CHAPTER XII.

BONDING, SCREENING AND EARTH SYSTEMS.

355. Bonding and screening is necessary in order to render an aeroplane suitable for wireless purposes and to prevent undesirable effects from static electricity. Screening is required for all actively electrified parts, such as magnetos and magneto leads and switches, and entails the enclosure of the various parts in an earthed metallic casing. The rigger has seldom to concern himself with this part of the system. The bonding and earthing system, on the other hand, should be thoroughly understood as, especially during repairs, the rigger will often need some knowledge of the systems employed.

356. The bonding and earthing systems are evolved on similar lines for each type of aircraft, and are incorporated to increase the effective electrostatic capacity of the aeroplane, as a necessary precaution against fire risk, and for the reduction of noises in the wireless receiver, owing to the intermittent contact of any loose metal members. Properly undertaken, the system ensures that all the metal parts of the structure are in good electrical contact and therefore at the same potential. For this reason, all the connections made are arranged to have a negligible electrical resistance. Every component which is bonded is marked in a conspicuous position with the letters "WT" enclosed in a diagonally divided square.

Bonding of wooden and composite aircraft.

357. On wooden and composite aircraft the earthing system consists of the main earth strip, feed wires and branch connections. The main earth strip is composed of a soft $\frac{1}{4}$ in. copper or brass strip between 26 and 30 S.W.G. in thickness. The main earth strip is fitted along each fuselage longeron, and soldered or otherwise attached to the metallic parts at the ends, such as the engine bearers and the stern-post. The strip is secured by small brass pins, 6 in. to 8 in. apart.

358. Each main plane is fitted with three 18 S.W.G. copper or brass feed wires, running parallel with one another, one along the leading edge and one along each spar. The outer ends of these wires are bridged across, either by means of the leading edge wire, which is left sufficiently long for the purpose, or, when the wing tip is of metal, by direct connection thereto by soldering if possible. The centre planes are treated in a similar manner.

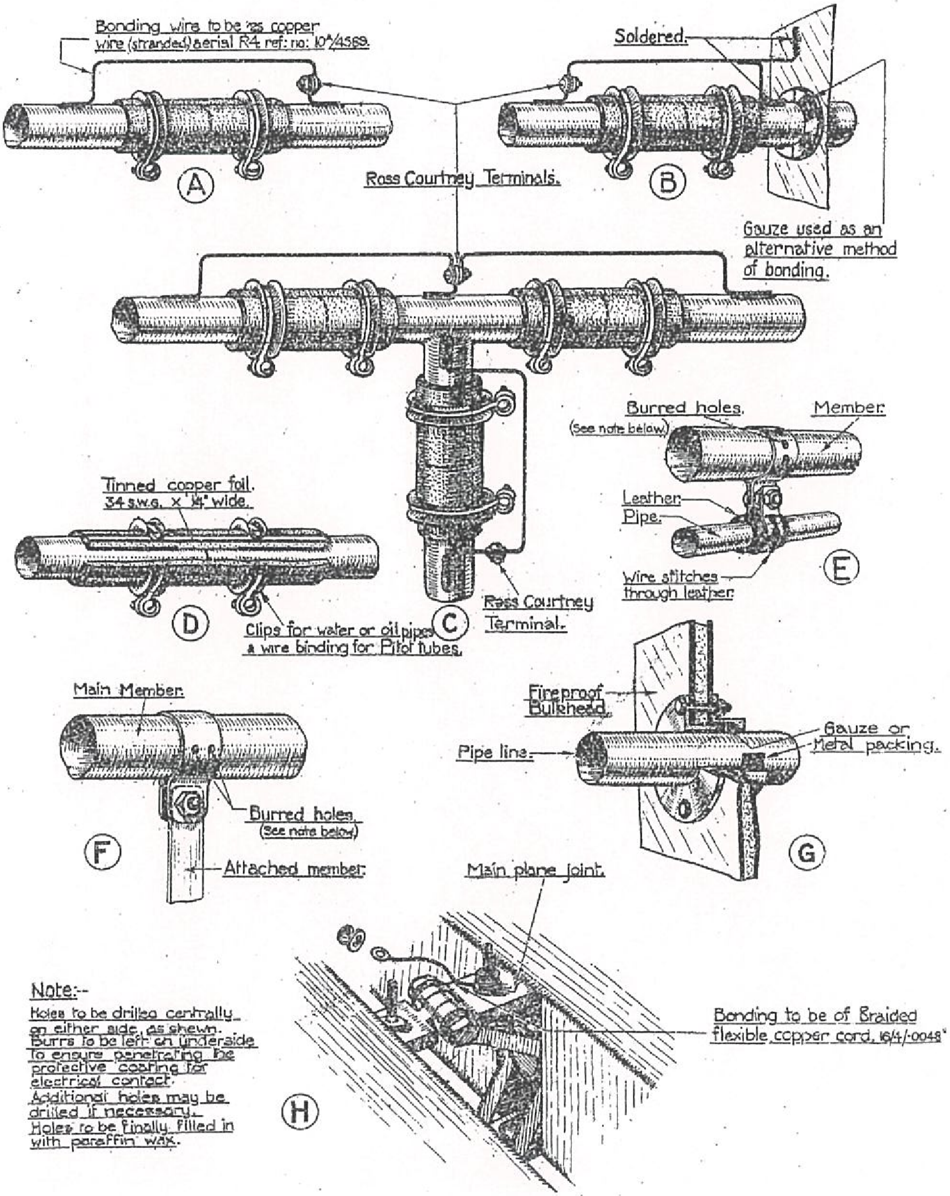

FIG.93 — METHODS OF BONDING.

359. Tail planes, fins, rudders, have no feed wires, but all the internal metallic fittings are connected together by 18 S.W.G. copper or brass wires and so arranged that the whole system on each component is connected by a soldered joint to one of the fittings which is in direct electrical connection with the main earth system. All metal fittings are connected to either the main earth strip or the feed wires by branch connections made from similar wire to the feed wires. All connections are soldered wherever possible, but where soldering cannot be done, special clips or lugs are employed.

360. Hinged or detachable fittings are bridged across by means of flexible copper wires, as indicated at H, fig. 93. These wires are usually 7/25 bare stranded copper wire, similar to the Service wire known as R.4, but sometimes a braided flexible copper cord is used. The ordinary fixed, or the Ross-Courtney type of terminal is used as required.

361. All fuel and oil tanks, either in the fuselage or in the planes, are connected to either a feed wire or the main earth strip. The connections are made by means of a copper strip soldered to each end of the tanks and also to the feed wires or earth strip. In order to avoid breaking the joints when dismantling, a Ross-Courtney or similar type of terminal with a spring washer is provided.

362. Undercarriages are bonded with flexible detachable connections throughout to ensure a good electrical path of low resistance to the main earth system of the fuselage. Special precautions are taken at all points where intermittent vibratory contact is possible. Cross bracing wires are separated by distance pieces of a high grade vulcanised fibre similar in shape to those shown at A, B and C, fig. 83, for internal and D and E, fig. 83, for external wires.

363. All pipes connecting fuel, oil or water tanks are bonded and in direct electrical connection with the main earth system. On many existing aircraft, the pipe bonding is arranged as shown at A, B and C, fig. 93. The bonding wire used is generally the 7/25 stranded copper aerial wire (R.4), Ref. 10A/4589. As shown, the ends of the wires are soldered to the pipes on each side of the joint or connection, and a Ross-Courtney or similar type of terminal is used to render the pipes easily detachable. The flexible wires are normally made as short as possible, and when finished the wires stand clear of the flexible sleeves of the joints by approximately $\frac{1}{2}$ in. The wires are never wound round the pipes in the form of a helix or coil, as an inductive effect may be produced thereby and this should be avoided. Where pipes pass through the fireproof bulkhead, they are bonded as shown at B or G, fig. 93.

364. Exhaust pipes are also bonded at intervals not exceeding 4 ft. The bonding material is usually a length of the copper main earth strip connected at one end to a lug on the pipe, and at the other end by soldering on to the main earth strip, or a metal fitting in direct connection therewith. The bonding strip should be long enough to allow the heat to be dissipated by radiation before reaching the soldered joint. All joints in the exhaust pipe are similarly bonded by a short length of strip attached to lugs or screws provided on either side of the joint.

365. All large bodies of sheet metal such as fireproof bulkheads, cowlings, fairings or tanks must be bonded at each end, and also in between if the size warrants.

Bonding of all-metal aeroplanes.

366. In principle, the bonding of all-metal aeroplanes is the same as that for wooden aeroplanes. The framework of the all-metal aeroplane is utilised instead of the main earth strip and the feed wires. In order that this can be done successfully, all the joints between the metal parts must have a good metal-to-metal contact. Since, in many cases, a film of varnish or enamel is deliberately inserted between the faces of the metal parts to prevent as far as possible the corrosive effect of interaction between the metals, the only electrical connection made during the manufacture or assembly of the parts is by means of rivets or bolts which secure the joints. This form of joint, although mechanically sound, is not always sufficiently reliable for wireless purposes, as the resistance may vary very considerably. In addition, if there are any points of high resistance, there is always the risk of sparking across the surface of the metal parts during wireless transmission, which is not conducive to safety. The cleaning off of the protective coating between the faces of the metal parts is not permissible, as this would defeat the object for which it was employed; therefore, in many cases a system of bonding is incorporated. When bonding is required, the types of bonding materials used for metal aircraft are copper foil, brass gauze, and flexible braided copper wires. When a flexible bond is made, the bond is generally so arranged that it will withstand, without breaking, the constant vibration encountered under normal service conditions.

367. The cleaning of the protective covering from the outer metal surfaces of the various components where bonding joints occur, is permissible if it is imperative in order to obtain a sound electrical connection, but when the joint is completed it must be recoated with a suitable protective coating. Where, for the purpose of attachment, clips are

wrapped round a member, the arrangements shown at E and F, fig. 93, are used. As indicated, two or three small holes are drilled through the clip, care being taken not to damage or clean off the burrs, which are used to pierce the protective covering of the member. At all detachable joints such as between the outer and centre planes, a removable metal bond is sometimes provided of the type shown at H, fig. 93. The flexible bridging connections must not be stretched too tight, nor yet be loose enough to make intermittent contact with neighbouring parts. It is essential that all bonding connections should make a good electrical connection with the main members on either side of the bonded joint, and that intermittent vibratory contact is avoided. Pipe joints are bonded by the insertion of strips of copper foil under the clips and also under the hose connection as indicated at D, fig. 93.

Soldered joints.

368. It is essential that when a soldered bonding joint has been broken for any purpose, great care and attention is given when re-making the connection. The main consideration is that all metal parts should be brought into permanent connection with the main earthing system. Therefore, positive electrical contacts must be made, as otherwise considerable masses of metal may be isolated or imperfectly connected.

369. All soldered joints must be positive, and every care must be taken to ensure this. It is not sufficient to place a blob of solder between the fitting and strip or wire, but each must be first tinned and the joint made by sweating up. The flux to be used when soldering should be resin or methylated spirit and resin, and immediately after a joint has been made all traces of the flux must be removed and the joints painted over with bituminous paint to prevent any possibility of corrosion.

Tests.

370. The normal method of testing a bonded aeroplane is to use a Wheatstone bridge or similar instrument, and, after deducting the resistance of the external wires used for connecting up the instrument to the aeroplane, the resistance observed should not exceed 0·025 ohm when contact is made between the points enumerated below :—

(i) Between the extremities of all main horizontal members of the fuselage.

(ii) Between the main spars and the leading and trailing edges and the selected ribs.

(iii) Between the two vertical and cross members of the fuselage.

(iv) Between the axle and the undercarriage supporting members.

(v) Between all bracing wires in the locality of the wireless compartment.

(vi) Between all interplane struts.

(vii) Between the fireproof bulkhead and all metal cowlings, fairings, and panels.

371. When a Wheatstone bridge or a like instrument is not available, a ready means of testing the electrical continuity of the aeroplane generally is provided by utilising a 2-volt accumulator and a standard 2·5-volt minature lamp. A 500-volt "megger" should not be used. The 2-volt lamp tester consists of a short flexible lead composed of an ordinary twin flex wire, with the bared ends twisted together, which is run from one terminal of the accumulator to the wireless earth terminal, and another length of similar flexible wire long enough to reach the most distant parts of the aeroplane (and thus form a wandering lead) is connected to the other accumulator terminal. At the outer end of the long wandering lead is attached a miniature lamp-holder and a sharp metal spike, connected in series. The spike is required to make contact with the various metal parts by piercing the enamel or other protective covering, but in so doing cause as little damage as possible.

372. The spike and lamp are conveniently made up in one unit by employing a large-sized file handle, screwing on a batten type miniature lamp-holder near the ferrule, and inserting a steel spike in place of the file heft. The wandering lead is connected to one terminal of the lamp-holder and the spike to the other.

373. Before testing, make a contact directly between the spike and the wireless earth terminal, and note the brilliancy of the lamp; then proceed with the testing by pressing the point of the steel spike firmly against the metal portions of the aeroplane. Under normal conditions the lamp should glow at practically the same brilliancy as when directly connected to the earth terminal. Should the glow of the test lamp diminish perceptibly, then an appreciable added resistance is indicated. When the lamp shows no light, then an isolated area is indicated. To ensure that no mistake has been made, the test should be repeated two or three times, and the lamp tested by making contact with the earth terminal.

374. The limits of the isolated area may be defined by making contact with the surrounding parts. If this is not

successful, the lead to the wireless earth terminal should be disconnected and attached to a second spike; then, with the first spike making contact with the isolated part, contact should be made with the second spike at various points surrounding the first spike until the cause of the resistance or break in the bonding has been ascertained.

375. A more accurate method of determining the resistance of joints, in default of specialised measuring instruments, is to pass a small steady current of known value through the portion to be tested, and measure the voltage drop with a sensitive milli-voltmeter. The resistance is then found by dividing the voltage drop by the current. If the circuit is

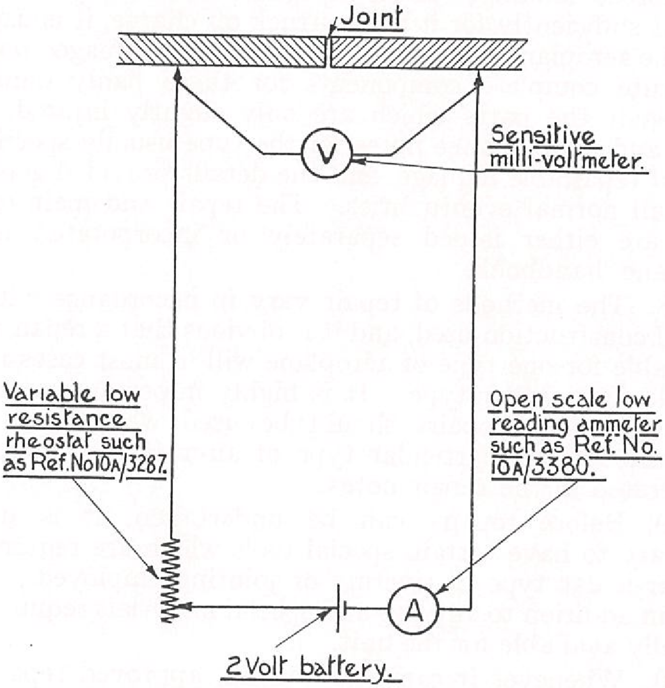

FIG. 94.—Diagram of connections for resistance tester.

arranged as shown in fig. 94 and the current is limited by an external variable resistance to one ampere, then the voltmeter will read directly in ohms, because the resistance $= \frac{\text{Voltage}}{\text{Amperage}}$, and, as we know the current passing to be one ampere, then the resistance $= \frac{\text{Voltage}}{\text{Unity}}$.

376. When tests are made across any single joint, the resistance observed should not exceed 0·05 ohm.