CHAPTER 2

PLESSEY WIRING SYSTEM

List of Contents

General

1. Prior to 1939, aircraft were wired for electrical services in much the same way as a house, factory or ship is wired; i.e. the individual cables were drawn into position, cleated down, and connected by conventional methods (screw terminals, etc.) to the various items of electrical equipment as the aircraft was being assembled. Such work had, of necessity, to be carried out by fully-skilled labour; other work on the assembly of the aircraft was liable to delay while the wiring was being installed, and the completed electrical installations of otherwise identical aircraft often differed in details of wiring. This latter feature of lack of wiring uniformity resulted in circuit tracing and fault location becoming a slow, uncertain process, and a relatively minor wiring defect could often render an aircraft unserviceable for a considerable period until the fault was laboriously traced and eventually rectified.

2. The war years of 1939—1945 saw rapid increases in the size and complexity of aircraft electrical installations, while at the same time the need for speed in the production of new aircraft and in the repair of damaged installations became imperative. A further difficulty arose from the scarcity of fully-skilled labour; unskilled or, at best, semi-skilled labour had to be utilized for assembly work, so that the very limited amount of fully-skilled labour could be employed exclusively on inspection, fault-location and similar duties requiring a considerable degree of knowledge and experience. This state of affairs resulted in the abandonment of the earlier "orthodox" methods of wiring, and a variety of proprietary wiring systems, in which almost all the wiring of the aircraft is pre-assembled into "wiring units", were introduced by a number of firms in the electrical industry. Each system had its own merits and defects, and in many instances the defects were considerable—so considerable, in fact, that with one exception these early efforts at "standardized" wiring have become obsolete. The exception just mentioned was the "Breeze" system; this system, now considerably modified and improved, was eventually re-named the Plessey Wiring System, and under this name it is still very extensively employed in Service aircraft.

Principle of Plessey Wiring System

3. In aircraft wired on the Plessey system the various cable runs of the installation are combined into 'cable assemblies', which generally terminate, at either end, in multiple-insert

sockets. These sockets mate with corresponding multiple-pin plugs mounted on the various items of supply, control or consumer equipment, with similar plugs fitted on the sides of junction boxes, or with double-sided plugs built into bulkheads, etc. The junction boxes provide convenient points at which small cable assemblies can be branched off from the main runs; they also permit the sub-division of the wiring into relatively short cable assemblies that can be removed and replaced with ease, and they afford a means of testing conductors at intermediate points between items of equipment. The arrangement of plug pins and socket inserts in the matching plugs and sockets is such as to render mis-mating, with consequent cross-connections in the circuits, a physical impossibility. A concise form of circuit coding and identification marking simplifies circuit tracing and fault location; every junction box, terminal, plug pin, socket insert, individual cable core and cable assembly is distinctively marked, and these markings are reproduced on the very detailed wiring diagrams supplied in the appropriate Air Publication or Air Diagram relating to the particular aircraft.

4. This technique results in a wiring system which can be pre-assembled and thoroughly tested on the bench before installation in the actual aircraft. The time taken to instal the wiring in the aircraft is quite short, since it involves only the fixing of junction boxes and the connection of the cable assemblies to the appropriate plugs. It provides ready accessibility for testing and fault-location; furthermore, a faulty section can be removed and replaced by a serviceable corresponding section (held as a spare for such contingencies). thus enabling the period of aircraft unserviceability by reason of wiring faults to be reduced to a minimum. Junction boxes and cable assemblies are specifically designed for a particular 'Mark' of aircraft, and to that extent they are non-standard items, but plugs and sockets (always the most vulnerable items) are, with few exceptions, drawn from the standard Plessey range of these components.

COMPONENTS

Standard Plugs and Sockets

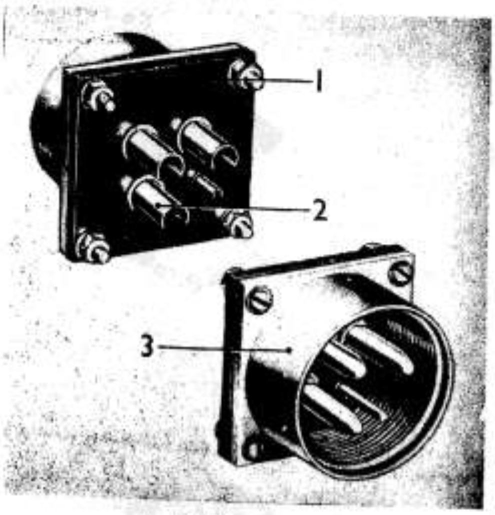
5. Since the majority of circuit connections in a Plessey wiring system are made by multiple-pin plugs and sockets, circuit defects are more likely to occur in these components than elsewhere. A sound knowledge of the construction, assembly and servicing of these items is therefore essential for all tradesmen whose duties are in any way concerned with the servicing of electrical equipment in aircraft.

6. Five types of standard multiple-pin plugs (three of single-sided construction and two double-sided types) and two types of standard multiple-insert sockets are in general use; these items are described in detail in subsequent paragraphs. Four sizes of plug pins and sockets inserts are used; these are rated for 7, 19, 37 and 64 amperes respectively (nominal continuous rating). Pin combinations available as standard plugs range from one to 27 pins (these may all be of one current rating, or pins of various ratings may be combined into one plug); a comparable range of standard sockets to mate with the range of standard plugs is also available. With the exception of single-pin plugs and single-insert sockets, the pins and inserts are always arranged in an asymmetric pattern that renders impossible any mis-mating of the plug and socket. All pins and inserts, which are made of brass and are silver plated, are marked for identification purposes; pins or inserts rated at 7 amperes are identified by a letter formed on the surface of the supporting moulding, while pins and inserts rated at 19 amperes or above are identified by a numeral—where *all* pins or inserts of a component are of 7 ampere rating they may, however, be numbered, instead of lettered, for purposes of identification. Cable cores are usually connected to the pins or inserts by crimping (swaging the end of the pin or insert over the bared end of the conductor); soldered connections are, however, still used on the earlier types of plugs.

7. **Fixed-Pin Plugs.** This is the original form of Breeze plug, and although classified as obsolete it is still in restricted use. The plug pins, which are permanently located in a one-

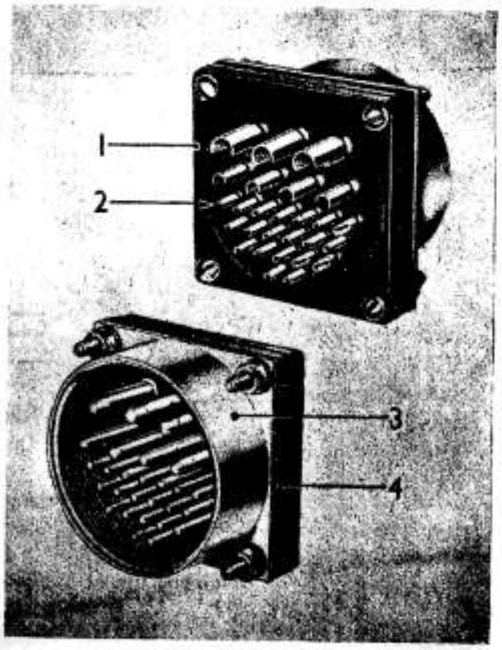
piece moulding, are recessed at the rear end (the end that projects into the junction box) to form solder buckets into which the cable ends are soldered. An aluminium plug shell, threaded internally to receive the externally-threaded shell of the matching socket, shrouds the plug pins; plug shell and moulding are secured to the junction box or other component by four 6 B.A. nuts and screws.

8. **Loose-Pin Plugs.** Two identical mouldings are used in this type of plug to position the centrally-flanged solder-bucket pins; the pin flanges are located between the front and rear mouldings to prevent lateral movement, but the pins are otherwise free. The plug shell is similar to that of the fixed-pin plug, and the complete assembly is retained by four 6 B.A. screws and nuts, which also serve for mounting the plug on the junction box. This range of plugs is classed as obsolescent, and is being replaced by the range of climatic-proof plugs described in the next paragraph.



1. Moulding.
2. Bucket-ended Pins.
3. Plug shell.

Fig. 1 SINGLE PLUG (FIXED PINS)

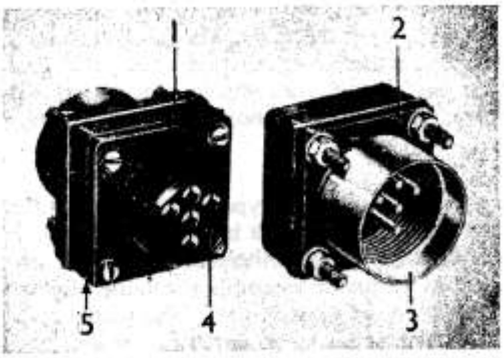


1. Rear Moulding.
2. Bucket-ended Pins.
3. Plug Shell.
4. Front Moulding.

Fig. 2. SINGLE PLUG (LOOSE PINS)

9. **Climatic-Proof Plugs.** The climatic-proof range of single-sided plugs has been developed for use in situations where the plug must be able to resist the entry of oil, water and humidity. The method of pin location is similar to that of the loose-pin type already described; the pins themselves are designed for attachment to the cable ends by crimping, while the rear moulding is extended to shroud the rear ends of all pins. Proofing is by means of three synthetic rubber gaskets; one gasket is located between the front and rear mouldings, a second is interposed between the front moulding and the plug shell, while the third covers the front of the flange on the plug shell. The component parts are retained by four 6 B.A. screws and nuts, which also serve for mounting the assembled plug.

10. **Flame-Proof Plugs.** The construction of this range of plugs is similar to that of the climatic-proof range described in the previous paragraph, except that the plug shell is of steel instead of aluminium.



1. Front Moulding.
2. Rubber Gasket.
3. Plug Shell.
4. Rear Moulding.
5. Rubber Gasket.

Fig. 3. SINGLE PLUG (CLIMATIC-PROOF)

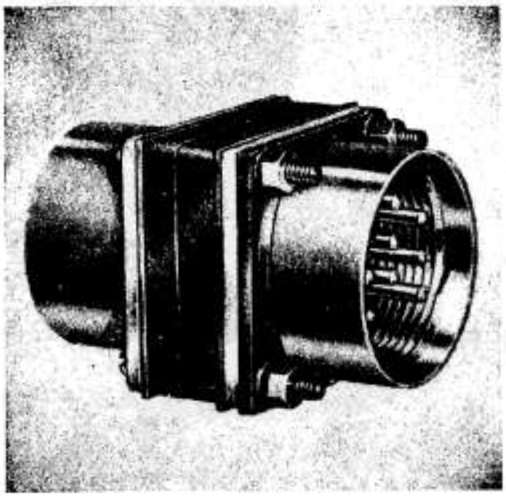


Fig. 5. BULKHEAD PLUG (CLIMATIC-PROOF)

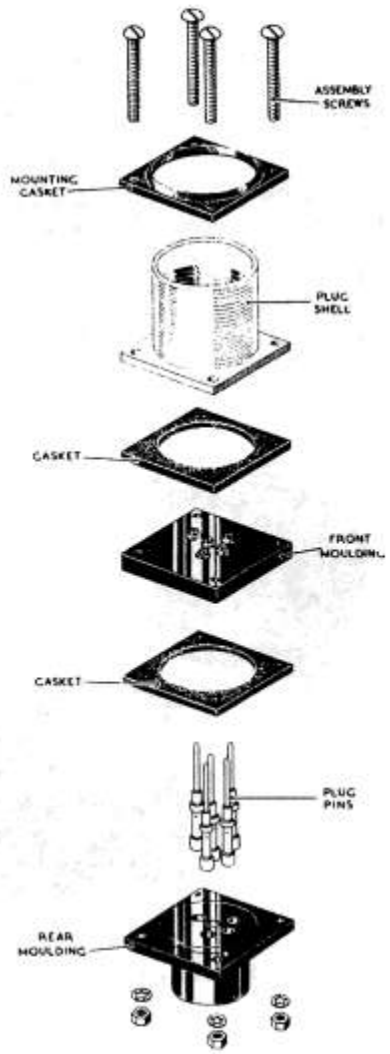


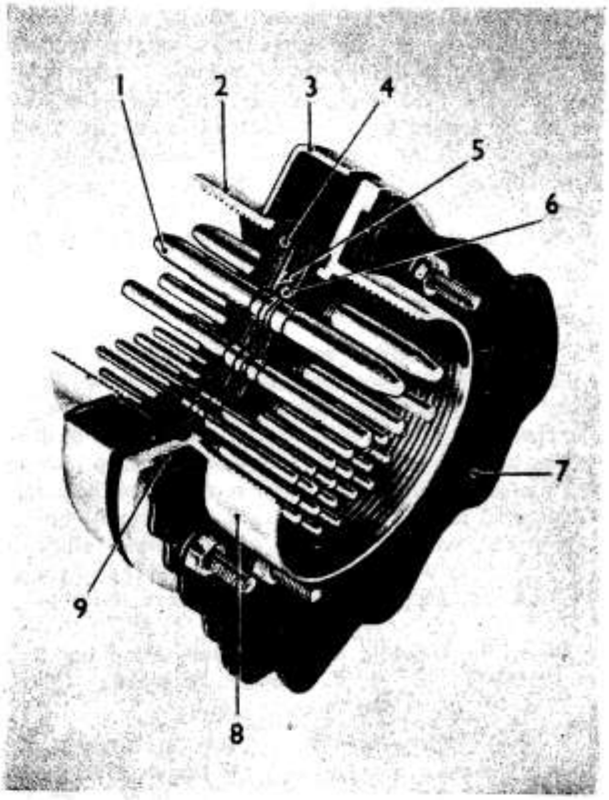
Fig. 4. EXPLODED VIEW OF CLIMATIC-PROOF PLUG

11. **Bulkhead Plugs (Climatic-Proof).** These plugs, which provide convenient breakdown points from either side of a bulkhead or similar fixture, consist of double-ended plug pins located by central flanges between two mouldings, with normal plug shells shrouding the plug pins on either side. A gasket is interposed between each moulding and its associated plug shell, while a third gasket is mounted on the flange of one of the plug shells.

12. **Bulkhead Plugs (Pressure-Proof).** The increasing use of pressurized cabins and pressurized equipment has led to the introduction of a range of bulkhead plugs that can withstand a differential pressure of 15 lb. per sq. in. between opposing faces. The double-ended centrally-flanged pins are held in the holes of two circular mouldings, the adjacent faces of which are coated with a sealing compound during assembly to seal the pins in the moulding. A plug shell with a wide circular flange is located on one moulding (a gasket is interposed between mating surfaces), and eight studs in this flange serve to mount the assembly to the bulkhead.

A standard plug shell fits on the other moulding and is retained in position by a cover ring secured to the rear ends of the mounting studs. The plug is supplied completely assembled and sealed; only the nuts and washers on the outer sides of the mounting studs need be removed before fitting the plug into the bulkhead.

13. **Climatic-Proof Sockets.** These sockets are used on the ends of cable assemblies that are not subjected to excessive vibration. The hollow socket inserts are positioned in stepped holes in the rear supporting moulding; a tag which is pressed out on each insert engages with



1. Plug Pins.
2. Standard Plug Shell.
3. Plug Cover.
4. Moulding.
5. Sealing Compound.
6. Moulding.
7. Bulkhead
8. Plug Shell (special).
9. Mounting Gasket.

Fig. 6. BULKHEAD PLUG (PRESSURE-PROOF)

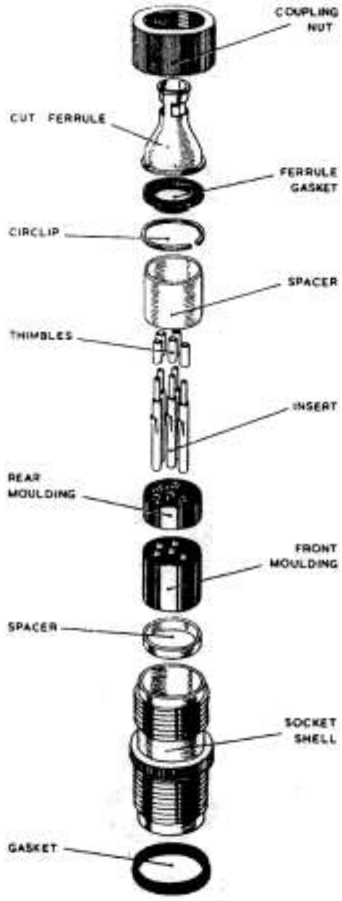


Fig. 7. EXPLODED VIEW OF CLIMATIC-PROOF SOCKET

a step in the hole to prevent the insert moving back, while the front moulding supports the inserts and prevents forward movement. The two mouldings, preceded by an insulating sleeve, are a loose fit in the socket shell; they are followed by a second (wider) insulating sleeve, and are retained in position by a circlip which fits into an annular groove inside the shell. The socket shell has a substantial flange formed on its outer surface, and both ends of the shell are threaded externally. The thread at the forward end engages with the internal thread of the matching plug shell, and a sealing gasket between the socket flange and the end of the plug shell makes the resulting joint watertight. The thread at the rear end of the socket shell accommodates the coupling nut which secures the conduit of the cable assembly to the socket. The cable ends are secured to the individual socket-inserts by crimping. The outstanding feature of this type of socket, when compared with the earlier types which it has superseded, is that the individual inserts, after being crimped to the cable ends, can be pushed into the previously-assembled socket—the inserts, when pushed home, automatically lock themselves in position, and cannot then be withdrawn except by using a special ejector tool.

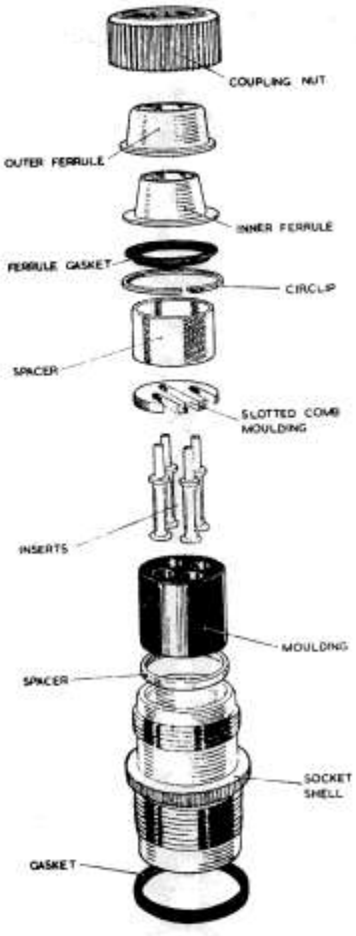


Fig. 8. EXPLODED VIEW OF VIBRATION-PROOF SOCKET

14. **Vibration-Proof Sockets.** These sockets, which are designed for use in positions where considerable vibration is likely to be experienced (e.g., forward of the engine bulkhead in piston-engined aircraft, differ from the climatic-proof type in the shape and method of location of the socket inserts. The inserts are turned from solid brass, and the external diameter is reduced at one point to form a locating gutter. After being positioned in the holes in the front moulding, the inserts are locked by a slotted comb moulding which passes through the insert gutters. Cable attachment is by crimping; other details of construction are as for climatic-proof sockets. This type of socket must be partially dismantled to replace inserts or to repair a broken connection.

Cable Assemblies

15. The term "cable assembly" is applied to any collection of cables that links two or more components. Most cable assemblies consist of single-core cables bunched in a flexible conduit, but occasionally braided cables without any further protective covering may be encountered. Where electrical screening of the cables is essential they are assembled in flexible aluminium tubing covered with braiding of aluminium alloy or tinned copper wire; alternatively, metal-braided cables (without conduit) may be used. Where screening is not necessary, polyvinyl chloride (P.V.C.) tubing replaces the metallic conduit; small assemblies may occasionally consist of non-metallic-braided cables, such as 'Pren' cables, without tubing.

> *Note.* Where screened cables or conduits are exposed to oil or other liquids, a length of P.V.C. tubing is usually fitted over the braiding to give additional protection.

16. **End Fittings.** The cables of a cable assembly may terminate in a multiple-insert socket for connection to a matching plug on the fixed item of equipment, or they may emerge as 'tails' from the cable assembly via a ferrule and be connected directly to conventional terminals on the fixed equipment. Details of end fittings are as follows:—

(*a*) *Screened Cable Assemblies* (*Socket Ends*). The conduit is secured to the socket shell by a coupling nut which retains the flange of a ferrule, swaged to the matallic conduit, against the end of the socket shell. Cables are crimped to the socket inserts.

(*b*) *Unscreened Cable Assemblies* (*Socket Ends*). The usual method of attaching the P.V.C. conduit to the socket shell is by inner and outer ferrules (*see Fig.* 9); the inner ferrule is located in the end of the tubing, the outer ferrule is then squeezed over the tubing and inner ferrule, and the flanges of both ferrules are held together against the end of the socket shell by a coupling nut—the tubing is firmly gripped between the tubular portions of the two ferrules. Alternatively, a ferrule with a cylindrical body and flanged end (*see Fig.* 10) is inserted in the P.V.C. tubing, and a pinch or screw-type clamp ring is passed over the tubing and the ferrule body, behind the coupling nut—the coupling nut retains the flange of the ferrule against the end of the socket shell in the usual way

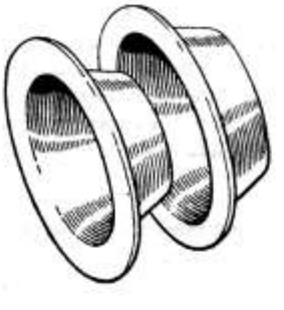


Fig. 9. INNER AND OUTER FERRULES

Fig. 10. FERRULE FOR PLASTIC TUBING

Fig. 11. CUT FERRULE (ROUND BASE)

(*c*) *Braided Cable Assemblies* (*Socket Ends*). The cables are passed through a trouser sleeve and a cut ferrule (*see Fig.* 11), in that order, before being attached to the socket inserts; the flange of the cut ferrule is located against the end of the socket shell by the coupling nut, the trouser is then pulled over the ferrule, and is secured in position by binding with waxed twine.

(*d*) *Unscreened Cable Assemblies* (*Direct Entry*). Where direct entry into a junction box is to be made by an unscreened (tubular) assembly, a ferrule with a tubular body and square end plate (*see Fig.* 13) is mounted on the side of the box, The end of the P.V.C. tubing passes over the body of the ferrule and is secured by a clamp ring.

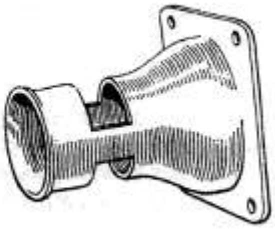


Fig. 12. CUT FERRULE (SQUARE BASE)

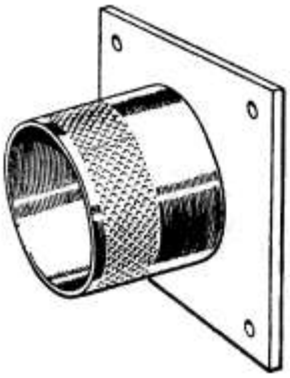


Fig. 13. FERRULE PLATE ASSEMBLY

(*e*) *Braided Cable Assemblies* (*Direct Entry*). A cut ferrule with square end-plate (*see Fig.* 12) is mounted on the side of the box; the cables are taken through the ferrule and secured by binding with waxed twine through the cut of the ferrule. Tinned copper wire is used for binding metal-braided cables to the ferrule.

(*f*) *Single Cables* (*Direct Entry*). A synthetic rubber grommet, the external diameter of which is reduced at the mid-point, is fitted over the cable and is then sqeezed into the appropriate hole in the side of the box or panel; it is retained in position by the groove formed on the outer surface.

17. **Socket-Insert Connections.** The individual cores of cable assemblies, when attached to sockets, are connected to the inserts by crimping. This form of connection is much less susceptible to breakage, under conditions of vibration, than is the soldered type of connection which was formerly used for this purpose. Additional protection is given to the crimped joint by covering it with a rubber sleeve to act as a shock absorber. In some cases the sleeve bears a letter or a number that corresponds to the identification of the socket insert; where plain sleeves are used a marker ring is placed over the core to provide identification. Where both ends of a cable assembly terminate in identical sockets, the ends of each individual cable core are always attached to socket inserts bearing similar identification markings, e.g., a cable core which is attached to insert A at one end of the assembly is invariably attached to insert A of the socket at the other end.

18. **Helvin Split Sleeves.** Where several minor braided cable assemblies (no tubing) are connected to one multi-insert socket, or where such assemblies enter a junction box through a single ferrule, a special form of sleeve is used to prevent the entry of oil, water, etc., into the socket or junction box. It is simply a main sleeve with smaller sleeves moulded on to one end. Each cable assembly is fed through one of the smaller sleeves into the main sleeve, which is then pulled over the cut ferrule to its full extent and bound firmly in place.

Junction Boxes

19. The junction boxes used in the Plessey wiring system have two functions—they are primarily splitter points, at which individual wires are connected to a common feed or return wire, but they also serve as breakdown points for ease of assembly and dismantling of the wiring units. As a general rule, junction boxes are light metal structures that contain several multiple terminal blocks and, in some cases, multiple fuse-holder blocks. Multiple-pin plugs serve as outlets to socket-type cable assemblies; other cable assemblies enter the box by plate-end ferrules or, in the case of single cables, through grommets. Wiring within the box is crimped or, exceptionally, soldered to the ends of the plug pins, the opposite ends of the internal wires being attached to the terminals of the terminal blocks or fuse-holder blocks. Direct wiring between pins of two outlet sockets is sometimes adopted if no splitting of a particular wire is required, but it is more usual to connect such pins together via a terminal in the box, since this simplifies testing and fault tracing procedures. Fasteners for the lid of the box are of conventional Oddie type.

20. **Terminal Blocks.** The original form of terminal block consisted of a moulded strip in which a number of screw studs were mounted; the wiring was connected by plate-type terminals secured by nuts and spring washers. This type of block has been superseded, to a large extent, by an improved form of quick-release block, in which a clamp channel, a spring, and a terminal coding plate are located beneath the head of a screw. The screw, when tightened, presses down on the terminal coding plate, beneath which is the quick-release tag of the wire. The tag is cranked to match similar cranks in the coding plate and the base of the block, thus providing an exceptionally secure mechanical connection. The blocks are available with 2, 3, 5, 10 or 20 terminals; in the latter type two rows of ten terminals are fitted on a single base-plate. Permanent connection of from two to ten adjacent terminals is possible by the use of connecting links.

21. **Fuse Blocks.** Standard fuse-holder blocks, like standard terminal blocks, are being superseded by quick-release components. The method of connecting the individual wires to the fuse-holders is similar to that used on quick-release terminal blocks. To facilitate removal and insertion, the fuses may be carried in fuse extractors; alternatively the fuse extractors may be omitted and the fuses covered by a transparent cover. Commoning

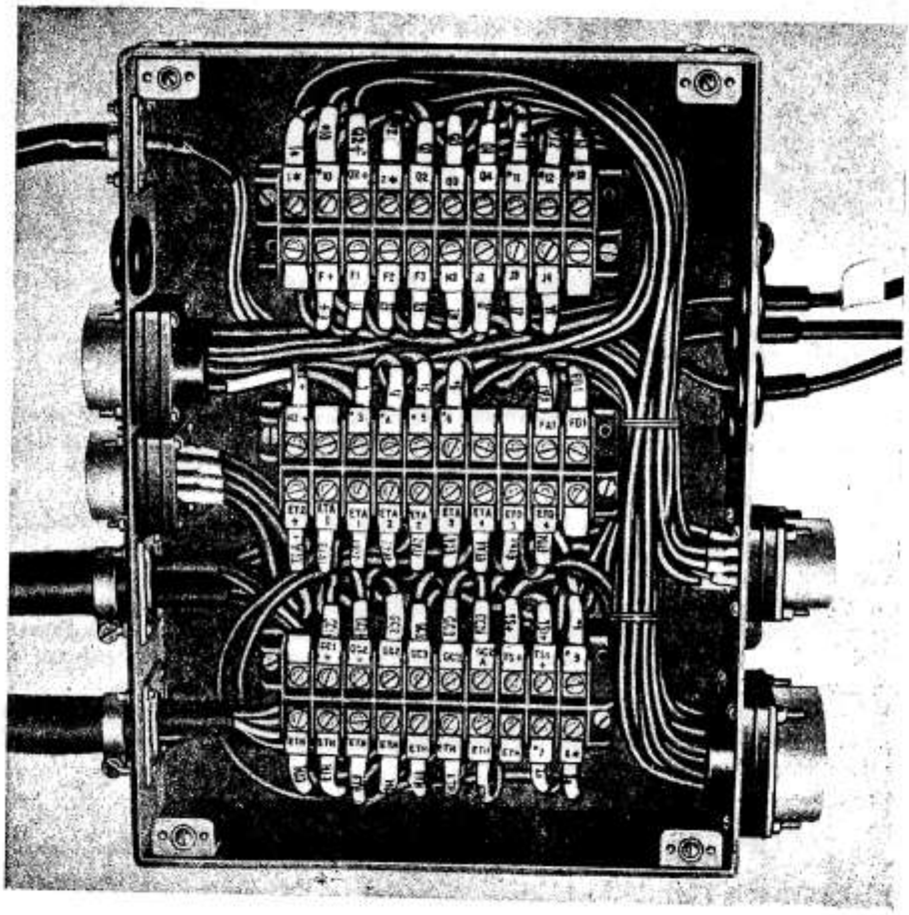


Fig. 14. TYPICAL JUNCTION BOX

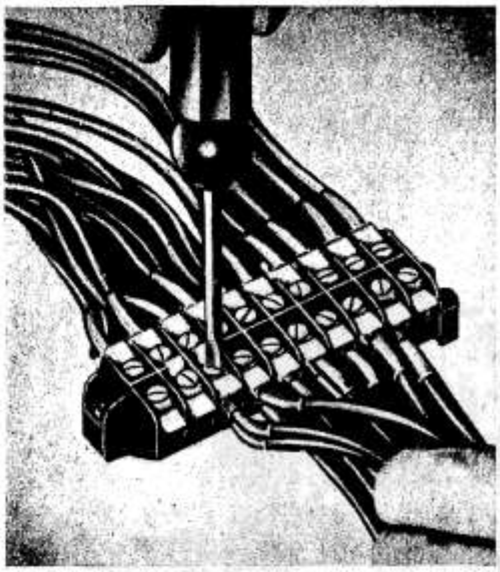


Fig. 15. QUICK-RELEASE TERMINAL BLOCK

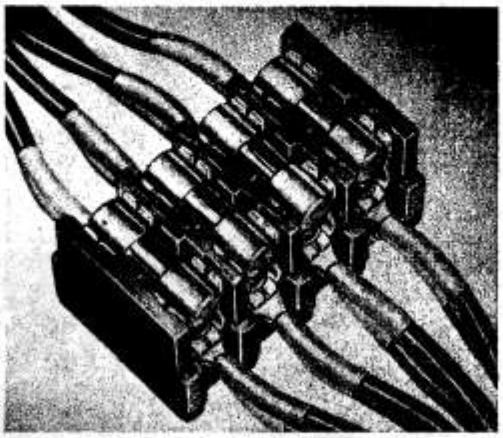


Fig. 16. QUICK-RELEASE FUSE BLOCK

links are used to connect adjacent fuse-holders to a common supply, where this is necessary; the method adopted is similar to that used when linking individual terminals on a terminal block.

22. Every terminal in a junction box is clearly marked with circuit and wire references (*see Paras.* 23—26). This marking is repeated on the quick-release tags of the internal wires connecting the terminals to the pins of the outlet plugs on the sides of the box; in the older boxes fitted with stud terminals the reference marking is painted or etched on the surface of the terminal block immediately adjacent to the terminal in question, and is repeated on a marker sleeve near the end of the internal wire that is to be attached to the terminal. The other ends of the box wires, i.e., the ends attached to the plug pins, carry markers showing the letter or numeral of the appropriate pin. Where a cable assembly enters a box through a grommet or ferrule, each individual core is marked, near the end, with the reference of the terminal to which it is to be attached.

CIRCUIT IDENTIFICATION AND CODING

Coding System

23. Circuit tracing in aircraft fitted with the Plessey wiring system is facilitated by a comprehensive system of marking all components of the installation, and by reproducing these markings on very detailed wiring diagrams. The marking is in accordance with a pre-arranged code; minor variations in the code are introduced by individual aircraft manufacturers, and subsequent paragraphs describe the coded system of marking used in Canberra aircraft.

24. Each circuit, or group of allied circuits, in the complete installation is allocated a code reference letter or group of two letters. For example, the power supply and main distribution circuits are allocated the code letter P, circuits supplying the external lighting equipment have the reference letter L, while the negative circuit (covering all connections from the negative terminals of equipment to earthing points) is referenced E. The appropriate code reference letter is embodied in the coded markings of junction box and panel terminals that form part of a particular circuit.

25. To avoid confusion between terminals of the same circuit, every circuit is divided into "wires"; each "wire" of a circuit is given a reference number, and this number, used as a suffix to the appropriate circuit letter, forms the code marking of individual terminals. A "wire" is considered to be a single conductor between two operative components, e.g., between a fuse and a switch, between a switch and a lamp, etc.—junction boxes, bulkhead plugs, etc., do NOT rank as operative components when the identity of a "wire" is being considered. A "wire" may therefore consist of several individual lengths of conductor connected in series through various junction boxes and plugs, and each such length bears the same wire reference as its predecessor. If a conductor splits at a terminal to form two or more branches, then each branch is still considered as part of the original "wire", and all such branches bear the same wire reference.

26. The basic wire reference is given to the wire connected to the fuse or circuit breaker feed point; e.g., the wire from the navigation lamps fuse to the navigation lamps switch is referenced L1, the wire that connects the taxying lamps fuse to the taxying lamps switch is referenced L2, the wire between the fuse and the control switch of the landing lamps circuit is given the reference marking L3, while the wire connecting the landing lamp filament to its supply fuse takes L4 as its reference. After each change of operative equipment, such as a switch or relay, the reference number of the wire undergoes a modification; whenever possible the modification consists of an addition to the basic reference. For example, the wire between the navigation lamps switch and the actual lamps is referenced L13; the corresponding wire in the taxying lights service has L21 as its reference, while the three wires between the landing lamp control switch and the landing lamp motor become L31, L32, and L33 respectively. Wires connecting the negative terminals of equipment to earthing points bear the reference letter E, with the coded number of the earth point as a suffix; e.g., the cables connecting the starboard navigation lamp and the starboard taxying lamp to earth point No. 10 are identified by the code reference E 10, while the negative cables of the port navigation and taxying lamps connected to earth point No. 9, are coded E9. As has been previously stated, all terminals in junction boxes and panels carry the circuit and wire references of the particular portion of the circuit in which they are incorporated.

27. Junction boxes are identified by the prefix J.B. followed by a number, e.g., J.B.2, J.B.7, etc.; this identification marking is shown on the lid or cover of the box. A cable assembly that extends between two wiring fitments (junction boxes, panels or bulkhead plugs) is identified by a code latter with a numeral suffix; this identification marking is shown on sleeves fitted at either end of the assembly, and the same marking appears on the plug outlets (or ferrule outlets) to which the assembly is attached. The letter of the marking is an indication of the position in the aircraft occupied by the cable assembly; assemblies bearing the identification letters N, F, C, T, S or P are located in the nose, front fuselage, centre fuselage, tail (or rear fuselage), starboard wing or port wing respectively. Where a cable assembly leaves a junction box for an item of operative equipment, the assembly takes the number of the junction box as the initial reference, followed by an identification letter. For example, cable assemblies leaving J.B.3 for different items of equipment would be marked 3A, 3B, 3C, etc.

28. The foregoing method of marking junction boxes and cable assemblies applies specifically to Canberra aircraft, and has been described in detail because typical wiring diagrams for this particular aircraft are illustrated in this Chapter. Full details of circuit coding and references for each type of aircraft in Service use are always given in that Section of the aircraft Air Publication which is devoted to the electrical and instrument installation, and it is suggested that the reader should examine any such information on other aircraft types which may happen to be available to him.

Wiring Diagrams

29. No tradesman can carry out fault location and rectification procedures on a modern aircraft in an efficient and expeditious manner unless he

(*a*) Is able to locate every individual item of electrical equipment, both operative and wiring, throughout the aircraft

(*b*) Has an adequate knowledge of the operating principles and circuitry of all electrical equipment.

(*c*) Is able to trace the individual circuits through all the compact complexity of junction boxes, panels, and cable assemblies.

Information on operational principles of all electrical equipment used in aircraft can be obtained from the appropriate volumes of the 4343 series of Air Publications, but information relating to the location and circuitry of equipment fitted in a particular type of aircraft is obtainable only from diagrams contained in the Air Publication that is relevant to that aircraft, or from specially prepared Air Diagrams.

30. Three sets of diagrams are incorporated in the aircraft Publication; they are as follows:—

(*a*) *Location Diagrams.* These are generally perspective views of the aircraft, cut away as necessary to show enclosed items of equipment in their actual positions in the aircraft. Insets of panels, showing the details of equipment fitted to these fixtures, are also included. Cable assemblies are not shown on Location Diagrams.

(*b*) *Schematic Diagrams.* These are purely theoretical drawings of the electrical services of the aircraft—they show how the components of each circuit would be interconnected if laid out, in close proximity to each other, on a bench or table. These diagrams are generally interspersed with the descriptive text in the Electrical and Instrument Section of the Publication, and in many instances the appropriate circuit and wire coding is also shown.

(*c*) *Routing Charts.* These drawings are concerned solely with the practical details of circuitry; they afford complete information on the actual route taken by each wire of a circuit, indicating not only the junction boxes, bulkhead plugs and cable assemblies through which the individual wires pass, but also the specific pins of plugs, inserts of sockets, and junction box terminals that form part of the circuit. Types and sizes of individual cables are also indicated.

Routing Charts

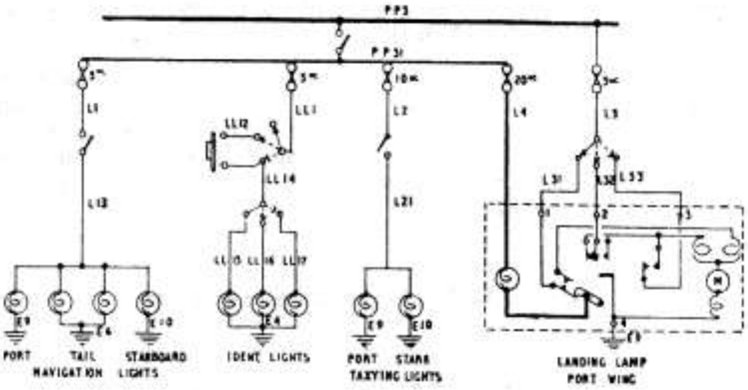
31. The circuits of part of the external lights services of a Canberra aircraft are shown, in routing chart form, in Fig. 17. This diagram may, at first sight, appear complicated and difficult to understand; this impression is quite erroneous—it arises from the unorthodox method of circuit presentation—and in practice the task of tracing a particular circuit is considerably simplified by the use of the routing chart.

32. The chart consists essentially of a straight-line circuit diagram (with the circuit lines arranged horizontally as far as possible) superimposed on a background of vertical columns. The chart in this particular instance is divided into six main columns; five of the columns represent the principal locations in the aircraft, viz., the pressurized cabin, the unpressurized portion of the front fuselage and the centre fuselage, the rear fuselage and tail portion, and the two mainplanes. Each location column contains smaller equipment columns; e.g., the cabin section contains two sub-columns which represent the pilot's console and the electrical control panel, while the front and centre fuselage section has sub-columns that represent the main distribution box and junction box No. 1. The sixth main column, on the extreme left, gives the title of the particular electrical service, together with the basic reference (*see para.* 26) of the individual circuits of the service.

33. Each terminal in a junction box, distribution box, or panel is indicated by a small lozenge, in which is inserted the code reference actually marked on the terminal. Where connection is made to the box by a plug and socket, the connection is indicated by a dot on the circuit line, and a code group (above the circuit line and adjacent to the dot) indicates the identification mark of the appropriate cable assembly and plug pin. For example, the code group C10—D, shown adjacent to the dot on the upper right-hand side of the distribution box column in the diagram, indicates that the individual conductor connected to terminal L21 in the box is continued, via pin D of the multi-pin plug marked C10, to cable assembly C10. Where, however, a terminal in a box is shown connected by a plain line, without a dot at the point of entry into the box, it must be assumed that entry is by ferrule or rubber grommet; in such cases the cable assembly marking only is shown above the circuit line, with the colour of the individual core if the cable assembly consists of one multi-core cable.

Use of Diagrams

34. The very complete information that is available from the full range of wiring diagrams (i.e., schematic, routing and location) will be appreciated if a thorough study is made of one particular circuit of a specified service, e.g., the landing lamp filament circuit of the external



EXTERNAL LIGHTING L

Fig. 18. TYPICAL SCHEMATIC DIAGRAM

lights service. The first step is an examination of the schematic diagram (Fig. 18): this shows that the landing lamp filament is supplied from sub-feeder PP3 through the external lights master switch, wire PP31, a 20-ampere fuse, and wire L4; the negative contact of the filament lamp is connected to earthing point No. 9 via the moving contact arm of the lamp through wire E9.

35. Turn now to the routing chart (Fig. 17). Sub-feeder PP3 is shown in the column headed CONSOLE; it is connected through the external lights master switch and wire PP31 to fuse No. 100, which is also located on the console. From the fuse the circuit continues, as wire L4, to pin No. 1 of the multi-pin plug outlet marked N72. Here the circuit is transferred to insert No. 1 of the multi-insert socket attached to one end of the cable assembly marked N72, from which it is continued, as Unipren 12 cable, to the corresponding socket insert at the other end of the cable assembly. At this end cable assembly N72 is connected to a pressure-proof bulkhead plug built into the bulkhead of the pressurized cabin, and the circuit picks up pin No. 1 of this plug. Note that the line representing the circuit cuts straight

across the column headed ELECTRICAL CONTROL PANEL; the absence of dots or terminal signs on the line indicates that the cable assembly N72 runs directly between the console and the cabin bulkhead plug, and does NOT enter the electrical control panel.

36. From pin No. 1 on the unpressurized side of the cabin bulkhead plug the circuit continues through cable assembly F72 to terminal L4 in the distribution box located in the front fuselage. No dot is shown at the point of entry into this box; entry is therefore understood to be via a ferrule marked F72. At terminal L4 in the box the single Unipren 12 cable which carried the circuit through cable assembly F72 is converted into two Unipren 6 cables; these are connected to pins G and L of the plug outlet marked C9 on the side of the distribution box. From this point the circuit continues as two Unipren 6 cables, attached to socket inserts G and L of cable assembly C9, to pins G and L of a second bulkhead plug, this time located at the port wing root.

37. From pins G and L of the wing-root bulkhead plug the circuit continues, still as two Unipren 6 cables, through cable assembly P9, to enter junction box No. 9 by pins G and L of a plug entry marked P9. Here the two Unipren 6 cables unite at terminal L4, and the circuit continues as the white core of a Quinpren 6 cable marked 9D. This Quinpren 6 cable leaves JB9 by a cut ferrule (note the absence of dots on the circuit line) marked with the letter D, and is connected by a multi-pin socket to a five-pin plug on the housing of the landing lamp, the white core being connected to pin 5. Pin 4 of the plug is connected internally to the negative of the lamp; the negative circuit is therefore through the yellow core of the Quinpren 6 cable 9D to terminal E9 in JB9, and thence to earthing point No. 9.

38. We are now in possession of all necessary data relating to cable assemblies, junction boxes, panels, bulkhead plugs, etc., through which the circuit of the landing lamp filament passes. The actual position in the aircraft of each component to be found in the circuit can now be ascertained by consulting the location diagram (Fig. 19). With such complete information at his disposal the competent electrical tradesman should be capable of locating any circuit fault with a minimum of delay.

ASSEMBLY AND SERVICING

Introduction

39. One outstanding advantage of the Plessey wiring system is the ease and speed with which a defective wiring unit can be removed and replaced with a serviceable spare unit of the same pattern, thus ensuring that any period of electrical unserviceability arising from wiring faults is reduced to a minimum. Although a certain number of spare units can be held in stock as replacements, defective units must be repaired without delay so that they are again available, in their turn, for use as future replacements. Electrical tradesmen must therefore be able to

(*a*) Repair and re-assemble cable assemblies (or, in emergency, construct complete assemblies from standard components).

(*b*) Overhaul the internal wiring of junction boxes and panels, and replace damaged plugs.

(*c*) Make emergency repairs when complete replacement of a defective wiring unit is not practicable.

(*d*) Maintain the wiring system in the highest possible state of efficiency.

Connecting Sockets to Plugs

40. The following procedure must always be adopted when connecting the sockets of cable assemblies to rigidly mounted plugs:—

(*a*) Slacken the rear coupling nut of the socket so that the socket shell can be rotated without twisting the cables of the cable assembly.

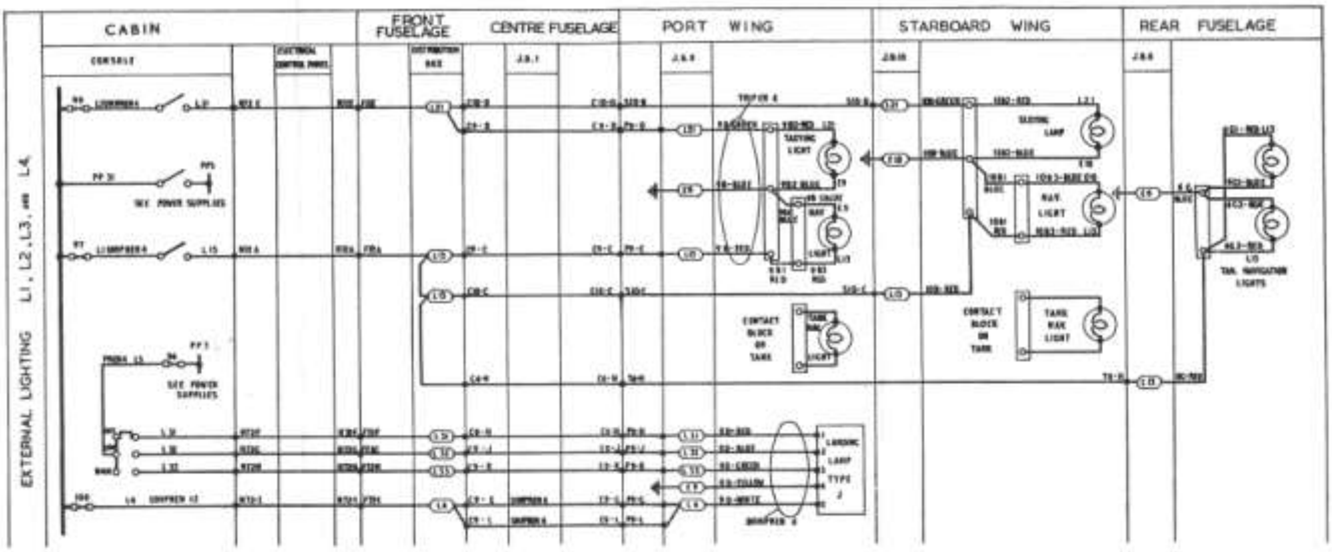


Fig. 17. TYPICAL ROUTING CHART

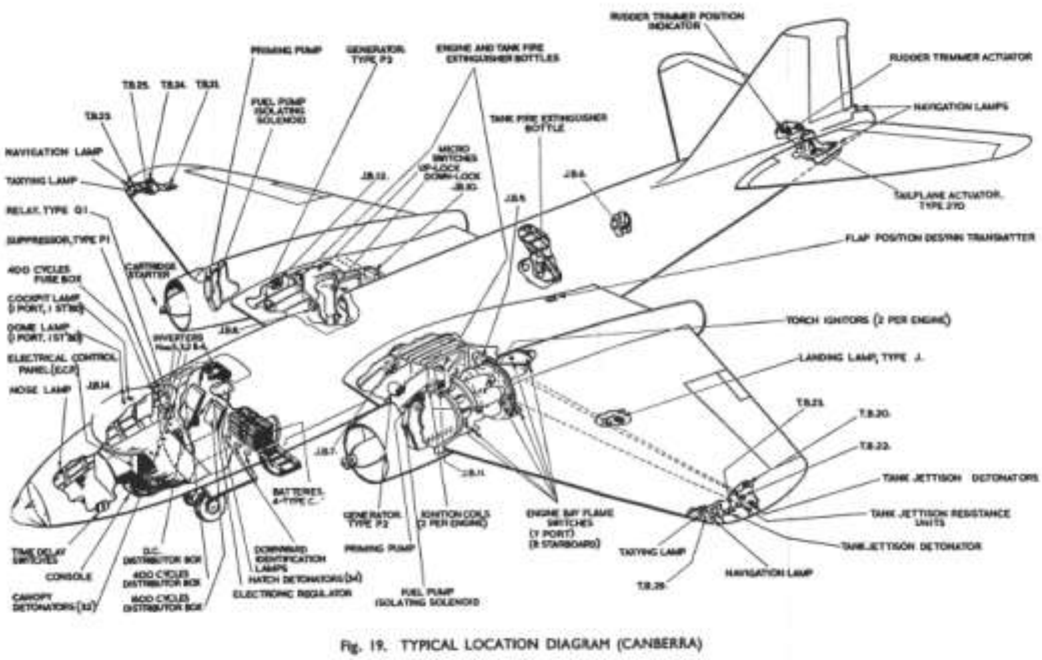


Fig. 19. TYPICAL LOCATION DIAGRAM (CANBERRA)

(*b*) Mate the inserts of the socket with the pins of the plug.

(*c*) Mate the internal thread of the socket shell with the external thread of the plug shell and tighten up *finger-tight*.

(*d*) Screw up the rear coupling nut *finger-tight*.

41. To uncouple a socket from a plug, first slacken off the rear coupling nut, then unscrew the socket shell from the plug shell. Never attempt to unscrew the socket shell before the coupling nut has been slackened, since this will inevitably lead to kinking of the interior

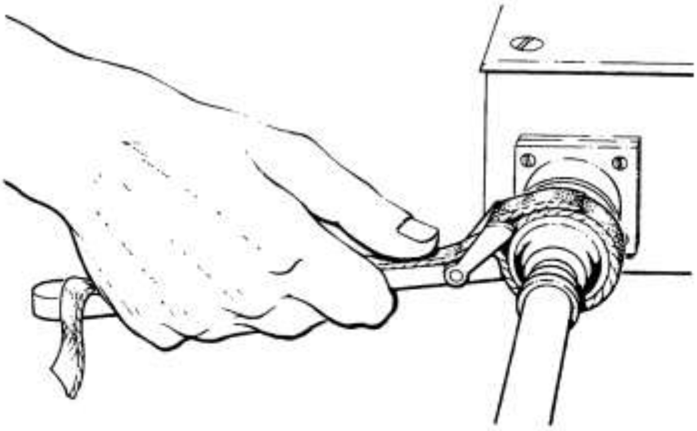


Fig. 20. USE OF STRAP WRENCH
(FOR SLACKENING OFF ONLY)

cables. If difficulty is experienced in slackening the rear coupling nut or the socket shell—this may occur when components have been undisturbed for long periods—it is permissible to use a strap wrench for this purpose. *Under no circumstances are strap wrenches to be used for tightening*.

Fitting New Sockets

42. A large proportion of circuit faults and defects occur at the socket ends of cable assemblies; these defects range from a single broken connection or a defective socket insert to mechanical damage of the socket shell or failure of the interior mouldings which retain the socket inserts. The following paragraphs describe in detail the procedure for fitting a new socket (climatic-proof, with crimped connections) to bunched braided cables.

43. **Preparation.**

(*a*) Remove the coupling nut, cut ferrule, and ferrule gasket from the rear end of the socket; remove the circlip from its groove in the rear of the socket shell; withdraw the insulating sleeve and both mouldings, together with the socket inserts.

(*b*) Bare the end of each cable core sufficiently for the exposed conductor to lie along the narrow section of the socket insert.

(*c*) Fit a trouser sleeve, the coupling nut, cut ferrule, ferrule gasket, circlip, and insulating sleeve (in that order) over the bunched cables.

44. **Crimping.**

(*a*) Fit a crimping thimble over the rear end of the first socket insert; locate the exposed conductor of the appropriate cable end in the insert.

(*b*) Settle the thimble centrally in the jaws of the crimping tool, then squeeze the handles of the crimping tool with a firm smooth action.

(*c*) Remove the insert from the crimping tool jaws; ensure that the thimble and insert are fully and tightly swaged about the cable end.

(*d*) With the aid of the Hellerman stretching tool, pass a marker sleeve over the newly-made joint.

(*e*) Repeat the foregoing process for each of the remaining cables and inserts.

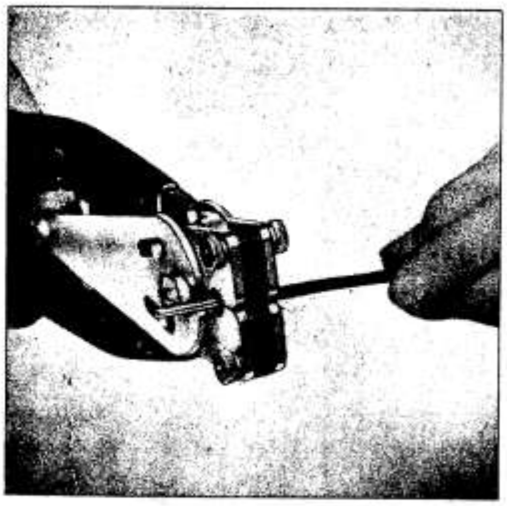


Fig. 21. CRIMPING OPERATION

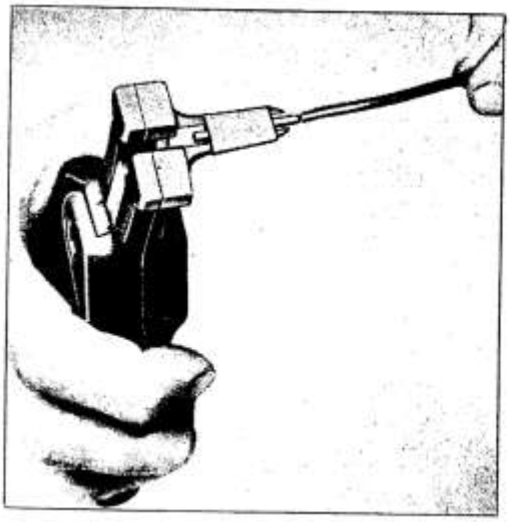


Fig. 22. FITTING MARKER SLEEVE

45. **Re-assembly.**

(*a*) Line up the front and rear mouldings; with the two mouldings held together by the thumb and forefinger, push each insert into the correct hole in the rear moulding (as determined from the marker sleeve) until it locks in position.

(*b*) Re-assemble the two mouldings and insulating sleeve in the socket shell; fit the circlip to retain them in position.

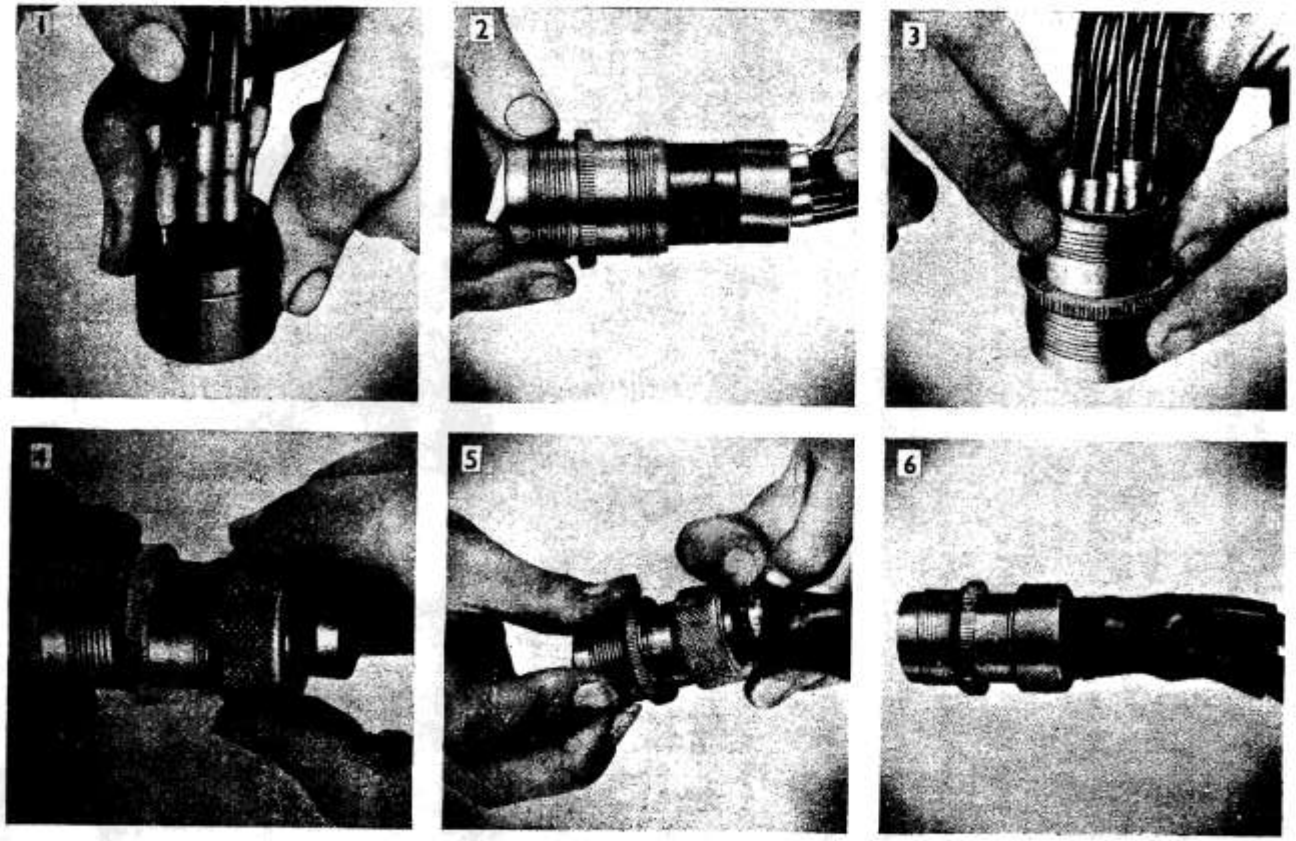
(*c*) Slide up and locate the ferrule gasket against the end of the socket shell; locate the flange of the cut ferrule against the gasket; screw up the rear coupling nut.

(*d*) Pull up the end of the trouser sleeve over the cut ferrule; bind securely in position with waxed twine.

46. **Vibration-Proof Sockets.** The procedure for fitting vibration-proof sockets, using cables in P.V.C. tubing with inner and outer ferrules, is as follows:—

(*a*) *Preparation.* Dismantle the socket. Thread the coupling nut and the outer ferrule, in that order, over the cables and the P.V.C. tubing, followed by the inner ferrule, the ferrule gasket and the insulating sleeve over the cables only. Prepare the cable ends as in para. 41(*b*).

(*b*) *Crimping.* Crimping thimbles are not used in vibration-proof sockets; after the bared cable end has been fitted into the duct of the insert, the rear end of the insert is placed direct in the jaws of the crimping tool. Apart from this detail, the procedure is as described in para. 42.



1. Locating the insert in the mouldings.
2. Assembling mouldings to socket shell.
3. Fitting the retaining circlip.
4. Fitting the coupling nut.
5. Positioning the trouser sleeve.
6. Assembled socket.

Fig. 23. SOCKET ASSEMBLY SEQUENCE

(c) *Re-Assembly*. Locate the inserts in the appropriate holes in the main moulding; lock them in position by sliding the comb moulding into place. Load the mouldings and the insulating sleeve into the socket shell; replace the circlip. Locate the ferrule gasket, followed by the inner ferrule, against the rear end of the socket shell; work the P.V.C. tubing over the body of the ferrule. Work the outer ferrule over the P.V.C. tubing towards the flange of the inner ferrule; screw up the coupling nut to squeeze together the inner and outer ferrules, thus anchoring the P.V.C. tubing.

Fitting New Plugs

47. **Climatic-Proof Plugs.** These plugs must be dismantled to make the crimped connections to the plug pins. The procedure to be followed is detailed below:—

(*a*) Remove the four nuts and screws which retain the plug assembly.

(*b*) Feed the cables through the correct holes in the rear moulding.

(*c*) Bare the cable ends; enough insulation should be trimmed off to allow the conductor to enter the pin recess to the full extent, while ensuring that the bucket end of the pin shrouds the end of the insulation. Fit the prepared cable end into the pin recess.

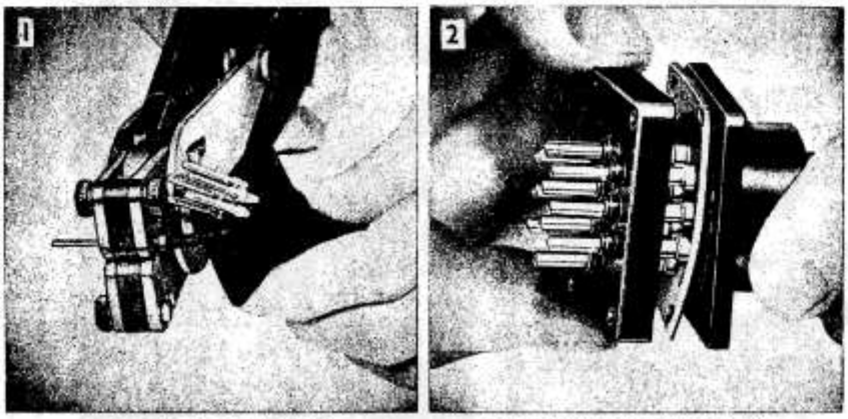
(*d*) Place the reduced diameter of the plug pin in the jaws of the crimping tool; squeeze the tool handles firmly to swage the pin to the cable conductor.

(*e*) Using the Hellerman stretching tool, fit the appropriate marker sleeve behind the plug pin.

(*f*) When all cables have been crimped to the plug pins, replace the sealing gasket and feed the pins through the front moulding.

(*g*) Replace the second gasket, the front shell, and the mounting gasket. Offer up the assembly to the entry hole in the box or panel, and secure with the nuts and screws originally removed when dismantling the plug.

48. **Soldered-Pin Plugs.** No dismantling of the plug is necessary when replacing a plug of this type. A marker and a rubber sleeve must first be placed on each core (use the Hellerman tool for this purpose), and the insulation must then be cut back sufficiently to allow the bared conductor to occupy the full length of the solder channel in the rear end of the plug pin. After soldering the conductor to the pin, work the rubber sleeve over the soldered joint to form a protective covering.



1. Crimping the Plug Pins. 2. Positioning the Front Moulding

Fig. 24. ASSEMBLING THE PLUG (CLIMATIC-PROOF)

Renewing Cables

49. A single defective cable in a conduit cable assembly that is fitted with climatic-proof sockets is replaced in the following manner:—

(*a*) Remove both sockets of the cable assembly from their associated plugs.

(*b*) Completely unscrew the coupling nut of one socket so that the conduit is disconnected from the socket shell; pull back the conduit as far as possible to expose the cable cores.

(*c*) Working from the front end, insert the socket ejector tool in the appropriate hole in the socket moulding, and eject the insert. Repeat the same process at the other end of the cable assembly.

(*d*) Remove the ends of the defective cable from the bunching sleeves that hold the cables together at either end; cut off the socket inserts.

(*e*) Secure one end of the new length of cable to one end of the cable that is to be replaced; using the old cable as a draw-wire, pull the new cable into the conduit.

(*f*) Cut the new cable to length; crimp on the socket inserts; fit the appropriate marker sleeves; tuck the ends of the cable through the bunching sleeves.

(*g*) Push the inserts of the new cable into the vacant holes in the rear moulding of the sockets; make certain that each insert locks into position.

(*h*) Connect the conduit to the socket shells by engaging the rear coupling nuts; do NOT tighten the coupling nuts at this stage.

(*j*) Connect the sockets to their plugs, as described in para. 40.

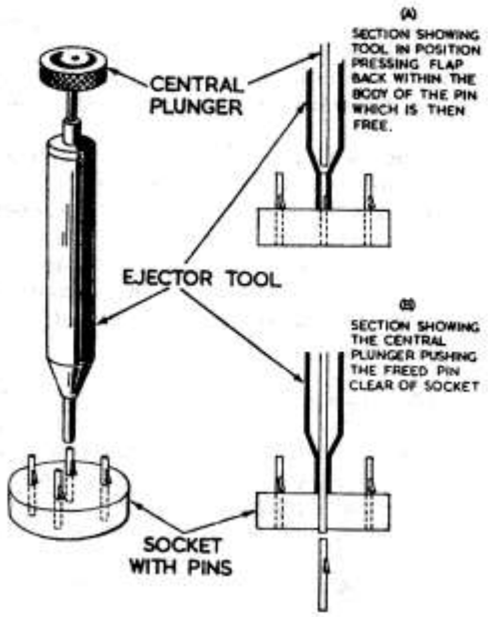


Fig. 25. SOCKET EJECTOR

50. The foregoing procedure is modified, when vibration-proof sockets are being fitted, in the following particulars:—

(*a*) After disconnecting the coupling nut from the socket and exposing the cables, remove the socket circlip and the insulating sleeve; push these back as far as possible.

(*b*) Working from the front of the socket, push out the mouldings just sufficiently to permit removal of the comb moulding.

(*c*) Remove the inserts of the damaged cable, then proceed as in para. 49(*d* to *f*).

(*d*) Fit the inserts of the new cable into the vacant holes in the main moulding, replace the comb moulding, and re-assemble the socket.

General Servicing

51. **Lubrication.** Correct lubrication of the threads of plugs and sockets is essential; low-temperature grease XG-290 is approved for this purpose, and no other grease is to be used for the lubrication of the threads. The lubricant must be free from dirt, it should be applied sparingly, and all excess grease must be wiped off. The need for correct lubrication and scrupulous cleanliness of threads cannot be over-emphasised—neglect of this precaution leads inevitably to seizure and damage.

52. **Protection.** All plugs and sockets, when not in use, must be protected with fibre caps; these caps prevent the ingress of dirt and swarf, and protect the external threads of socket shells.

53. **Alignment.** Coupling nuts must never be cross-threaded or forced on to socket shells; the same precaution applies when connecting a socket to a plug. Should excessive tightness be felt when connecting a plug and socket the cause should be investigated immediately before proceding further; the tightness *may* be due to lack of lubrication, but it is much more likely to be the result of displacement of the plug shell in relation to the plug pins. A cure can often be effected by slackening the plug shell fixing screws, inserting the socket, then re-tightening the screws.

54. **Thread Damage.** A socket with a damaged thread must not be inserted into a plug; fine metal shavings are liable to be detached while screwing up, and these may cause short-circuits between the pins of the plug. Badly damaged fittings should be renewed, but minor damage to threads may be cleared with a thread chaser.

55. **Junction Boxes.** Terminals in junction boxes are coated with Bakelite varnish after final assembly to lock the screws; when wires are replaced in terminals, the varnish must also be replaced to prevent loose connections developing. Periodical inspection of boxes should be carried out with a view to ensuring that all screws are tight, that no loose parts, ends of wire, swarf, or similar objects capable of causing short-circuits have been left in the boxes, and that there are no signs of condensation. Preventive action must be taken immediately if condensation is apparent; if allowed to persist it may cause corrosion between pins and plugs.

56. **Disturbance.** A visual inspection is generally sufficient to ascertain if deterioration is occurring at connection points. Excessive handling of cable assemblies is not advisable, and plug connections should not be disturbed unless there are unmistakeable signs of trouble. Continuity testing should, as far as possible, be carried out between junction box terminals; disconnection of plugs and sockets during continuity testing is not usually necessary unless non-contact or high resistance between terminals under test is encountered.

57. **Re-connection of Sockets to Plugs.** Several cable assemblies entering a junction box or panel may be fitted with sockets of identical pattern. To avoid errors, ALWAYS check that the cable assembly identification mark, shown on the marker ring at either end of the assembly, corresponds with the marking of the plug (shown on the side of the box or panel, immediately adjacent to the plug) BEFORE offering up the socket to the plug.

58. **Corrosion.** When a plug or socket repeatedly shows signs of severe corrosion because of the ingress of moisture, the pins or inserts should be *lightly* smeared with insulating silicone compound MS4.

59. Aircraft batteries must always be switched off or disconnected when the aircraft is on the ground and the electrical equipment is not in use. Quite apart from normal considerations of safety, this precaution is essential to prevent electrolytic action being set up between multi-pin connections or groups of wires should the aircraft be subject to heavy internal condensation.