charging  
 at 29.578 volts  
 1/e reached after 0.25645 sec  
 10% reached after 1.1324 sec  
 Received charge = 149.583 nC  
 Capacitance loading = 804.457

**Summary of decay observations made by a JCI155v5 instrument**

Factors used in charge and capacitance loading formulae

Induction charge factor 2.2  
 Voltage sensitivity factor 0.73  
 Capacitance loading factor 1.7

Formula for Q(nC) #####  
 Formula for CL #DIV/0!

C:\Documents and Settings\John Chubb\My Documents\JCI-Graph Data\04092193\2004-10-14

Run	Description	Time	Vc	tc(s)	V start	t to 1/e	t to %	%	Q(nC)	CL	T(C)	RH (%)	Serial	Date	CondQ (nC)	IndQ (nC)	Pre (V)	Vpk	t delay (s)
269	Copy paper	14:35:31	-3000	0.01	11.3	0.198	0.700	10	1.1	34.7	22.8	58.6	4092193	14.10.2004	1.057		0.45	13.1	0.1
272	Copy paper	14:37:15	-3000	0.01	9.9	0.290	1.123	10	1.1	36.9	22.8	58.4	4092193	14.10.2004	1.139	0.001	0.81	13.3	0.1
273	Copy paper	14:39:22	-10000	0.01	29.4	0.253	1.089	10	150.2	768.0	22.8	58.4	4092193	14.10.2004	150.128	0.041	0.89	84.0	0.1
274	Copy paper	14:40:06	-10000	0.01	29.6	0.256	1.132	10	149.6	804.5	22.8	58.1	4092193	14.10.2004	149.495	0.040	0.45	79.8	0.1