BENDING WAVEGUIDES

Until quite recently, it was not considered advisable to use other than pattern article bends and twists in any waveguide run, but it was realised that sooner or later, the time would come when it would be necessary to make a unit locally or have the Radar set inoperative. In consequence, several methods of bending and twisting waveguides have been tried and tested, both from a mechanical and an electrical point of view and, if the following instructions are followed very carefully, a satisfactory job can be accomplished by any competent coppersmith. Always use "factory" bends, however, whenever possible.

Before attempting this work, it is essential that certain principles should be understood :-

(a) Any change in waveguide runs tends to produce a power reflection whether the change be a change of section or a change of direction. A number of such changes in a run from set to aerial may produce reflections, which will render the set inefficient over some parts of its frequency range. It is absolutely essential, therefore, that no individual component introduces a standing wave ratio less than 0·95.

(b) Since the work involved in testing every component electrically would be prohibitive, the following limits and tolerances must be worked to :-

(i) A tolerance on the 3" dimension of ± 30 thou. is acceptable.

(ii) A tolerance on the 1" dimension of ± 20 thou. is acceptable.

(iii) The rate of change of dimensions of the section must not exceed 10 thou. (0·010) per inch length of guide.

(iv) In a bend the standard radius to the surface nearest the centre of the circle must be a minimum of 18".

(v) In a twist the standard rate of twist will be 90° in 36" length.

Note : Gauges will be supplied as soon as possible.

(c) The guide must be free from dents. The process of bending causes a distortion of the cross section which is relatively harmless if the change of shape along the length is very slow, and which the gauges will pass. Rapid changes of cross section in the form of dents or corrugations, even if they pass the gauges will cause trouble. Such dents must be beaten out to leave a smooth surface and, if this cannot be done, the component must be rejected.

(d) No more than two bends or two twists, or one bend and one twist are allowed in a single 14 ft. length of guide.

A component which fulfils these conditions should be satisfactory, one which does not, will cause trouble which may show only when the magnetron is changed.

Thus, because a certain waveguide run appears to be satisfactory with obviously defective tubing, the faulty section should be replaced immediately.

METHOD NO. 1.

Tools required :-
(i) Hydraulic or other suitable bending machine.
(ii) Hardwood formers.
(iii) Oxyacetylene torch.
(iv) Cleaning etc., baths, (boiling water, caustic solution for de-greasing and dilute acid solution for cleansing).

Materials required :-(i) "Cerrobend" a low temperature (about 75°) melting point alloy (alloy of tin, lead, cadmium and antimony. Obtainable from Messrs. I.C.I. Ltd., Thames House, Millbank, London).
(ii) Colloidal graphite grease.
(iii) "Easiflow" brazing alloy and flux for attaching flanges.

PREPARATION OF WAVEGUIDE.

The Waveguide to be bent is heated to a red heat (600/650°C) and cooled in air. The heating can conveniently be done with an oxyacetylene torch, but must be thorough.

The inside surfaces of the waveguide are then lightly covered with colloidal graphite and one end of the tube closed with a wooden plug.

Filling.

Sufficient "Cerrobend" is heated under water in a ladle and poured into the waveguide, and immediately chilled by immersion in cold water. This rapid cooling has been found essential as air cooled "Cerrobend" will expand and distort the tube, and further, being brittle, may break during bending. It may be of some advantage to support the wide faces of the tube by clamping between wooden planks during filling.

Bending.

The machine is shown in the sketch Fig. 1. The hardwood former "A" is slightly smaller than the inside radius required - viz. 17¾" for 18" bend. Pressure is applied by "A" and the formers "B" and "C" move outwards as the bend progresses.

Cleaning.

The "Cerrobend" is removed by heating the tube in hot water. The tube is then degreased in a caustic bath, rinsed and cleaned in an acid bath prior to brazing on the flanges.

Notes.

It may be noted that the exact radius of the bends are not important but the curvature must be uniform. For example, a uniform bend of 17¾" radius would be acceptable but the dimensions between the flanges as shown on the drawing, must be maintained by introducing a short length (¼") of straight guide at each end of the bend.

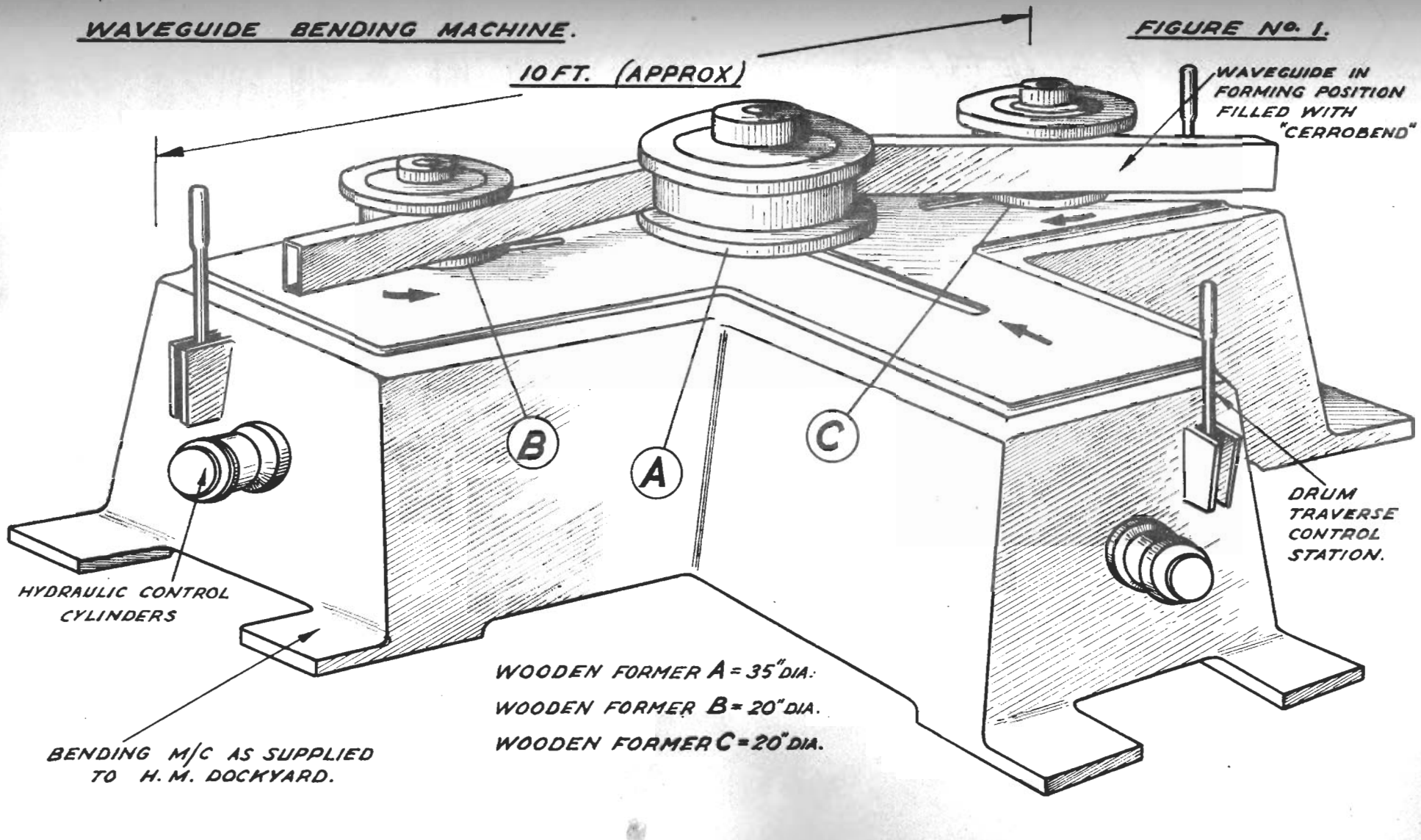
It has generally been found at Devonport that guides bent as above are satisfactory, nevertheless, in cases of failure to pass the gauges, it is possible, by careful beating with a coppersmith's hammer, to remove any wrinkles that may appear on the inner radius or bulging at either end of the 3" faces. This beating is preferably carried out with the tube filled or on a slightly undersize mild steel mandrel.

TWISTING.

In making these components, annealing, filling and finishing are done as for bends. The twist is ideally made in a machine (Fig.2 is a sketch taken from an American publication) but satisfactory twists have been made with hand tools only. It is very necessary that the waveguide section shows no SUDDEN distortion, and it is desirable therefore, to hold the tube in shaped clamps as sketched in Fig. 2A.

WAVEGUIDE BENDING MACHINE.

FIGURE No. 1.



METHOD OF TWISTING.

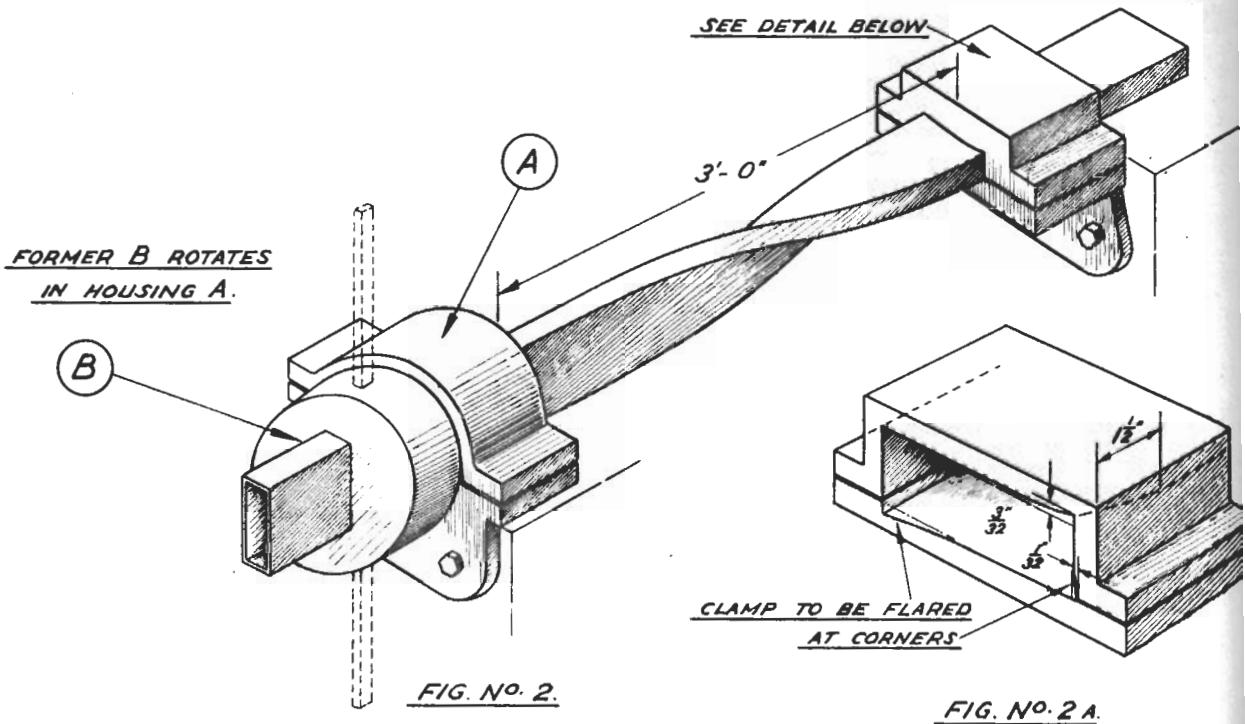


FIG. No. 2.

FIG. No. 2 A.

WAVEGUIDE BENDING TOOL.

METHOD No. 2.

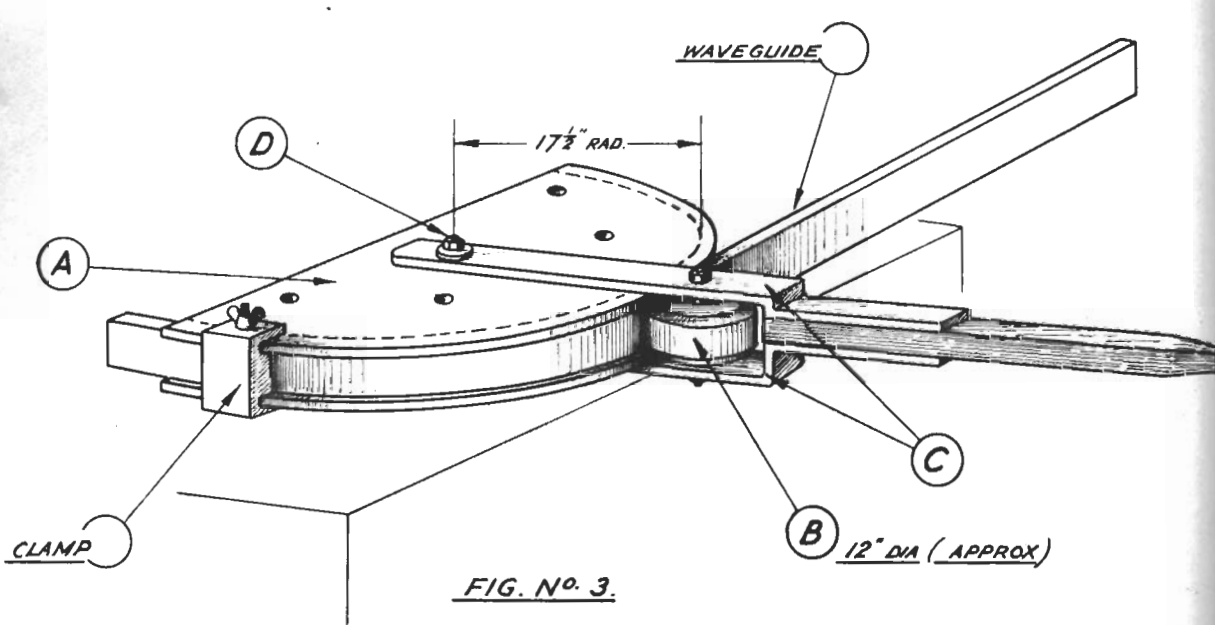
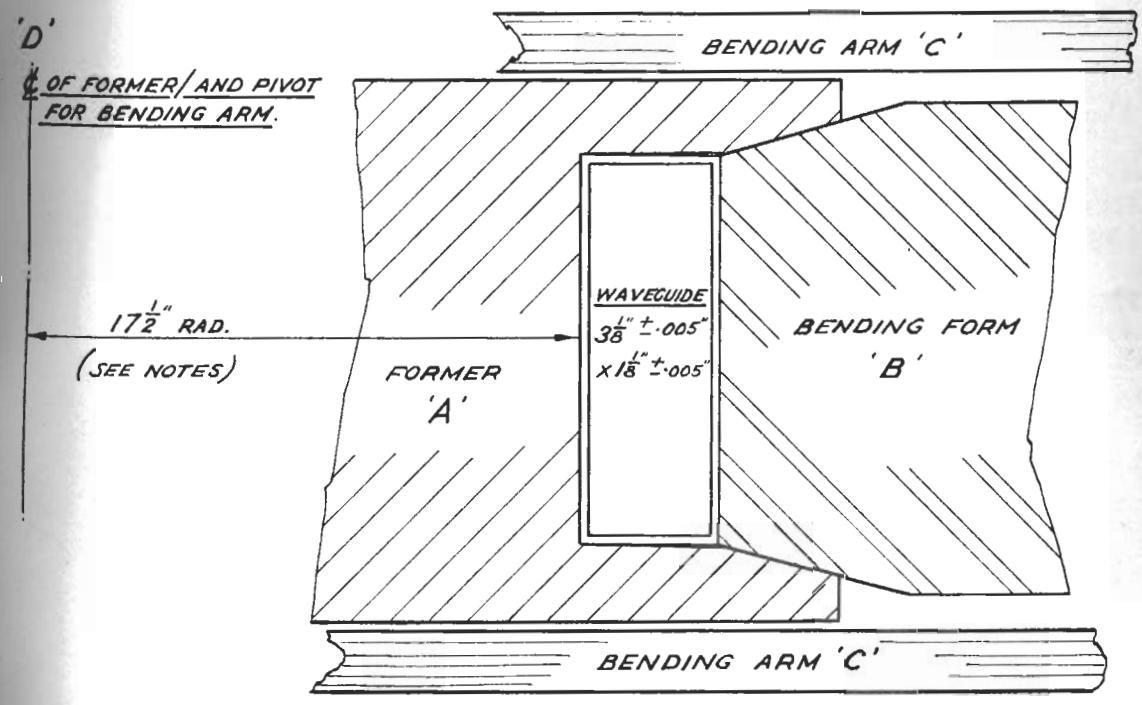
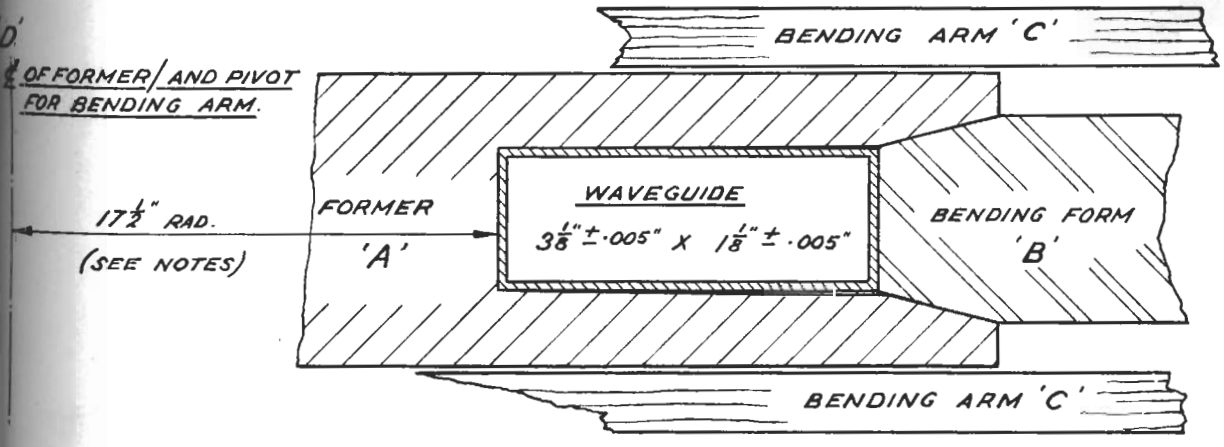


FIG. No. 3.

DETAIL OF BENDING TOOL. FIG. No. 4



DETAIL OF BENDING TOOL. FIG. No. 5.



MANDREL FOR MINOR BEND.

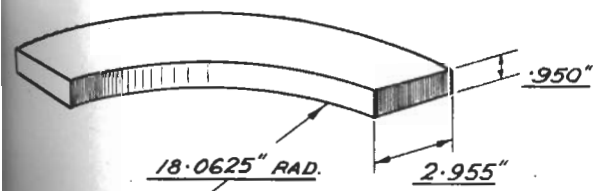


FIG. No. 6

MANDREL FOR MAJOR BEND.

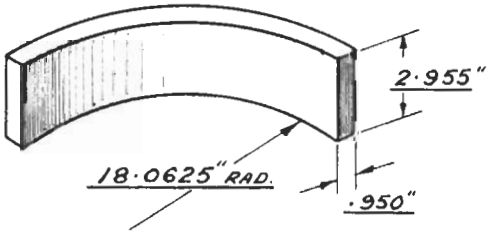


FIG. No. 7

METHOD NO. 2 BENDING WITH HAND TOOLS.

Tools required :-
(i) Mild steel formers as sketched in Figs. 3 (assembly), 4, (detail for major bend) and 5, (detail for minor bend).
(ii) Cast or mild steel mandrels as sketched in Figs. 6 and 7.
(iii) Cleaning baths (water and acid).
(iv) Oxyacetylene torch etc.

Materials required :-
(i) Resin for filling.
(ii) "Easi-flow" brazing alloy and flux.

ANNEALING.

The waveguide is heated to a red hot heat on a coke forge and air cooled.

Filling.

One end of the tube is plugged and the tube filled with molten resin and closed with another plug.

Bending.

The tube is bent slowly in one sweep to an angle rather exceeding 90°. It is found that two men on an 8' lever can bend the waveguide in the major axis.

Cleaning.

The plugs are removed and the resin is melted out. The tube is again annealed and cleaned.

Finishing.

The tube is then cut to 90°, examined and slipped on to the mandrel, Figs. 6 and 7 and beaten to remove imperfections.

The flanges are attached and the tube cleaned in an acid bath and hot water rinse.

Twists are made as described under the previous method except that resin filling is employed.

RADIO MAINTENANCE

The upkeep, maintenance and servicing of radio equipment has been cause for some concern over the past two or three years. Growing complexity has made the servicing of equipment by ratings who are comparatively unskilled a difficult problem. In addition to this, it has been estimated that a great deal of equipment has been working at a very much reduced efficiency over long periods in which users thought it to be working satisfactorily. With a view to overcoming some of these difficulties, a number of improvements to W/T and Radar handbooks and the introduction of other maintenance aids are now contemplated. Many of these are taking shape and will be issued to the Fleet shortly and the purpose of this article is to review the purposes of each one and the use to which it can be put.

The process by which equipment is kept in good running order comprises :-

1. Day to day upkeep or maintenance.
2. Routine check on performance.
3. Servicing.

The first two steps may be thought of as prevention and the third cure. The aids which are to be introduced are thus :-

1. Routine Maintenance Directions.
2. Radio Equipment Log.
3. Servicing Manuals.

and these will now be described in that order.

Routine Maintenance Directions.

These instructions cover daily, weekly and monthly routines which are to be carried out for each item of equipment. All major items of equipment will have their own routine maintenance directions, some of which can be carried out by comparatively unskilled personnel. The points in them cover cleaning, greasing, switching on and warming through, inspection of aerials and various parts of the equipment which are liable to give trouble. They are intended to be "lists of things to do" rather than "Instructions of how to do them". In some cases, simple daily tests are included which, if carried out by ratings of little experience, should be followed closely.

Radio Equipment Log.

A Radio Equipment Log has been introduced which is analagous in many ways to the magazine log of the Gunnery Department and will require the Commanding Officer's inspection and signature monthly.

It is a loose leaf log and will contain between stout covers lists of the ships equipment, with details as to where and when fitted, of modifications ordered and when carried out, and record of major defects and how remedied, etc. But its most important feature, from the "Maintenance" viewpoint, is its performance record sheets. Each major item of equipment will have its performance record sheet. On this sheet are contained instructions to carry out periodical tests on the performance of the set. It is intended as a general rule that these tests will be such that no special equipment is required, and that the instrument provided with the equipment itself shall give all the necessary information. In the majority of cases, these tests will

be carried out weekly and columns are provided for inserting the resulting readings, voltages, anode currents, aerial currents, and for Radar, Aerial efficiency, Transmitter Power outfit, Receiver sensitivity, Display efficiency etc. Provision is made in the case of W/T equipment for tests to be carried out on most ranges of the frequency band.

The first set of figures given on the performance record sheet will be "typical figures". If not printed on the sheet they should be inserted from the handbook. These will be derived either from information given by the designer, or be an average of readings obtained from testing a number of equipments. The second set of figures will be those obtained by the ship fitting-out officer (or working up party) on first fitting of that individual equipment and will, at the same time, constitute his certificate to the Commanding Officer of the ship that the equipment has been installed satisfactorily. Thereafter, figures will be inserted by the ship's staff. Any large variation from the second set of figures will be taken to indicate possible falling off in efficiency, leading to a more detailed investigation, requiring, perhaps, use of the servicing manual.

Servicing Manuals.

These may be regarded as an appendix to, or an extension of, the handbook. They are intended to be kept with the equipment and will be plan-packed with it. Their function is to assist fault finding when either the apparatus fails to work, or when inspection of the figures on the performance record sheet shows that its efficiency has fallen off. The layout and make up of Servicing Manuals is described in greater detail in a separate article on Page 57. -

Introduction.

Routine maintenance directions are being introduced to cover all new equipments and the more important of those already in use. These latter will in general be first issued as amendments to existing handbooks. Radio Equipment Logs (Form S1274) will be issued to all ships as soon as they are printed. Performance Record Sheets for insertion in the log will be produced for all new equipment and for the more important of those already in use. Servicing Manuals will be produced for all new equipment and for the more important existing radar equipment. It is not being found practicable at present to consider servicing manuals for existing W/T equipment.

(Editor's Note :-

The above was submitted by the Staff of C.S.S.)

RADAR SERVICING MANUALS

(Submitted by the Staff of H.M.S. COLLINGWOOD)

We are pleased to be able to announce that a Servicing Manual and a set of Maintenance Directions for Types 276/7/293 have gone to print. Similar publications for Types 291, 253, 242 and 243 are under way; others will follow. This article describes the evolution of Servicing Manuals and the layout of that for Types 276/7/293, which may be taken as typical of those to follow.

(a) The Servicing Manual originated from the principle adopted by manufacturers of Radio sets of supplying their outside Servicemen with Information Sheets. After considerable thought had been given to the subject, it was decided that this could be taken a stage further by supplying, in addition to facts and figures for each panel, a few Block diagrams showing simple external tests to lead the mechanic to a faulty panel. It is hopes that, for the majority of faults, the faulty panel will be located rapidly. Any external faults should also be discovered by these simple tests.

For each panel, a considerable amount of data is given and a system has been devised whereby the Mechanic is instructed to make tests in a logical order; in other words, the order which an experienced engineer would use.

The system of providing a list of possible faults and the appropriate remedies has been discarded. It is quite impossible to cater for all probable combinations except for the simplest of cases. (This system is, however, of some value for the initial approach, and is used, in a modified way, in the Block diagrams already mentioned).

Instead, it seems preferable to supply all the testing information a Mechanic is ever likely to need and to guide him through a short series of quick tests to localise a fault area. The full test data for that area is then made readily available. This is considered to be the best system devised so far for rapid fault location.

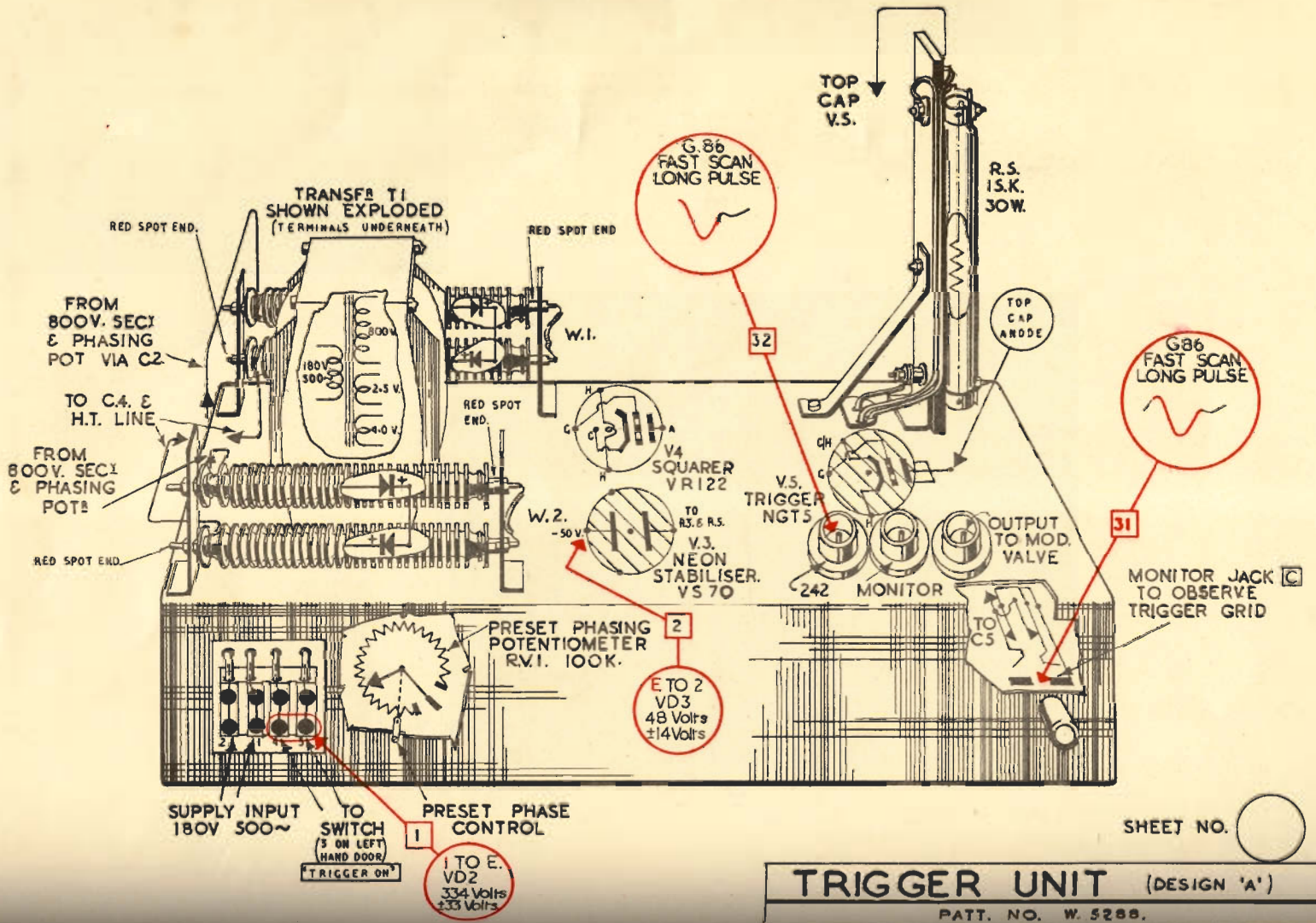
A collection of details of individual components which may be of assistance in the repair of, for example, coils and transformers, is included under the heading "Repair Data".

(b) Layout of Book.

(i) A Block Diagram. This is self explanatory and shows a number of external tests in a "preferred" order.

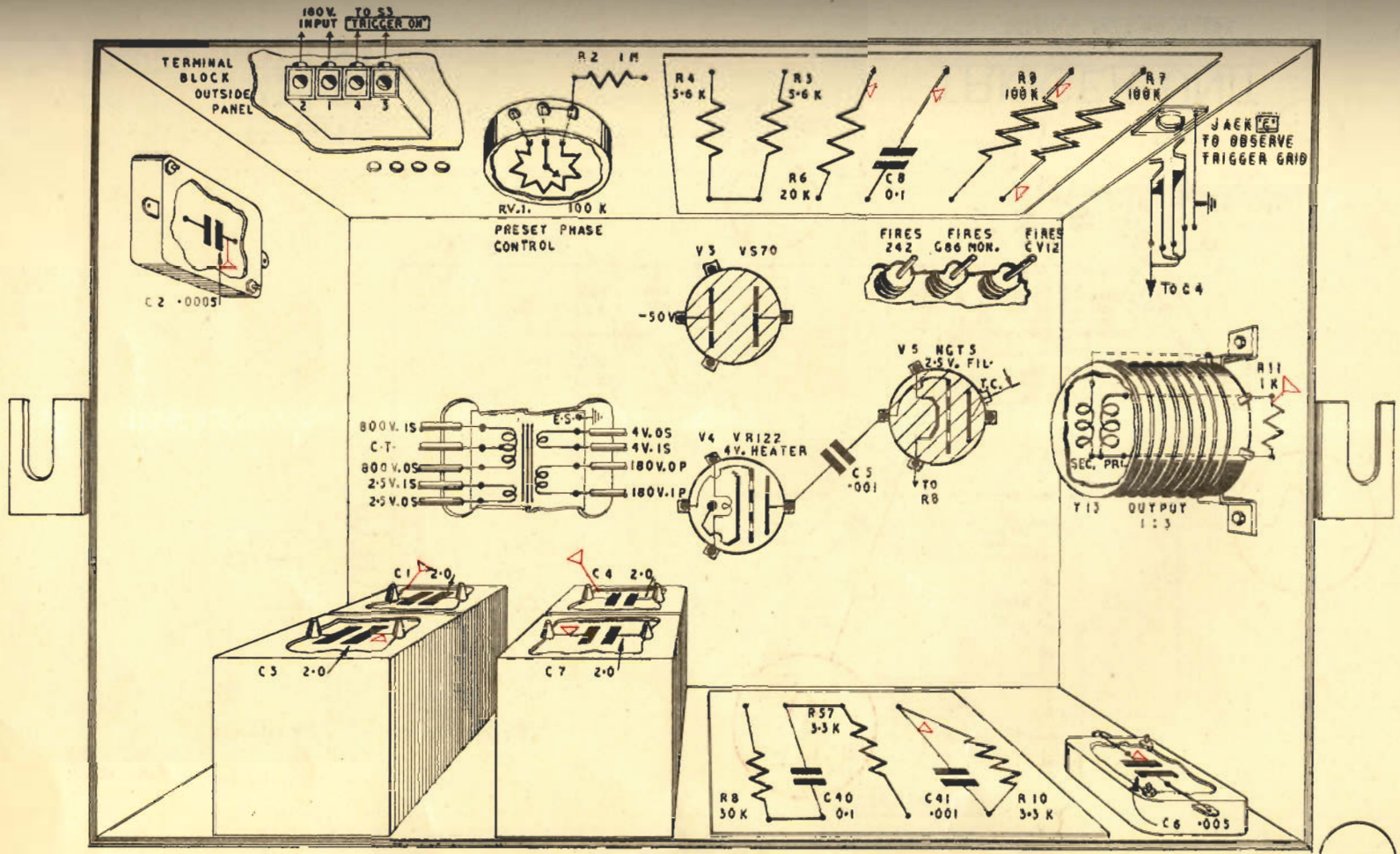
(ii) For a typical panel, information is presented as follows:

(a) Two lay-out Drawings showing top and underneath views.
(b) Immediately adjacent is the circuit diagram.
(c) "Hot" (or "Live") Data sheets, containing all the voltages with "expected" Limits or "outside" limits and Oscillograms for each test point in the panel.
(d) "Cold" (or "Dead") Data sheets, giving component values, tolerances, Patt. Nos, etc.
(e) Repair Data.



TRIGGER UNIT (DESIGN 'A')

PATT. NO. W. 5288.

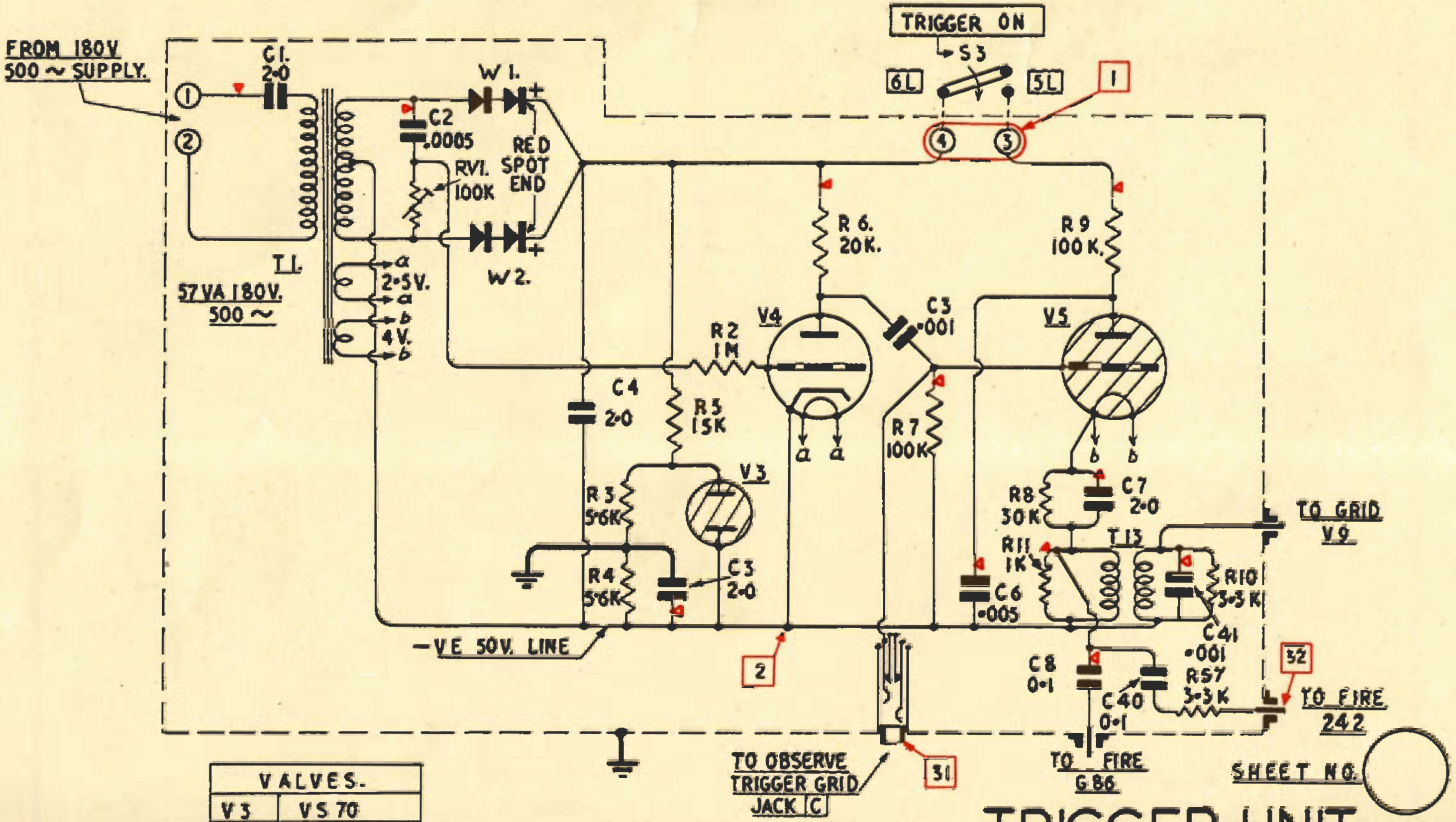


UNDERSIDE OF UNIT

TRIGGER UNIT (DESIGN 'A')

PATT. NO. W5288

C	1. 2. 4. 3. 5. 6. 8. 7. 40. 41.	C
R	3. 4. 5. 2. 6. 7. 8. 11. 9. 57. 10.	R
V	3. 4. 5.	V
MISC.	T1. RV1 W1/2. JK'C'. S3. T13.	MISC.



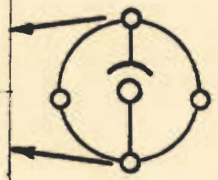
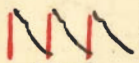
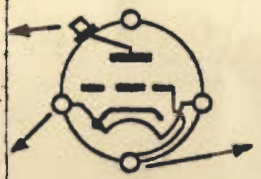
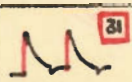
VALVES.	
V3	VS 70
V4	VR 122
V5	NGT5

TRIGGER UNIT

DESIGN 'A' PATT. NO. W5288.

TRIGGER UNIT DESIGN 'A'.

PATT. No. W5288

WAVEFORM G86	WAVEFORM COSSOR DB	VOLTS TO EARTH	CURRENT (mA)	RESISTANCE FROM ELECTRODE TO TEST POINT		RESISTANCE FROM ELECTRODE TO TEST POINT	CURRENT (mA)	VOLTS TO EARTH	WAVEFORM G86	WAVEFORM COSSOR DB
CV1070		(VS70)			V3			STABILISER		
		+48 VD3 ±14		5K TO 6·2K OHMS (E)						
		-48 (2) VD3 ±7		5K TO 6·2K (E)						
CV1122		(VR122)	(FIL.4v. 1·1A)		V4			SQUARING VALVE		
	 88 83	+146 VD1 ±36·5	9 CD4 ±2·25	19K TO 21K (1)		5K TO 6·2K (E)		-49 VD3 ±15		
	 88 83									
CV1144		(NGT5)	(FIL.2·5v. 5A)		V5			TRIGGER VALVE		
	 88 83	+158 VD1 ±32	1·4 CD4 ±·28	90K TO 110K (1)						
		-12 VD3 ±3·6		32K TO 39K (E)		95K TO 116K (E)			 (3) 88 83	

On the layout drawings are shown "Quick Test Points" in Red squares, together with Test Information in Red circles. Each quick test point has a number in the Red square which indicates both the "preferred" order of testing and the instrument to be used for making the test. This information is conveyed by means of the following code:

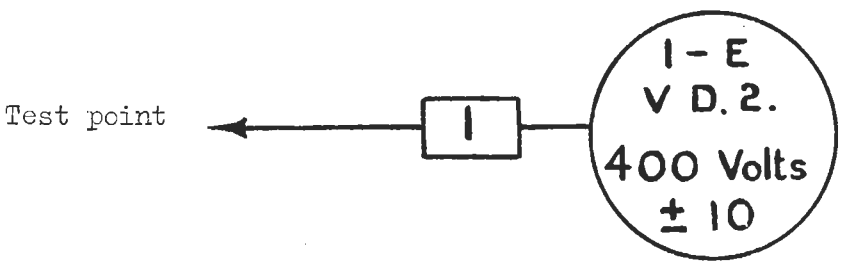
(i) Figures 1 - 20 indicate that Patt. 47A Avometer is used and the preferable order of testing.

(ii) Figures 21 - 30 indicate that Patt. W3332 Electrostatic Voltmeter is used and the preferable order of testing.

(iii) Figures 31 - 50 indicate that Oscilloscope (Cossor or G.86) is to be used and preferable order of testing.

Inside the Red circle is given (a) A self-evident code for the switch settings of Avometer, Oscilloscope and Monitor and (b) The test information i.e. the voltage to be expected and the variation which may be accepted without suspecting fault. Where oscilloscope information is given, the important portion of the waveform is printed in red.

(c) Example.



Both the square and circle above, as well as the arrow, will be in red. The square [1] which is the quick test point 1 of the Indicator, will appear,

(a) In the Lay-out drawing.
(b) On the circuit diagram.
(c) On the "Hot Data Sheet".

The red circle with its self-evident test information contains:

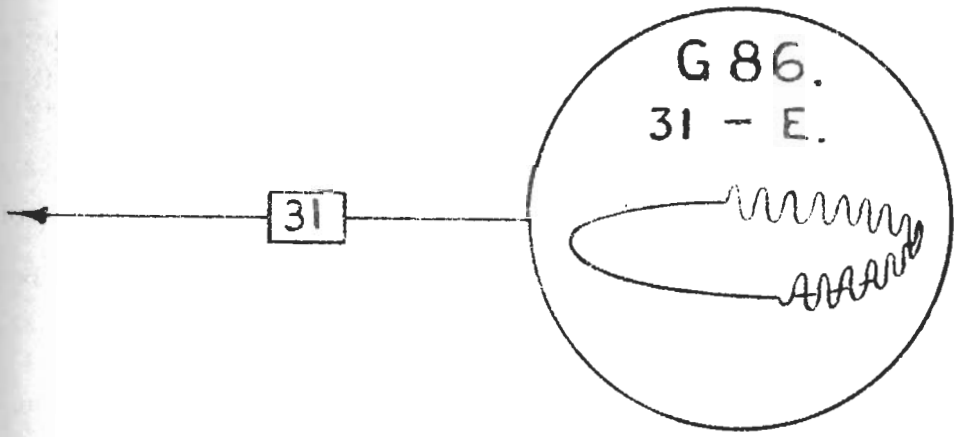
(a) 1. (in red) - E (in black). This indicates

(i) Avometer is used (the number does this)
(ii) Positive lead of Avometer on test point 1 and negative lead on chassis. (Polarity indicated by colours of number and letter).

(b) V.D.2-Patt. 47A Avometer is used on the second D.C. Voltage range, counting from the high voltage end of the switch i.e. 480v. range.

(c) Correct voltage reading is 400v. but anywhere between 390v. and 410v. can be accepted.

The calibrator pips in this example would appear in red.



(d) Care is being taken to "tie-up" all the associated drawings, so that the reader may refer from one to another, and to the panel, without losing his place. To assist in this, certain components are marked with a small red triangle. Red triangles occur both on the circuit and on the lay-out drawings, in places where there may be doubt in the reader's mind as to which particular end of a component in the panel is the relevant end on the circuit diagram.

(e) The first Radar Manuals will not contain any Radio Frequency test information. Sufficient data is included, however, to establish the correctness or otherwise of nearly all D.C. and low frequency A.C. conditions so that the majority of the more common faults should be much more speedily traced.

(f) Limits.

The complexity of apparatus, combined with the wide tolerances on components which are an economic necessity, has given rise to some difficulty in stating the permissable variation in reading at any given test point. After considerable thought and discussion, it has been agreed to establish two different types of limits, which will be used as appropriate in each particular case :-

"Outside" Limits. These are limits outside which the successful performance of the unit is impossible. They give however no guarantee that the unit will work if the reading is within the limits.

"Expected" Limits. These are limits within which it is expected that the reading will lie. In general they will be stated after measuring a number of samples. If a point is found where the reading is just outside the expected limit, the unit will be considered under suspicion. Unless the reading is considerably outside the limit, it should not be considered as furnishing sufficient evidence, without corroboration, to start pulling it to pieces. Some unusual distribution of wide tolerance components may well have made it give a reading outside the limits expected, whilst other variations in the unit may compensate for this departure from normality and it may work perfectly well.

All the limits in the Types 276/7/293 Service Manual are "expected" limits.

(g) As "expected" limits can generally not be determined until after measurement of a number of production samples, it follows that it will not usually be practicable to issue Servicing Manuals with the first few models. To meet this difficulty it has been agreed to issue provisional information with preliminary handbooks. These will take the form of circuit diagrams, on which have been inserted the readings for a number of test points. These readings will be those obtained by test on a single development model. They must therefore be treated with the appropriate discretion as the production models, apart from embodying changes in design, may embody different types of components, e.g. a standard transformer in lieu of a hand-made one.