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USER MANUAL:
JCI 131 Electrostatic Fieldmeter

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CE CONFORMANCE

John Chubb, proprietor of John Chubb Instrumentation of Unit 30, Lansdown Industrial Estate, Gloucester Road, Cheltenham, GL5l 8PL, declares as designer and manufacturer, that the JCI 131 electrostatic fieldmeter conforms to the requirements of the EC Directive on Electromagnetic Compatibility (EMC) 89/33/EEC to Standards EN 50081-1:1992 and EN 50082-1:1992. This instrument also conforms to the requirements of the Electrical Equipment (Safety) Regulations 1994 (SDI. 1994/3260),

Signed for and on behalf of
John Chubb Instrumentation Ltd

John Chubb

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 either be returned to JCI or otherwise disposed of or recycled in an environmentally appropriate manner.

USER MANUAL: JCI 131 Electrostatic Fieldmeter

for precise, high resolution, continuous measurement of electric fields in adverse environmental conditions

1. INTRODUCTION

The JCI 131 Electrostatic Fieldmeter is a compact and robust instrument for continuous long term measurement of electric fields in adverse environmental conditions. It is particularly suitable for continuous monitoring of atmospheric electric field conditions - for example those associated with varying weather conditions and thunderstorm and volcano activity.

The design of the JCI 131 is based on the proprietary approach that has been developed for 'field mill' type fieldmeters that do not require earthing of the rotating chopper [1,2]. The overall form of the JCI 131 and its internal structure are shown in Figures 1 and 2.

The output signal is proportional to the electric field. Signal output is 2.0V for electric field values at the sensing aperture of 2, 20, 200 or 2000kV m^{-1}. Measurements are to high precision (better than 1%) with low noise (around 1V m^{-1}) and with a stable zero. The sensitivity is calibrated according to the procedure in British Standard BS 7506: Part 2: 1996 [3,4]. When the fieldmeter is used as a potential probe, well away from nearby structures, the full scale readings of the 4 ranges of sensitivity are equivalent to local space potentials of 200, 2000, 20,000 and 200,000V full scale. This means that when the fieldmeter is used, for example, for atmospheric electric field measurements mounted 2m above ground level at the top of a vertical mounting pole (for example a JCI 137) and connected to earth these sensitivities correspond to ranges of atmospheric electric field of 0.1, 1, 10 and 100kV m^{-1} for 2V output. In this arrangement the JCI 131 can form a major component of a system for the advance warning of lightning activity [5].

The fieldmeter circuit includes facilities for automatic selection of sensitivity range and the range selected is available externally as 2 logic level signals. A step down of sensitivity is made at a signal level close to the full scale output of 2.0V, and a step up in sensitivity at an output level around 0.15V. The internal sensitivity selection can be over-ridden remotely by setting the range signaling lines high or low (5V or 0V). The zero reading can be adjusted remotely by applying a regulated positive or negative signal. Setting the zero requires that the sensing aperture of the fieldmeter is placed into a large clean metal zero check chamber – preferably gold plated (for example a JCI 152).

Measurement of quasi-continuous electric fields has been made immune to mains frequency (50/60Hz) electric fields up to x10 full scale of the d.c. field operating range. If this is exceeded the operating range will auto-change down to the next less sensitive range. This ensures reliable measurements even in the presence of large mains frequency fields. This is relevant when, for example, making measurements of atmospheric electric fields near or under high voltage power lines.

A fast response version of the JCI 131 is available for investigations where it is necessary to measure mains frequency alternating electric fields in combination with quasi-continuous electric fields. This is relevant for measurements of atmospheric electric fields near high voltage power lines. The fast response version has a flat frequency response to about 70Hz. Separation of the alternating and quasi-continuous signal components is available using the JCI 234 Base Unit.

An optional facility to ensure full confidence of measurements during long term continuous operation of fieldmeters in adverse environmental conditions is 'operational health monitoring'. The present facility, JCI 133, is a development of that for the JCI 501 Lightning Warning System [5]. The facility involves an additional circuit board within the JCI 131 (for which there is space provided) and a shield unit around the outside of the fieldmeter.

The JCI 131 head unit can be operated directly from a single supply of 10-36V and about 1A capability. Running current is about 400mA. The JCI 134 Base Unit (and the JCI 234) provides for operation from 100-240V 50/60Hz mains supplies or from a12V battery supply. The arrangement enables a 12V battery to be used as battery back up in the event of mains supply interruption. The JCI 134 and JCI 234 display fieldmeter readings. When the operational health facility is fitted then the operational health drive signal and the operational health signal can also be displayed. Fieldmeter observations are presented both as direct values of electric field as measured and interpreted as atmospheric electric field values when the fieldmeter is mounted, for example, on a pole.

Analogue output signals are provided from the JCI 131, and also via a JCI 134 or JCI 234, so observations may be recorded for analysis and re-display using computer based signal processing systems. A convenient approach is the Picoscope attachment that turns a PC into a digital storage oscilloscope (www.picotech.com). That is Windows compatible (up to XP)

2. PRACTICAL DESIGN FEATURES

The JCI 131 is based on a proprietary JCI design of 'field mill' electrostatic fieldmeter which does not need earthing of the rotating chopper [1,2]. This design, together with use of an electronically commutated drive motor, is appropriate for long term continuous measurement of electric fields.

Immunity to adverse environmental conditions is achieved using large gaps from the sensing surfaces to other nearby surfaces (7mm to nearby stationary surfaces), long insulation surface tracking paths and a sealed region for the signal processing circuit board [5]. The large gaps and long tracking paths can be seen in the photographs in Figures 1 and 2. The large gaps avoid risks of water bridging.

Low noise and good reading and zero stability are achieved by gold plating all the rotating chopper assembly and sensing surfaces and all surfaces of the sensing region. For best performance the fieldmeter casing is also gold plated. Gold plating helps avoid electrochemical potential differences between surfaces and ensures that when surfaces are cleaned they return to well defined surface conditions. The large gaps between the rotating chopper and sensing surfaces also minimise the influence of any surface contamination during operation.

Operation is immune to the presence of ionized air up to the point at which the rotor assembly becomes charged above some 20V or so. Immunity is achieved because signals from ionization currents are in quadrature to electric field signals and so are removed by phase sensitive detection.

The response for the standard JCI 131 is -3dB at about 3Hz. Response is immune to operation in 50/60Hz alternating fields up to the x10 maximum field of the d.c. operating range of sensitivity. For the fast reponse version the frequncy response is flat up to about 70Hz.

High measurement precision is achieved by using rigid structures for the sensing surfaces and for the rotating chopper assembly. The sensing surfaces and chopper parts are electrochemically machined hard brass and gold plated. The rotating chopper assembly is mounted on the motor shaft with an alumina insulator and the electronically commutated motor is free of end float. The motor shaft is well shielded to minimise risk of capacitive coupling from motor commutation signals. With the large gaps between chopping and sensing surfaces, to avoid water bridging (as shown in Figure 2), a rather large instrument diameter is needed to provide good signal modulation and achieve good signal to noise ratio at low signal levels [1].

The electronically commutated motor provides a once per revolution logic output signal. This signal is used in conjunction with digital multiplication and a phase lock loop circuit to provide the signals needed both for motor speed stabilisation and for phase sensitive detection of the sensing surfaces signals. This arrangement includes opportunity to generate the phase related operational health signal and its phase sensitive detection. The basic chopping frequency is set close to 275Hz. This frequency is chosen to be well away from harmonics of possible 50 or 60Hz mains power supply signals. For the fast response version the chopping frequency is 465Hz.

The standard sensing head unit includes two circuit boards, one for providing regulated power supplies the other for running the fieldmeter. Where operational health facilities are provided then an additional circuit board is fitted and a special back plate to provide connection to the operational health shield around the fieldmeter body. Where radio signal observations are made, as in the JCI 501 or JCI 503 lightning warning systems [5], a furtherr circuit board is included in the head unit. The special back plate also includes connections to link the radio circuits to the mounting pole so this can be used as the radio antenna when provided with bottom end insulation.

A major application of the JCI 131 fieldmeter is for monitoring atmospheric eletcric fields. A sketch of the arrangement of the fieldmeter on a suitable mounting pole (JCI 137) for such measurements is shown in Figure 3. A stainless steel tube of 47.5mm internal diameter and, for example, 2m long will provide a suitable mounting for the sensor unit. The JCI 137 is such a support pole with an earth mounting base and attachment ring for guy lines. The fieldmeter sensing head unit can be lifted off the top of the support tube and replaced without disturbing the support pole or the stabilising guy lines. The cable linking the fieldmeter to its power supply source and signal recording and display equipment passes up the inside of the mounting tube.

3. SPECIFICATION FEATURES:

Sensitivity ranges:	2, 20, 200 & 2000kV m^{-1} full scale output of 2V
Accuracy and linearity:	within 1% of operating range of sensitivity.
Zero stability:	within $\pm$50V m^{-1} over extended periods. within $\pm$5V m^{-1} over short periods
Zero noise:	below 5V m^{-1} pk-pk (5mV on Range 1)
Zero adjustment:	external adjustment by potentiometer from $\pm$1-2V regulated supply via zero adjust connection
Controls:	auto-ranging sensitivity external selection of range by holding range indicating signal lines low (earth) or high (+5V) relative to signal earth or cable sheath
Signal outputs:	2.0V for 2, 20, 200 or 2000kV m^{-1} FSD for ranges 1, 2, 3 & 4. 2 logic level indication of sensitivity range (0V or 5V LO/HI)
Mounting:	47.5mm diameter by 75 mm long plug on backplate of head unit provides mounting by socketing into 51mm diameter (1.6 mm wall) support tube. (Cable connector on axis within 39mm dia)
Operating environment:	0-40C, 0-100%RH including direct rain precipitation.
Power supply:	18-36V 1A capable power source. Running current about 400mA
Earthing:	via mounting of sensing head unit and/or cable braid
Dimensions:	102mm dia 250mm long. 3.5kg (170mm diameter with operational health shield fitted)
Calibration:	the sensitivity is set up in manufacture on the basis of measurements with accuracy traceable to National Standards. Option for formal Calibration to BS 7506: Part 2: 1996.

4. POWER SUPPLY REQUIREMENTS

The JCI 131 fieldmeter can be operated from a single supply of 18-36V about 1A capability. Running current is about 400mA at 20V. While the power supply may be floating relative to the earth connections of the instrument it is better for one side of the supply to be earthed to minimise noise pick up. The wide range of supply input makes it easier to work with long cables and less well defined supply sources. With long cables the voltage drop along the lines needs to be noted and it will be wiser to expect to operate from a voltage source supply nearer to 36V rather than 18V. A switched mode power supply unit inside the fieldmeter head unit generates the supply voltages needed for instrument operation.

5. CONNECTIONS

Power input and signal output connections are made via a sealed 19w Mil socket connector on the back of the fieldmeter (Pattern 105. Socket: AB05 210014-19SN00 Free plug: AB05 602714-19PN00). A suitable cable is DEF Stan 61-12 Part 4: 7/0.2 PVC insulated, overall braid screened, PVC sheathed type 7-2-20C. The following table lists both the connections at the 19w cable socket of the JCI 131 and connections at the 25w D type diagnostic port on the JCI 134 or JCI 234 Base Unit. It is advised that the power supply lines (C & D) are doubled up in the cable as shown to reduce resistive voltage drop in the cable and are not linked to the 0V earth lines (B) of the fieldmeter itself. The signals indicating and controlling the sensitivity range and external zero adjustment are relatve to instrument 0V - the black lead, connection B.

Cable feature	19w cable connector	25w D type diagnostic socket
Cable sheath & case	A green/yellow	
0V	B black	1
+ve power supply	C red & yellow/blue	2
- ve power supply	D blue & blue/white	3
Fieldmeter 0V	E green	4
Fieldmeter signal	F white	5
Range bit 0 (field x10)	G yellow	6
Range bit 1 (field x100)	H brown	7
Zero adjust	J violet	8
Field overrange	K orange	9
Noise signal	L pink	10
Noise x10	M turquoise	11
Health inhibit	N grey	12
Field health drive	P red/blue	13
Noise health	U green/red	14
Impulse signal	V yellow/red	15
Impulse x10	R white/red	16
Impulse health	S red/black	17
Field health signal	T red/brown	18
Field DVM		19
Field range +1		20
Field range -1		21

Fieldmeter operation will be satisfactory with cable lengths to at least 100m. The cable should include a shielding braid and this should be earth bonded at both ends. For good quality analogue signal observations over long cable lengths it will be wise to use a unity gain differential buffer amplifier between the fieldmeter signal 0V and the signal line at the signal processing end. This is included within the JCI 134 Base Unit.

6. SAFETY AND PROTECTION

Do not allow any articles, or fingers, to enter the sensing aperture - particularly when the chopper assembly is rotating.

Do not drop or hit the fieldmeter sensing head unit as this could damage the alumina sleeve insulator that mounts the rotor assembly on the motor shaft.

7. OPERATION IN FLAMMABLE ATMOSPHERES

The JCI 131 is not Certified as suitable for use in areas where flammable atmospheres are, or may be, present.

8. OPERATING ENVIRONMENTAL CONDITIONS

No specific tests have been made to find the allowable operating environmental conditions. An operating range is suggested of 0-40C and 20-100%RH including direct rain precipitation into the sensing aperture. There is no reason why the JCI 131 will not operate satisfactorily below 0C purely in terms of ambient temperature If there is a prospect of snow or freezing rain or of sub-zero temperatures after snow precipitation then it is recommended that the Sensor Unit is kept in continuous operation, and so kept warm, to avoid clogging operation of the rotating chopper assembly.

9. ZERO READING AND ADJUSTMENT

The zero reading of the JCI 131 is set internally at manufacture. This setting should remain stable over an extended period of operation. Provision is included in the external connections (pin J, violet) for a remote adjustment of the zero setting. The zero reading should be checked from time to time and particularly before any application where it is critical to measure low values of electric fields with accuracy. The zero reading is checked by placing a Zero Check Chamber (for example JCI 152) over the sensing aperture end of the instrument. This large clean metal chamber is electrically bonded to the case of the JCI 131 and has no surfaces closer to the sensing aperture than about 100mm. Because the JCI 131 is a high sensitivity instrument it is desirable the zero check chamber is gold plated to avoid the possible influence of electrochemical potentials on the chamber surfaces. All values measured with the JCI 131 are relative to the zero reading as set. Checking and any zero setting adjustment must be done with the JCI 131 fieldmeter operating on its most sensitive range.

When the JCI 131 is fitted with the operational health monitoring facility (JCI 133) the JCI 152 Zero Check Chamber is aligned over the health shield by the 3 studs in the top plate. The operational health facility needs to be turned off and the JCI 131 set to operate in its most sensitive range.

When the JCI 131 is used in conjunction with a JCI 134 or JCI 234 Base Unit a potentiometer is provided for remote adjustment of the zero setting.

If the zero reading becomes unstable, or noisy, or is appreciably different from zero then it is probably desirable to clean the instrument sensing region (see Section 10 below) and then recheck the zero.

10. CARE AND CLEANING OF JCI 131

Although the JCI 131 is of robust construction its operation and/or performance may be impaired if it suffers mechanical impact damage or if the sensing aperture or the internal parts becomes dirty or debris enters the sensing region. The following checks and cleaning may be safely undertaken by the user without adversely affecting instrument performance or sensitivity. If satisfactory operation is not restored by these operations then the instrument should be returned to JCI for repair or servicing. DO NOT attempt any adjustments to the circuits as such actions will, almost certainly, adversely affect instrument operation.

If there is any visual evidence of dirt or contamination on any of the sensing aperture or the sensing region surfaces, or if the zero reading has drifted or become unstable, then the first action is to remove the front cover of the instrument. (For instruments fitted with the operational health facility the health shield needs to be taken off first. This requires removal of the 6 M4x6 retaining screws). There are two sets of 4 M2 screws around the middle of the instrument casing. Carefully remove the four M2x6mm stainless steel screws towards the sensing aperture end of the casing - and leave the other four untouched. Carefully remove the front casing to reveal the sensing surfaces and rotating chopper assembly (as shown in Figure 2). The sensing surfaces and rotating chopper assembly should be inspected for any signs of physical damage, dirt, hairs or debris. Any debris should be removed. Contamination of the surfaces should be removed by washing in warm soapy water and rising well or by using an aerosol spray cleaner. The same actions should be applied to the inside of the front casing. (DO NOT undo the grub screws securing the rotor assembly to the motor shaft. DO NOT undo the 6 M2 screws around the front edge of the sensing aperture. Such actions will necessitate full resetting of instrument operation at JCI. When the internal structure of the sensing region is clean the front cover may be replaced and resecured with the 4 M2x6mm screws. Instrument operation and the zero reading should now be checked before returning the instrument to normal operation.

11. OPERATIONAL HEALTH MONITORING

To give confidence in operational performance in long term continuous observations an operational health system has been developed. This is available as an optional extra facility.

Operational health monitoring was originally developed as part of the JCI 501 Lightning Warning System [3]. In that system the whole fieldmeter sensing head unit was modulated with a low frequency square wave alternating signal of some 50V peak to peak amplitude. This modulated the observed electric field signal and the amplitude of modulation was compared to the level expected. The present facility involves an additional shield mounted around the casing of the JCI 131 fieldmeter sensing head (which is earthed) and this shield is driven with a sinewave voltage relative to earth at a frequency and phase locked to the chopper rotation signal.

The voltage swing of the shield is set appropriate to the fieldmeter operating sensitivity, and is about 2.2V rms on the most sensitive range, 22V rms on the next range and 220V rms on the top two least sensitive ranges. Feedback arrangements aim to keep the health signal constant despite any leakage losses that may be present and the circuits are safety protected to avoid any risk of shock by body contact at the higher voltage levels. Provision is included for direct monitoring of the level of the health drive signal so there is positive monitoring of the health of the operational health facility.

Phase sensitive detection enables the health modulation signal observed by the fieldmeter from the shield to be selectively extracted. Phase sensitive detection is also used to monitor the level of the health drive signal. There is no influence from the health monitoring signals on normal ambient electric field measurements. Both health and health drive signals are made available via the output connector as nominal 1.0V signals. The levels of the health drive signal can be expected to remain very stable with time, unless there is serious contamination of the shield mounting. The health signal may vary by a few % in normal operation. This variation can be due to rainwater droplets on the primary sensing surface changing the gap spacings slightly.

12. CALIBRATION

JCI 131 fieldmeter instruments are carefully set up in manufacture with the sensitivity set using the same arrangements as for formal calibration to BS 7506: Part 2: 1996 Annex 1 [3,4]. Instruments can, optionally, be formally calibrated at JCI to this Standard with measurements whose accuracy is traceable to National Standards.

13. APPLICATIONS

13.1 Introduction

The JCI 131 electrostatic fieldmeter measures the strength of the electric field at its sensing aperture. If this aperture is mounted flush with a large surrounding plane conducting surface then the fieldmeter reading relates directly to the electric field at the surface of this plane. This is the mode in which the instrument is set up and calibrated [3,4]. In many situations, however, it may not be practical to mount the fieldmeter in a large plane conducting surface - or the electrostatic conditions of interest are some way away from accessible positions of measurement in a complex earthy structure (for example for measurements in silos and in the cargo tanks of large crude oil tankers during tank washing [9,10]). In such situations it is necessary to relate measurements at the fieldmeter sensing aperture to conditions elsewhere by some modelling action. This may be appropriately done by computer solution of Laplace or Poissons equations in two or three dimensional models of the practical situation [6,7,8].

A particularly useful application of an electrostatic fieldmeter is as a 'potential probe' [9,10]. So long as the size of the fieldmeter sensing head unit is small compared to its structural environment and well away from nearby conducting structures (more than 5 or 10 diameters) then the electric field observed by an earthed fieldmeter depends upon the local potential, V (kV), which was at the fieldmeter mounting position before it was introduced, is close to $E_f = V / d$ - where E_f is the fieldmeter reading (kV m^{-1}) and d the effective sensing head diameter (m). There will, of course, be a contribution to the electric field measured dependent on the alignment of the sensing aperture relative to the ambient electric field, but this effect is usually fairly small.

The actual sensitivity of fieldmeter measurements can be checked in-situ by having the fieldmeter assembly insulated at its mounting from the main earthy structure and applying a calibration voltage to the fieldmeter assembly. With zero electric field at the fieldmeter sensing aperture the potential is directly the local voltage. Opportunity for such checking is provided with the JCI 137 Support Pole. The pole is mounted into a Delrin socket into the tube on the spike that is driven into the ground. An earthing terminal is mounted at the lower part of the pole. In normal operation this is connecdted to the local earth – or the system is earthed via the cable sheath. If the power supply and signal measuring instruments are isolated from earth then there is opportunity to test the relationship between electric field signals and the local voltage around the fieldmeter sensing aperture. With the earth link from the 'earthing connector' on the pole connected to a high voltage supply a voltage applied to the fieldmeter system to give a zero signal output from the fieldmeter. This is the voltage that relates to the electric field reading of the fieldmeter when operated in the usual earthed mode.

Fieldmeters have been used as potential probes in studies of tank washing on large crude oil tankers [9,10] and in food product silos [10]. This is also an appropriate approach for measurement of ambient atmospheric electric fields with the fieldmeter mounted at the top of a metal mounting pole. A suitable arrangement is illustrated in Figure 3. Notes on such applications are described on the JCI Website [11].

Atmospheric electric field E_a may be measured using the fieldmeter mounted on a support tube at a mounting height, h (m), with the fieldmeter earthed. In this mode thje fieldmeter is operasting as a potential probe. The atmospheric electric field $E_a = V/h$ - where V is the local voltage (kV) and h the height (m) of the fieldmeter above ground level. The sensitivity of a fieldmeter mounted well clear of nearby surfaces is close to $V = E_f\, d$ - where E_f is the fieldmeter reading (kV m^{-1}) and d the effective sensing head diameter (m). Hence the ambient electric field is obtained from measurement of the electric field at the fieldmeter sensing aperture as:

$$E_a = E_f\, d / h$$

There will be a contribution to the electric field measured dependent on the alignment of the sensing aperture relative to the ambient electric field. If for example the two field components are in directions to add (e.g. the fieldmeter looks upwards on the top of the mountig pole), then the atmospheric field can be derived as:

$E_a = E_f\, d / (h\,(1\text{-}d/h))$

As d/h is normally small the influence of this effect is small.

Where a fieldmeter is mounted other than above a large scale flat ground area, and well clear of any buildings or earthy projections, there will be need to interpret electric field measurements in relation to the geometric arrangement of the surroundings. This can be done with computer modelling calculations - but this is not easy and may lack conviction in complex three dimensional arrangements. One approach to tackle this problem is to normalise readings in relation to measurements of ambient atmospheric electric field values made in an area that is nearby, plane and free of interfering structures and features. Such normalising measurementss may conveniently be made using a JCI 140 Static Monitor held at arm's length above the head. It will be best to match observations between the two instruments at the same time in clear blue sky conditions and with the reference site not too far away. (Although it is stated that the ambient atmnmospheric electric field in clear blue sky conditions is typically around 100V m^{-1} this is susceptible to fine atmospheric pollution, so cannot be relied upon in practical observations).

If the sensitivity of a fieldmeter to the local voltage (or an applied calibration voltage) is S kV m^{-1} per kV, and at a height h (m) in a local atmospheric electric field E_a shows an electric field E_o (V m^{-1}) (as shown by its output voltage and its sensitivity range setting) then:

$E_a = E_o / (S\,h)$ V m^{-1}.

If at the same time measurement of the atmospheric electric field in a nearby large flat area is E* then there is a shielding (or gain) factor F at the set measurement location $F = E^*/E_a$.

In this case the true atmospheric field at the set observation location is:

$E_a = F\,E_o / S\,h$ V m^{-1}.

For a JCI 131 without the operational health shield fitted S = 10.0 kV m^{-1} per kV. With operational health facility fitted S ~ 7 kV m^{-1} per kV.

For a mounting pole height of say 2.0m and operational health fitted:

$E_a = E_o / 7 * 2.0$ V m^{-1}

If the shielding factor at the test location is say 1.5, then:

$E_a = 1.5\,E_o / 7 * 2.0 = 0.107 * E_o$ V m^{-1}.

13.2 Pole mounting

To mount the JCI 131 fieldmeter on the JCI 137 mounting pole the spike is first driven into the ground at the required location. If necessary the driving may be by a collar tube fitting over the housing for the bottom end of the mounting tube so that impact is direct to the wings of the sheet metal 'spike'. The mounting tube may be used to check verticality from time to time during driving. With the spike in position and the mounting tube laid on the ground, the cable connector may be passed through the side hole in the housing and then along though the length of the tube and left free at the far end. There are two options: the fieldmeter may be connected to the cable and mounted into the top end of the mounting tube. This assembly is then raised upright and socketed into the insulator in the bottom housing. The guy lines are then secured. Alternatively, and more conveniently for any in service inspection, the tube may be mounted into the housing and guy lines attached and secured. The fieldmeter head unit may now be connected to the cable and then socketed back into the top of the mounting tube. Care is needed to ensure easy movement of the cable in and out of the side hole in the botton housing.

The pole mounting arrangement provides insulation between the earthed housing and spike and the mounitng tube. This is to enable in situ calibration of the voltage sensitivity of the fieldmeter by operation of the fieldemeter from an isolated power supply, or battery, and application of defined voltages to the fieldmeter assembly. At all other times the fieldmeter should be connected to earth using the earthing terminal near the botton of the mounting tube to connect to a local earthing rod driven well into the ground.

JCI 131 fieldmeters without the operational health facility fitted have a brass back plate. This will provide direct electrical connection between the fieldmeter and its mounting tube. When the operational health facility is fitted (and/or the radio system) then the back plate is insulating and spring loaded connectors are included to link the internal circuits to the mounting tube (antenna) and to the operational health shield. Two spring loaded connectors are provided for each facility – one of the pair is linked to operational health drive circuitry the other to the observation circuits. This ensures confidence in operational health monitoring.

14. BASE UNIT JCI 134

The JCI 134 and the JCI 234 provide opportunity for operation of JCI 131 fieldmeters from a 100-240V 50/60Hz mains input power supply or from a 12V battery. When operating from mains a battery connected at the same time provides back up for uninterruptible operation in the event of mains supply failure. Connections are provided for two battery inputs so that recharged batteries can be connected without interrupting operation. Supply to the JCI 131 is 24V. This helps minimise resistive losses in the connecting cable. The top cover display includes LED indicators to show power supply sources actively available. The layout of the top cover is shown in Figure 4.

Operational power is switched on with a key switch. This provideas protection against accidental interruption of long term monitoring operation.

Fieldmeter readings are displayed on a 3½ digit LCD as kV m^{-1}. Six ranges of full scale sensitivity are provided using led indicators to show if the displayed readings are V m^{-1}, kV m^{-1} or MV m^{-1}. Two key switches are available to increment or decrement the displayed range. When both keys are pressed at the same time operation reverts to automatic range selection.

When used for atmospheric electric field measurements the obervations are displayed as ambient electric field values. Opportunity is provided, via the push button at the top left of the back plate, to see the local electric field values as measured by the fieldmeter at any time. As noted in Section 13.1 above, when the filmeter is pole mounted at a height h(m) the local ambient atmospheric electric field E_a relates to the electric field measured by the fieldmeter E_o as:

$$E_a = F\ E_o / S\ h \quad V\ m^{-1}$$

- where F is a shielding factor and S is the sensitivity of the fieldmeter assembly in terms of kV m^{-1} per kV.

The JCI 134 and JCI 234 provide opportunity to match the displayed values of electric field to actual values of atmospheric electric field. Where the fieldmeter assembly is mounted in a large flate area with no shielding from nearby buildings or structures then atmospheric electric fields are determined simply from the voltage sensitivity of the assembly and the height of mounting. If the JCI 131 has to be mounted in a position where there may be some enhancement of ambient atmospheric fields by mounting on a local hill or reduction by shielding from a nearby building or structure then the true ambient reading can be normalised by direct comparison to readings of a portable fieldmeter (for example a JCI 140) held aloft at a location somewhere near where the shielding/enhancement effects are negligible.

A potentiometer and a 3 position slide switch are provided in the back plate to enable the display to be adjusted to match correct interpretation of ambient atmospheric electric field. The push button in the back plate provides easy switching of the display between fieldmeter reading and interpreted values.

Ambient electric field values can be obtained in two ways:

1) using the voltage sensitivity of the fieldmeter – which is about 10kV m-1 per kV for a JCI 131 by itself and about 7 kV m-1 per kV for a JCI 131 fitted with the operational health shield. Then knowing the heigth of the pole mounting to calculate, as above, the anbient field in relation to the local fieldmeter values.

2) use the value of ambient electric field derived from measurmens made at a nearby flat area of ground - as described above.

Displayed ambient electric field values on the JCI 134 are adjusted as follows:

a) wind the 'gain' potentiometer fully clockwise to show maximum value and set to auto-ranging operation (press the two range control push buttons at the same time)
b) move the range swith in the back panel so the ambient reading is between x1 and x10 the target ambient field value
c) now adjust the gain potentiometer to make the displayed reading correspond to the known ambient electric field.

As ambient electric field values may be changing with time, in non-'blue sky' conditions, it may be most convenient to establish the ratio between the ambient and local field values so this can be used to set the gain with the display alternated between local and ambient displays. Where comparisons are made to nearby flat area field values it may be useful to use a mobile 'phone to match 'local' to nearby field readings. With the ratio established this can then be used to make switch and potentiometer adjustment relative to the current 'local field' value.

A potentiometer is provided in the back cover for adjustment of the zero reading of the JCI 131. This needs to be adjusted with care when a suitable Zero Check Chamber (for example a JCI 152) is placed over the sensing end of the fieldmeter. The fieldmeter needs to be operating in its most sensitive range with the display showing direct readings of electric field at its sensing aperture.

The JCI 131 is connected to the JCI 134 or the JCI 234 Base Unit via a 19w connector in the front plate. A 25w D type connector is provided for external linkage of all signal channels from the JCI 131 for external display and recording of observations.

The operational health of the fieldmeter can be shown on the LCD using the two key switches just below the LCD. Pressing the top key shows the operational health as % of expected level. Pressing the lower key shows the level of the operatioanl health drive signal as a % of the value expected. Operational health can be toggled switched on and off if it is desired to check lack of interaction between operational health and fieldmeter observations.

15. COMPUTER DATA PROCESSING

Earlier versions of the JCI 131 fieldmeter offered the optional facility of an integral and proprietary RS 232 serial interface PCB within the head unit. This could be linked directly to the serial port of an IBM PC or a compatible microcomputer for display and numerical recording of observations using proprietary software JCILOG. This approach was appropriate in the days when MSDOS was available and widely used. Operating systems after Windows 98 no longer provide opportunity for operation in MSDOS so this computer linkage option has been dropped. An alternative approach for computer based data recording, which is Windows compatible (up to XP), is use of a Picoscope digital storage oscilloscope facility (www.picotech.com).

16. REFERENCES

[1] J. N. Chubb *"Two new designs of 'field mill' type fieldmeter not requiring earthing of rotating chopper"* IEEE Trans Ind Appl 26 (6) Nov/Dec 1990 p 1178

[2] J. N.Chubb *"Experience with electrostatic fieldmeter instruments with no earthing of the rotating chopper"* 'Electrostatics 1999' Inst Phys Confr Series 163 p443

[3] *"Methods for measurements in electrostatics"* British Standard BE 7506: Part 2: 1996

[4] J N Chubb *"The calibration of electrostatic fieldmeters and the interpretation of their obsrevations"* Inst Phys Conference 'Electrostatics 1987'. Inst Phys Confr Series 85 p261

[5] J. N. Chubb, J. Harbour *"A system for the advance warning of the risk of lightning"* Proc ESA Annual Meeting 2000. Brock University, Niagara Falls, Ontario June 18-21, 2000

[6] C. L. Thomas *'POTENT - A package for the numerical solution of potential problems in general two dimensional regions'* Proc Confr of Software for Numerical Mathematics and its Applications, Loughborough University, April 1973 p315 (London, Academic Press)

[7] C. L. Thomas *'THREED'* IEE Confr Computer Aided Design, Southampton, April 1974

[8] C. W. Trowbridge *"Computer modelling of electrostatic fields"* Electrostatics 1991 Inst Phys Confr Series 118 p253

[9] J. M. Van der Weerd *"Electrostatic charge generation during washing of tanks with water sprays, II Measurements and interpretation"* Static Electrification Conference, London, 1971 IoP p 158

[10] J. N. Chubb, G. J. Butterworth, *"Instrumentation and techniques for monitoring and assessing electrostatic ignition hazards"* Electrostatics 1979 Inst Phys Confr Series No 48 1979 p 85

[11] JCI Website: www.jci.co.uk (for example www.jci.co.uk/Measurements/AtmosEfield.html and www.jci.co.uk/Electrostatics/Wshop-00.html)

Figure 1: General view of JCI 131 Electrostatic Fieldmeter

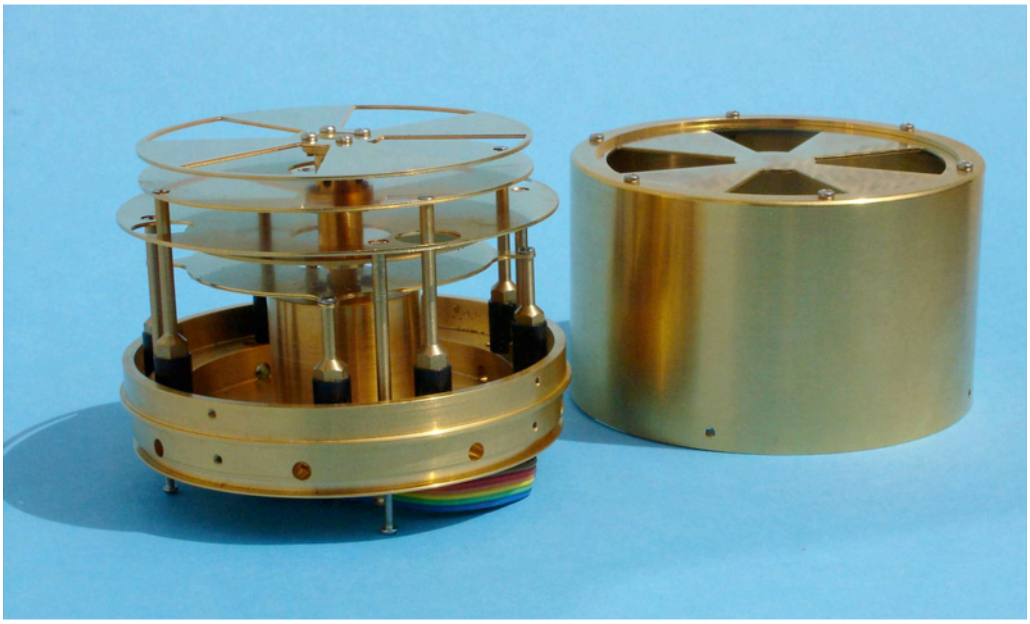

Figure 2:Internal features of sensing region of JCI 131

Figure 3: Electronics of JCI 131 with rear case section removed

Figure 4: JCI 131 fieldmeter with operational health shield mounted on JCI 137 Support Pole for measurement of atmospheric electric fields

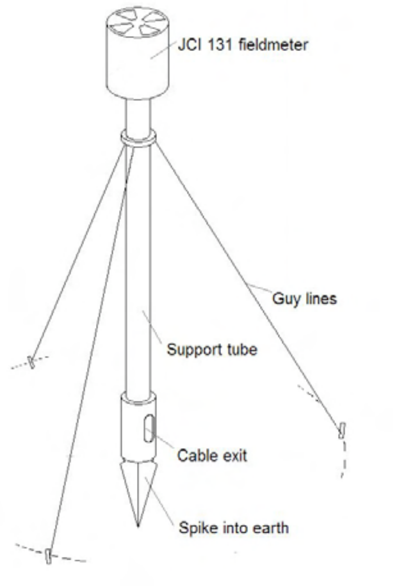

Figure 5: Diagram of JCI 131 mounting

Figure 6: JCI 134 Base Unit