



(Minor changes to the previous edition are indicated by ◆ placed before the relevant paragraphs)

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1. Scope

This Specification is written to comply with Engineering Standard 1-202 in defining the requirements for the overhaul of all variants of Style N Time Element Vane relays which are used in the signalling system on the London Underground.

The specification hierarchy which supports these requirements is detailed in Attachment 4 to the Specification.

2. References

The text of this document cites other documents that provide information or guidance. These are listed in Attachment 1.

References to British Standards or standards in other standards systems shall be taken to include the words 'or equivalent'.

3. Abbreviations

The following abbreviations are used in this document (if from a published source this is indicated):

CPS	Critical Parameter or Setting
JR	Time delay relay
LU	London Underground
OEM	Original Equipment Manufacturer
WSL	Westinghouse Signal Limited

4. Definitions

The following terms are used in this document (if from a published source this is indicated):

The Client – The Client is the Infracore representative responsible for administering the contract under which the overhaul work is being performed.

The Contractor – The Contractor refers to the organisation responsible for the delivery of overhauled equipment.

Front Contact – A front contact provides a very low resistance (short circuit) electrical connection between two terminals of the relay when the relay is in an energised state.

Back Contact – A back contact provides a very low resistance (short circuit) electrical connection between two terminals of the relay when the relay is in a de-energised state.

5. Introduction

This specification has been written to detail the overhaul requirements of Style N Time Element Relays which are used in the signalling system on the London Underground.

The Style N Time Element Relay, hereafter referred to by its usual colloquial title as a Style N JR, is classified as an item of vital signalling equipment which means that it may be used in the most critical safety circuits directly authorising the movement of trains. It has been designed to fail-safe principles and manufactured to exacting tolerances to ensure that it fulfils its safety role throughout a very extended life. It is a mandatory requirement that a relay that has been overhauled shall have a functional performance, a safety integrity, a reliability, an expected service life in its installed condition and a shelf life equivalent to that of a new relay.

Any failure condition which causes

- any front contact to close before the set time delay has elapsed ,
- any front and any back contact to be closed simultaneously,
- any contact or coil to have an electrically conductive path to any other contact or coil, or
- the relay not to reset to its full time delay setting,

is classed as a 'wrong-side' failure. Wrong-side failures are investigated exhaustively to establish the cause of the failure. Investigations into wrong-side failures will examine materials, processes and the history of overhaul operations to establish the exact cause of the event and to ensure that no other items are likely to suffer a similar failure. An occurrence of a wrong-side failure or a misoperation showing a tendency towards a wrong-side failure, even if no accident or damage is caused, can be extremely costly to investigate and could result in the need to change many units in service.

Figure A shows a general view of a Style N time element relay.

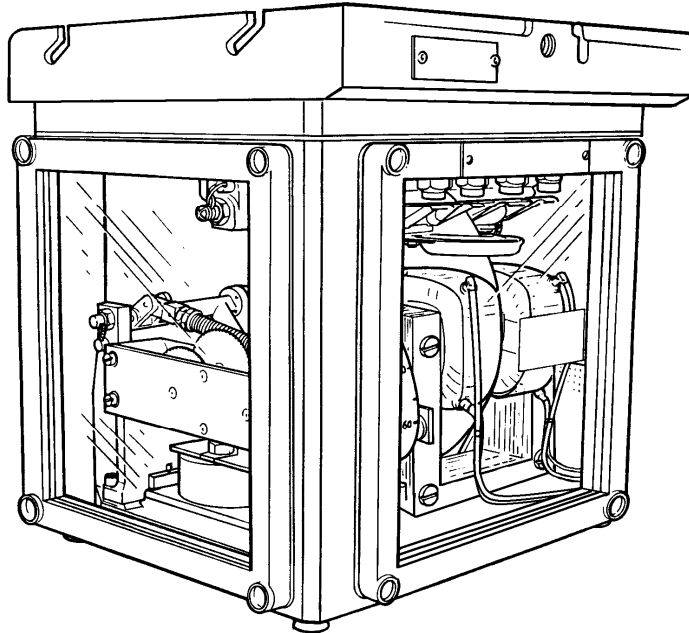


Figure A – General view of a Style N Time Element Relay

Items supplied for overhaul will be complete units which may be in working order or may have failed in service. The failure mode of items will vary, ranging from simple causes such as open circuit contacts, to items which have suffered severe damage. In the latter case there will be an element of salvage involved in the overhaul process. The equipment will be returned for overhaul or repair in an 'as found' condition after being removed from its working position on the railway.

The service life of this equipment is 10 years. The shelf life is 3 years.

6. Usage of item

Style N JR relays are used in circumstances where it is necessary to provide a fail-safe time delay between application of the controlling voltage and the front contacts of the relay closing. A typical application is in providing the delay for the release circuit on Interlocking Machines.

The time delays available using this style of relay range between 20 and 120 seconds.

All relays operate with a 100v AC input at either $33\frac{1}{3}$ Hz or 125 Hz.

The relay top frame is uniquely keyed for each time delay setting to ensure that only a relay giving the correct time delay is fitted into the circuit in the Interlocking Machine Room.

The design of the signalling system is based on fail-safe principles and hence the regular and expected failures (wires breaking, fuses blowing, loss of power supply, etc.) do not cause dangerous situations to arise.

Six variants of the Style N JR are covered by this specification as detailed in Section 8.

7. Equipment design outline

Key design features of all Style N JR's are that they have been designed to include:

- Construction that is designed to be, as far as is practicable, fail-safe in operation



- Jewelled bearings for the vane spindle, the quadrant wheel and the contact carriage
- A combination of contact materials, pure carbon and silver, that are non-weldable
- An operating mechanism that only responds to AC energisation
- A timing mechanism that will reset to provide the full time delay if the supply voltage is interrupted
- A timing mechanism that is extremely unlikely to operate in less than its required time setting

An AC energised eddy current motor is used to raise a quadrant wheel which tensions an operating spring used to pull the operating arm towards its energised position. The quadrant wheel is returned to its de-energised position by gravity. The aluminium motor disc is coupled via a slipping clutch to the pinion which drives the quadrant wheel. This is necessary to dissipate the rotational energy stored in the disc when the quadrant wheel is driven into the end-stops at the limit of its travel in the upward direction. A spring recoil mechanism is also built into the slipping clutch which engages when the clutch has slipped by nearly a full revolution. This mechanism operates in both directions of rotation of the vane.

A permanent magnet eddy current brake is connected to the operating arm to provide the resistance to motion required to slow its movement. The braking effect is provided by a plated copper disc running between the poles of two permanent magnets. The disc is connected to the operating arm via a step-up gear train and a double ratchet pawl wheel. The ratchet and pawl allows the quadrant wheel and operating arm to fall back to its de-energised position without the need to rotate the copper brake disc thus giving a very quick reset response.

The operating arm acts on a contact carrier which has 6 front contacts and 2 back contacts. All contacts have independent armature connections. The armatures have a pure silver tip which makes contact with a pure carbon contact. This combination of materials is designed to be non-weldable when handling the currents to which the relay is exposed.

As gravity alone is relied on to return the relay to its de-energised position, the mechanical movement of all parts of the assembly is designed to be as frictionless as is practical. Jewelled bearings are used for the vane pivots as well as for the contact carriage pivots. The alignment of the shafts and their bearings is critical to keep the mechanism as free-moving as possible. All linkages have been designed to be easily visible and as simple as possible.

8. Scope

This specification applies to the following relay variants.

Item	Stores List No.
33 ¹ / ₃ Hz style N time element relay – 60 seconds	55s118
33 ¹ / ₃ Hz style N time element relay – 120 seconds	55s146
125 Hz style N time element relay – 20 seconds	55s471
125 Hz style N time element relay – 30 seconds	55s482
125 Hz style N time element relay – 60 seconds	55s163
125 Hz style N time element relay – 120 seconds	55s164

The Illustrated Parts List, Attachment 2 to this document, forms part of this specification.

9. Critical functions

Critical Functions of the Style N JR are defined to be:



High Integrity Electrical Insulation: All electrical wiring and insulating components are designed to maintain their integrity throughout the life of the equipment. No failure mode is allowed to compromise electrical isolation between any part of the contact arrangement of the equipment.

Non-weldability of contacts: The contact materials are specified to be a pair of materials (silver and pure carbon) that have been proven to have a very low probability of welding. The composition of the carbon contact is critical to maintain this design goal.

Defined minimum operate time: Operation in less than the specified time, after allowing for the tolerance allowed, will be classified as a wrong-side failure.

Freedom from mechanical binding: The design of the relay has taken into account the need for the contact carrier to drop to its de-energised state and for the timing mechanism to reset to provide its full time delay throughout an extended service life. To this end, agate bearings are employed for both the quadrant wheel and the contact carriage and all linkages have been kept simple. Clearances between components have been kept as large as practical and in most cases can be visually seen from outside the relay when it is in its operating position.

Electrical Safety. Satisfactory earthing and bonding of the relay is crucial to ensure that leakage paths to the case or other extraneous metalwork in the event of faults do not give rise to electric shock hazards or to a loss of vital system integrity.

The ability of the item to meet the critical functions listed above throughout its life depends on many factors, not all of which are immediately obvious to people not familiar with all aspects of the design, overhaul and use of the equipment. To ensure that the significance of certain of the detailed requirements is understood and complied with, a number of Critical Parameters or Settings have been designated throughout the text.

Attachment 3 to this Specification lists all the Critical Parameters or Settings [CPS], a reference to the section from which the requirement originates and provides a Criticality Rating of the importance of each CPS item.

The Criticality Rating is based on the severity of the consequence if there is a deviation of the subject parameter from the value specified. Numerical values have been assigned to various levels of the Criticality Rating (CR) according to the table below.

Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
10	Life critical – sole dependence Occurrence of this deviation alone may lead to an incident causing death or injury.	
8	Life critical – shared dependence Occurrence of this deviation, together with a second deviation which is potentially latent (i.e. not self announcing), may lead to an incident causing death or injury.	
7	Life critical – contributory Occurrence of this deviation	Service critical – sole dependence Occurrence of this deviation alone may lead



Criticality Rating (CR)	SAFETY RELATED CRITERIA	RELIABILITY RELATED CRITERIA
	increases the probability of an event which may lead to an incident causing death or injury.	directly to an incident causing major service delays, and indirectly to the danger of a life threatening incident through enforced use of manual rules for operating the railway.
6		Service critical – shared dependence Occurrence of this deviation, together with a second deviation which is potentially latent (i.e. not self-announcing), may lead directly to an incident causing major service delays, and indirectly to the danger of a life threatening incident through enforced use of manual rules for operating the railway.
5		Service critical – contributory Occurrence of this deviation, increases the probability of an event which may lead to major service delays, and indirectly to the danger of a life threatening incident through enforced use of manual rules for operating the railway.
1	Not life critical	Not service critical

The criticality rating provides a scale of the importance of achieving the specified parameter and therefore of the care needed in designing the process or processes that will lead to the parameter being achieved. The design of the process or processes that will lead to the parameter being met are the responsibility of the Contractor and they shall be designed and documented in accordance with the requirements of Engineering Standard 1-202, Signalling equipment overhaul.

10. Performance parameters

10.1 Operating voltage

The Normal Operating Voltage for all variants is 100 volts A.C., being the voltage applied to terminals R1 and R2 to cause the relay to commence its timing function.

The Minimum Operating Voltage for $33\frac{1}{3}$ Hz relays is 80 .0 volts.

The Minimum Operating Voltage for 125 Hz relays is 85 .0 volts.

The Maximum Operating Voltage for all variants is 110.0 volts.



10.2 Time delay period

The Time Delay Period, measured in seconds, is defined as the period between applying the input voltage to the energising terminals, R1 and R2, and the front contacts, except No. 2 contact of 60 second relays, closing.

The Time Delay Period shall be as defined in Table 1 below.

Stated time delay	Minimum Time Delay	Maximum Time Delay
20 seconds	18 seconds	22 seconds
30 seconds	27 seconds	33 seconds
60 seconds	54 seconds	66 seconds
120 seconds	108 seconds	132 seconds

TABLE 1. Time delay settings for relay variants

10.3 Contact Resistance

The contact resistance of closed contacts, with between 0.1 and 1 Amps (AC or DC) flowing through the contact, shall be less than 0.5Ω .

10.4 Insulation Resistance

The insulation resistance between all parts of the electrical circuits and the case of the relay shall be at least 50 M Ω when measured at 1000V DC.

The insulation resistance between any parts of insulated circuits shall be at least 50 M Ω when measured at 1000V DC.

11. Equipment configuration

An Illustrated Parts List is provided as Attachment 2 to this document, comprising an itemised list and associated exploded component drawings, to describe all variants of the equipment as identified in Section 8 of this specification. The Illustrated Parts List contains all relevant drawing numbers.

Drawing CS13427 details the terminal configuration of the detachable top for each type of relay. This drawing shall be used to configure the relay terminals with the exception of the earth terminal shown on the drawing, which shall not be fitted to any relay. All unused terminal positions shall be fitted with blanking plugs (item 2-45).

A convention of using the figure number followed by the item number has been adopted in this document to uniquely refer to specific components where necessary. Thus, item 1-31 is the relay case.

Unless specifically noted, drawings and figures used in this Specification are for reference only.

12. General requirements

12.1 Compliance with specification

No departures from the requirements of this Specification shall be permitted (either permanently or temporarily) without compliance with the relevant change control procedures.



Neither equivalence of process nor substitution of materials shall be recognised by the Client in receiving work performed against this specification. The Client shall have the immutable expectation that equipment overhauled to this version of the specification shall be 100% compliant with the specification herein.

12.2 Workshop environment

A number of operations associated with the overhaul of the JR relay are sensitive to the ingress of airborne dust and other contaminants, particularly into the three pairs of jewelled bearings used in each relay. Therefore any operation or process in which '*inspected bearings*' are present, either as individual components or as part of a sub-assembly, shall be carried out in a '*clean*' environment.

An '*inspected bearing*' is defined to be a jewelled bearing assembly or vane shaft pivot or a contact carriage pivot or a Quadrant Wheel pivot which has passed the final stage of inspection before being used to build up a sub-assembly. To meet the requirement of the previous paragraph it is therefore necessary to inspect the bearings within a clean area.

The silver and carbon contacts are also sensitive to contamination from handling. The carbon contacts are prone to absorb grease and soap residues from the skin if touched with bare hands. Lint-free protective gloves shall be worn by operators when handling carbon and silver contacts.

A '*clean*' environment is defined to be an area, with defined boundaries, inside which no food or drinks are allowed and no contaminants are generated or are allowed to circulate. A contaminant may be generated by filing, sanding, sawing, cleaning or any other similar operation.

Contaminants shall not be allowed to enter the environment from the surroundings through the airflow from unsuitable conditions

An acceptably clean environment shall not contain

- unsealed walls (bare brickwork)
- high ceilings with rafters, beams and light fittings with the potential for the build-up of dust which cannot be easily removed by regular cleaning during shut-down hours
- windows opening into other areas or the outside environment
- through passage routes between other uncontrolled areas

Once a sub-assembly becomes subject to clean area handling it shall not leave the clean area except that it be sealed in a clean transportation container or the relay is complete with all glasses fixed in position.

Calibrated test equipment shall be used to carry out all measurements specified.

12.3 Calibre of staff

Any staff involved in the overhaul process shall be competent in the tasks they carry out and the overhauling contractor shall demonstrate this in accordance with the requirements of Engineering Standard 1-203, Competence of personnel working on signal and control systems.

12.4 Operator accountability

Process control documentation is required to be completed by identified certified (stamp-holding) operators and inspectors throughout the overhaul process. Each certified operator and inspector shall possess a uniquely numbered stamp which is traceable to the owner. Only competent operators shall be provided with a stamp. Records of the issue and withdrawal (if appropriate) of every stamp shall be kept and shall be made available to the Client on request. The retention period of these records is required to be indefinite.

13. Overhaul definition

13.1 Full overhaul

A full overhaul will be performed on relays which generally will have been in service for their full routine service life, or which will have been removed from service as a result of a failure.

No item returned after failing in service shall be overhauled until the failure report has been reviewed and accepted by the Client in accordance with a defined arrangement agreed with the Client.

Unless stated to the contrary, all processes detailed in this specification shall be performed for each overhaul.

13.1.1 Dismantle

The relay shall be dismantled in a manner that shall not damage or shorten the life of any component that is required to be re-used. The life of all recyclable components is indefinite.

Hammers and other percussion tools shall not be used during the dismantling process of any assembly containing jewelled bearings.

The items listed below shall be discarded and replaced with new items at every overhaul.

Top Gasket	Window Gaskets (all)	PVC Glass Seals (all)
Aeronuts (all)	Locking plates (all)	Locking wires
Contact Braids (all)	Earth Braid	Internal Wiring
Headed (link) Pins (all)	Spade Terminals (all)	Carbon tips (all)
Cable Clips (1-48)	Shims (2-20)	Split Pins (all)
Coils (both)	Coil Retaining Plates (5-5)	

The items listed below shall be discarded and replaced with equivalent items as specified in the detailed parts listing.

Aluminium Top Frames		
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The items listed below and their associated fixings shall be left in position at the time of dismantling. Some may need to be replaced if their condition warrants it at the time the item is examined.

Quadrant top stop bracket (1-19)	Counterweight top stop bracket (1-20)	
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The Contact Carrier Assembly (items 2-22 to 2-26) shall not be dismantled further unless examination of individual components requires it.

The Vane Assembly shall not be dismantled but shall be put aside for gauging and inspection as a complete unit. The vane assembly shall be stored and transported in specially designed containers to ensure no damage is caused to the components throughout the overhaul process.

The bearing assemblies shall be stored and transported in specially designed containers to ensure no damage is caused to the components throughout the overhaul process. The container shall be constructed of materials which are not susceptible to static electricity to prevent the attraction of dust and other light fibrous material from the atmosphere. No fibrous material shall be present in the container. The bearing assemblies shall be stored open end downwards to prevent dust or other material from entering the bearing. The containers shall be fitted with dustproof lids which shall be kept in place at all practical times.

The impact detector shall be removed from the relay as a complete unit. No further dismantling is required.

13.1.2 Cleaning and stripping

The following shall be implemented after the relay has been dismantled in accordance with Section 13.1.1 above.

All components shall be cleaned and degreased using a technique suitable for that component. A 'suitable technique' shall not cause short term or long term degradation to the component nor shall any solvent used leave undesirable residues on the component which will affect the performance of the component when it forms part of an overhauled unit.

13.1.2.1 Top Frame, Main Case and Window Frames

Components shall be cleaned and stripped back to bare metal using a process that ensures complete removal of all existing paint without causing damage or degradation to the component. Particular attention shall be paid to the preservation of thread forms.

13.1.2.2 Other metallic components

All components shall be cleaned and degreased using a technique suitable for that component.

All gunmetal castings shall have a bright finish

13.1.2.3 Jewelled Bearings

Jewelled bearings within the main and contact carrier bearing assemblies shall be cleaned and degreased by soaking in a solution of Bioplex 500, or approved alternative solution, for one hour before thorough rinsing in clean water followed by thorough drying off before the assembly is inspected prior to re-use.

13.1.2.4 Top Plate

The Bakelite top plate shall be cleaned and degreased.

13.1.2.5 Vane

The surface of the vane shall be cleaned using a non-abrasive cleaner or solvent. No residue shall remain on any part of the assembly, particularly in the vane slots. Any previous inspection stamp shall be completely removed.

13.1.2.6 Glass

Glass from the side frames shall be cleaned and dried to remove any residue.

13.1.2.7 Impact Detector

After removing the transparent cover and the weight, the impact detector shall be lightly cleaned using an air-line, soft brush or other similar technique.

13.1.3 Examination and gauging

All components shall be examined for the effects of excessive or unusual wear, general damage, damage caused by misuse or age, electrical arcing or tracking or overheating. All thread forms shall be checked for

signs of over-tightening. Items exhibiting damage that will not be corrected by the specified re-furbishing processes shall be discarded.

All occurrences of excessive or unusual wear or damage shall be catalogued and reported to the Client. Signs of electrical tracking or arcing shall be treated as excessive wear.

The subject items of such reports and as much of the unit from which they were removed as possible, shall be saved in their as near as original condition after being discovered and shall be clearly tagged and identified and shall be made available for Client inspection if so desired.

It is critical that **only** those components specified for refurbishment should be reclaimed after failing the wear tolerances specified.

Items not meeting the examination criteria shall be discarded if there is no refurbishment process detailed for it in this Specification.

Major components and items with specific examination criteria are listed below.

All component parts set aside for use at assembly shall be to a current approved design. Modification schemes may have been commenced which may not yet have been fully implemented. Units submitted for overhaul may not be to the current build standard. Some components may therefore require to be modified or discarded.

13.1.3.1 Relay Case (Item 1-31)

The stripped case shall be examined for signs of damage or cracking. Cases exhibiting cracking are not acceptable.

Tapped holes shall be checked for damage to threads. Cases with unusable tapped holes are not acceptable.

The blanking discs, (eyelet with disc, item 1-30) shall be checked for tightness and soundness. Loose or damaged items shall be replaced with new.

13.1.3.2 Jewelled Bearing Assemblies (Items 2-2, 3-2 and 3-2a)

All external surfaces of the housings shall be checked for signs of wear or damage. The thread form shall not exhibit signs of cracking or over tightening.

The diameter of the barrel jewel shall be gauged to be within the limits of 0.0950" to 0.0970". [CPS01]

The barrel jewel and endcap jewel shall be examined using a Mantis 3-D microscope or other equivalent instrument equipped with a suitable light source and holder for the bearing being examined and having a magnification of at least 6 times. No cracks, chips, scoring or other evidence of wear shall be visible. The bearing shall be checked to ensure it is free of any foreign objects particularly dust, fibre hairs or any other item. [CPS02]

No assembly shall exhibit any chip, crack, score or sign of wear.

13.1.3.3 Contact Spring Assembly (Item 2-13)

The Contact Spring Assembly shall not exhibit any signs of distortion.

Where Contact Tips exhibit severe pitting, burning or evidence of melting, the tips shall be replaced. Where light pitting only is evident, the Contact Assembly may be re-used after refurbishment of the tip.

13.1.3.4 Contact Carrier Assembly (Items 2-22a to 2-26)

The Assembly shall be examined for signs of corrosion and peeling plating. Corrosion and peeling plating are not acceptable. Items may be re-plated if required.



The Assembly shall be securely riveted together to form a rigid structure. Both Arms shall be securely riveted to the carrier. Loose Arms may be reattached with new rivets.

The Assembly shall be flat and straight, in both planes, to within 0.005".

The Pivots (item 2-23) shall be securely riveted to the Carrier sections. The minimum acceptable diameter of the Pivots is 0.0911". The surface finish of the Pivots shall be free of scratches, scoring and other signs of wear. [CPS03]

The maximum acceptable diameter of the Link Pin hole is 0.101". There shall be no burrs around the hole. [CPS04]

13.1.3.5 Top Plate (Item 2-46)

The item shall be examined for signs of chipping and cracking. Chipped or cracked items shall be discarded. There shall be no evidence of arcing or tracking.

13.1.3.6 Vane, spindle and clutch assembly (Items 3-6a/b)

The assembly shall be inspected for sound attachment of all riveted components. If any unsound items are found the whole assembly shall be fully dismantled and reassembled using replacement components as required.

The vane (item 3-7a/b) shall be inspected for cracking, particularly in the area of the ends of the slots. Vanes detected with any cracking at all shall be discarded and replaced with a new item. There shall be no visible signs of wear on the Pinion Pins (item 3-19) forming the pinion.

The Pivots Pins (item 3-10) shall be firmly attached to the Spindle (item 3-22). The Pivots shall have a polished finish and be free of scratches, scoring and other defects. They shall be tested for diameter and true running with respect to the shaft diameter. Each pivot shall have a diameter of not less than 0.0911" when measured in three orientations at approximately 120° apart. [CPS05]

Failure of either pivot to meet the parameter specified in the previous paragraph shall result in both pivots being replaced.

The slipping clutch mechanism shall be tested. The clutch shall start to slip at a torque of 650 to 700 gram cm. when applied in each direction, until the spring (item 3-20) engages with the Catch Pin (item 3-24b). [CPS06]

The vane alignment shall be tested using a suitable jig that will ensure the vane is capable of running in a gap of 0.046" without touching any part of the test gap. An electrical (continuity) check shall be employed as part of the test rig to detect that the vane does not touch any part of the test gap. The Vane Spindle Assembly shall be cleaned before it is gauged for alignment as described in this paragraph. [CPS07]

13.1.3.7 Vane Support Casting (Item 3-23)

The casting shall not exhibit any signs of cracking or corrosion.

The centre-lines of the axes of the Jewelled Bearing Assemblies shall be 3.124" - 3.126" apart at the point of meshing of the Quadrant Wheel and the Vane Pinion. The axes shall be parallel in two planes at right angles to each other to within 0.002" per 3" run of the shafts. [CPS08]

Failure to meet the above criteria shall cause the casting to be discarded.

The alignment of the tapped holes for the Jewelled Bearing Assemblies shall be checked using a jig manufactured to drawing 7034-A3-110088 using $\frac{5}{16}$ " x 32 T.P.I. bushes. [CPS09]

The use of any form of cutting tool (e.g. a tap or reamer) to check alignment of bearing holes is expressly forbidden.

13.1.3.8 Quadrant Assembly (Item 3-27)

The Quadrant Gear (item 3-28), Counterweight Rod (item 3-35) and the Pivots (item 3-33) shall all be firmly riveted to the Quadrant Spindle Casting (item 3-31). Any loose item shall be dismantled and re-assembled. Only new Pivots shall be used in the re-assembly.

The Quadrant Gear (item 3-28) shall not exhibit any signs of wear. Worn items shall be discarded.

The Quadrant Stops (item 3-29) shall be securely attached to the Quadrant Gear. Loose items shall be dismantled and securely re-assembled.

The Pivots of the Quadrant Assembly shall have a burnished finish and shall be free of scoring and other surface defects. The minimum acceptable diameter of each pivot is 0.0911". The diameter shall be measured in three orientations at approximately 120° apart. [CPS10]

13.1.3.9 Bearing Plates (Items 4-4, 4-6 and 4-7)

The plating shall be examined for signs of peeling or corrosion. Peeling or corroded plating may be stripped and the item re-plated to the original manufacturing specification. There shall be no plating inside the bearing holes.

The bearing holes in the three Bearing Plates (items 4-4, 4-6 and 4-7) are identified according to the components which run in them. The location of the holes in the various plates and the maximum acceptable diameter of each hole is given in Table 2 below. [CPS11]

Component identity	Bearing Plate identity			Maximum acceptable diameter
	Item 4-7	Item 4-6	Item 4-4	
Retarder Vane Assembly (item 4-17)	Y		Y	0.0640"
Operating Crank (item 4-21d)		Y	Y	0.0990"
Gear and Ratchet Assembly (item 4-20)	Y	Y		0.0990"
Gear and Pinion Assembly, (2 nd Idler) (item 4-19)	Y	Y		0.0640"
Gear and Pinion Assembly, (1 st Idler) (item 4-18)	Y	Y		0.0640"

Table 2. Table of maximum acceptable bearing hole diameters

13.1.3.10 Retarding Vane Assembly (Item 4-17a/b)

The components of the assembly shall be firmly attached together.

The Vane shall run true when rotated on its journals with a lateral wobble not exceeding 0.005" TIR (total indicated reading). [CPS12]

The plating on the Vane shall not show any signs of peeling or corrosion.

All bearing journals shall have a polished finish and be of a minimum diameter of 0.0585". [CPS13]

13.1.3.11 Pinion Gear Train (Items 4-18, 4-19 and 4-20)

All items shall be examined to check that the gears and pinions are firmly attached to their spindles.



All spindles shall have polished bearing journals which have no scoring or scratches. The minimum acceptable diameter of the bearing journals is as given in Table 3 below. [CPS14]

Component	Minimum acceptable journal diameter
Gear and Pinion 1 st Idler (item 4-18)	0.0585"
Gear and Pinion 2 nd Idler (item 4-19)	0.0585"
Gear and Ratchet Assembly (item 4-20)	0.0915"

Table 3. Table of minimum acceptable bearing journal diameters

Each ratchet tooth of the Gear and Ratchet Assembly shall be examined using a viewer with a magnification of at least 4 times. The root of each tooth shall be free of any build-up of foreign material. The face and engaging edge of each tooth shall not show any signs of wear. Wear to any tooth or the existence of foreign matter which cannot be removed in the root of any tooth shall cause the Assembly to be discarded. [CPS15]

13.1.3.12 Operating Crank Assembly (Item 4-21)

The Time Indicator (item 4-22) shall be firmly attached to the Casting (item 4-21).

The Pawl Shaft (item 4-21b) shall be firmly attached to the casting. The minimum acceptable diameter of the Shaft is 0.150". The surface of the shaft shall have a polished finish and be free of scratches, scoring or step changes of diameter which produce ridges on the shaft. [CPS16]

The Pivots (item 4-21d) shall be firmly attached to the Casting. The minimum acceptable diameter of each Pivot is 0.0915". Each Pivot shall be measured across three diameters, approximately 120° apart. All measurements shall be in accordance with the stated criteria. [CPS17]

13.1.3.13 Ratchet Pawl (Items 4-24a and 4-24b)

These items are the most critical components in the relay. The utmost attention shall be paid to examining them.

The plating shall not show any signs of peeling or corrosion.

The maximum acceptable diameter of the pivot holes is 0.1550". [CPS18]

The profile of the tooth shall be examined using a viewer with a magnification of at least 4 times. Any visible wear to the tooth shall cause the item to be discarded. [CPS19]

13.1.3.14 Spring (Item 4-29)

The Spring shall be a close fit onto the screwed jaw sections used to anchor it.

The extension of the Spring shall be tested with each end screwed $\frac{3}{8}$ " onto a $\frac{5}{16}$ " BSW bolt. A 49 ounce load shall be applied which shall cause an extension of $\frac{1}{2} \pm \frac{1}{8}$ ". [CPS20]



13.1.3.15 Laminations (Items 5-1, 5-2 and 5-3)

All Laminations shall be flat with no distinct fold lines, free from signs or corrosion and with the insulating layer intact over the whole area of the Lamination. Laminations may be discarded and replaced with reclaimed items (salvaged from other sets). New laminations shall only be used as complete sets.

There shall be no cracks in the Shading Bands (item 5-8).

13.1.3.16 Impact Detector (Item 6-1)

The assembly shall be checked for signs of corrosion on the contact spring (item 6-7) and the weight (item 6-13). The Contact spring shall be discarded if corroded and replaced with a new spring complete with rivets. The Weight shall be stripped and re-plated or discarded if corroded.

13.1.4 Refurbishment

13.1.4.1 Paint finishes

All paint used shall be air drying, suitable for spray application. Products used shall be suitable for the material to which they are applied and shall be compatible with other paint products applied above or below them. It is a particular requirement that no paint applied to the inside of the relay shall flake off any surface to which it has been applied over the whole life of the relay.

13.1.4.1.1 Top Frame (Item 1-8a - f)

All surfaces shall be painted with one coat of undercoat over bare metal. One topcoat of black gloss to be applied to all surfaces over the undercoat.

13.1.4.1.2 Case (Item 1-31)

The flexible cable retaining clips shall not be painted. Masking shall be attached before the undercoat is applied and removed after the topcoat has dried.

No flaking paint is acceptable. The finish of the inside of the relay case is required to be to the highest standard with no runs or accumulation of paint which could dry out and peel or craze during an extended life at high temperatures. Adhesion of all coats to the base metal and each other is a crucial factor to the safety of the relay.

All surfaces shall be painted with one coat of undercoat over bare metal.

One topcoat of white gloss shall be applied to all surfaces except the bottom, over the undercoat.

The final coat shall be a gloss coat, colour coded to requirements of drawing BS14224, applied to the four vertical external faces of the case.

It is permitted to use external masking plates to prevent top colour coding coat from entering inside the relay case. Masking plates for sides of relay shall be smaller than the outline of the window frame to prevent any white base coat from showing when relay is assembled with the window frames.

13.1.4.1.3 Window Frame (Item 1-2 and 1-2a)

Frames shall be spray painted on all surfaces with one coat of undercoat followed by one gloss topcoat, colour coded to requirements of drawing BS14224.

13.1.4.2 Vane support casting (Item 3-23)

The Vane Support Casting shall be lightly shot blasted to remove any tarnish accumulation.

All threaded holes shall be fitted with threaded inserts to prevent the threads in the casting from being damaged during the blasting process.



All blasting residue shall be removed by use of high pressure air-line, or other suitable and efficient means, to ensure no residue can be introduced into the new relay case at, or after, time of assembly.

13.1.4.3 Vane Spindle Assembly (Item 3-6a/b)

Worn pivots (items 3-10) shall be replaced in pairs using new Pivot Pins (item 3-10).

13.1.4.4 Contact Carrier Assembly (Item 2-21)

The Carrier may be stripped and re-plated after removing the pivot pins and dismantling the assembly into its component parts. Pins shall be replaced with two new Pins, as below.

Pivot Pins (item 2-23) shall be replaced in pairs using new pins. Pivot Pins shall be fitted to the Carrier using tool J2838.

13.1.4.5 Contact Assembly (Item 2-13)

Tips with a flattened surface which cannot be restored to a cylindrical form shall be replaced with a new tip with a finish at least as good as the refurbished tip described below.

The silver contact tip shall be lightly dressed using a flat 10000 grit whetstone lubricated with water before being burnished on a hard flat leather strop loaded with jewellers' rouge. All residue from these processes shall be thoroughly cleaned off the component.

It is important to maintain a cylindrical form to the silver contact tip. A domed or spherical form to the contact tip is not acceptable.

13.1.4.6 Retarding mechanism

All spindle bearings shall be re-burnished at each overhaul.

13.1.5 Assembly criteria

This section covers the assembly requirements of all variants. The exact configuration requirements are as detailed on section 11.

◆ All soldered joints shall be inspected to ensure that they are correctly formed. The joints shall be marked to show that they have been inspected. Marking shall be with a benign permanent substance which will not adversely affect the soldered joint. An example of a suitable product is the Berol Autoseal Ink Toughpoint Permanent Marker, Colour – Red. [CPS 50]

The Case shall be cleared of paint to provide a bright metal surface to ensure good electrical continuity between the Earth Braid (item 2-9) connection and the Case.

The counterbores for the fixing screws in the Top Frame (item 1-8) shall be cleared of paint to provide a bright metal surface to ensure good electrical continuity between the Top Frame and its fixing screws (items 1-11).

13.1.5.1 Impact Detector (Item 6-1)

Each Impact Detector shall be adjusted using a Drop Tester built in accordance with drawing DS26302. The Impact Detector shall be adjusted so that, when used on the Drop Tester it does not trigger when tested at a height of less than 1" but does trigger when tested at a height of 1½". [CPS21]

The gap between the Spring (item 6-7) and Impact Detector Body (item 6-6) shall be a minimum of 0.010".

The Impact Detector shall be attached to the Vane Support Casting in accordance with drawing AS37994.

13.1.5.2 Contact Carriage and Contact Assemblies

All the silver tips of the Contact Assemblies (items 2-13) shall have been refurbished to the requirements of section 13.1.4.5 or shall have a surface finish at least as good as that specified in that section. [CPS22]



All Contact Springs shall be biased against their keepers with a force of 14 ± 0.2 grams except for No. 2 Contact of 60 second relays which shall be set to $30 +3 -0$ grams. [CPS23]

All front contacts in the fully energised position and back contacts in the de-energised position shall have a contact pressure of $21 +3 -0$ grams except for No. 2 contact of 60 second relays which shall be set to $30 +5 -0$ grams.

Each contact Insulator (item 2-14) shall be fitted to the Contact Carrier Assembly (item 2-21+) using a locking plate (item 2-8) and 2 BA full nuts (item 2-7). In cases where the Insulator stud is too short to protrude completely through a nut then a half nut (not identified in parts list) may be substituted provided the stud protrudes through the half nut. If the stud does not protrude through the half nut then the Insulator shall be discarded.

The length of all Braids (Items 2-20) shall be $1\frac{3}{4}$ " before forming and soldering. Apart from the length required to form the solder joint at the end attached to the Contact Assembly (items 2-14) they shall not be stretched over any part of their working length. Attachment of braids shall be in accordance with drawing AS65611.

It is imperative that all braids shall be positioned in accordance with Drawing 7034-A1-109153 maintaining at least $\frac{1}{2}$ " clearance in all directions around each braid. [CPS24]

The open tang ends of each Spade Terminal (item 2-19) shall be closed down over the Terminal Post (item 2-42) after assembly. [CPS25]

The new Carbon Tips (items 2-41) shall not be touched with bare hands (see section 12.2, Workshop environment) during any part of the assembly or testing stages. The surface of the tips shall be kept free of all contaminants. The manufactured finish on the contact face shall be preserved.

The Contact Retaining Nuts (items 2-38) shall be tightened to a torque of 8.5 lbf.ins. Care shall be taken that they are not slackened when the locknut is tightened. The Locking Plate (item 2-40) shall be formed around the Contact Retaining Nut, the Locknut and the Carbon Post in accordance with drawing AS51046. [CPS26]

All front contacts, with the exception of the No. 2 contact on 60 second relays, shall be adjusted as near as possible to make at the same time. The No. 2 contact on 60 second relays is required to make slightly later than the other front contacts. Therefore at initial assembly before testing can confirm the correct setting, this contact is set to have a gap of 0.030" to 0.040" when then other contacts are at their point of closure. Both back contacts shall be adjusted as near as possible to make at the same time. [Note: Final adjustment of the alignment of the contacts is performed when the relay is fully assembled but a good approximation to the final setting should be achieved at initial assembly.]

The Contact Carrier shall be fitted with an earth connection in accordance with drawing BS62423.

Two styles of Carrier Support Bracket are in circulation. Both styles may be re-used. Two similar items shall be fitted to any one relay. Those brackets possessing a boss for wire-locking the Jewelled Bearing Assembly shall be fitted with the boss to the outside of the relay. Those with a hole for taking the locking wire shall be fitted with the hole to the rear of the relay. The machined side of the threaded hole for the Jewelled Bearing Assembly shall face the outside of the relay.

The Contact Carriage Bearing Screws shall be adjusted to centre the contact assemblies (items 2-13) over the carbon contacts (items 2-41). The end-play of the Contact Carriage shall be set to $0.020 - 0.022$ ". [CPS27]

Each Contact Carriage Jewelled Bearing shall be wire-locked, after adjustment to give the required end-float, in accordance with Figure B of this specification.