B.R. 575 (2)G

AUDIO FREQUENCY EQUIPMENT

A.F. 100 SERIES

BROADCAST SYSTEMS

RELAY PANELS

THE A.P. 12653 AND 12597 SERIES AND RELAYS

1953

CHANGES
~~AMENDMENTS~~

~~Amendment~~ No. CHANGE	A.F.O. "P" No.	Date of insertion in this copy	Initials
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2.	80/64	13-3-66	[illegible]

Admiralty

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B.R. 575(2)G, *Audio Frequency Equipment—A.F. 100 series, Broadcast Systems, Relay Panels*, A.P. 12653 and 12597 series and Relays, 1953, having been approved by My Lords Commissioners of the Admiralty, is hereby promulgated for information and guidance.

This pamphlet should be inserted in B.R. 575, guard cover for this series.

Attention is directed to the notice printed below.

By Command of Their Lordships.

D. E. Lang

To Flag Officers and Commanding
Officers of H.M. Ships and
Vessels concerned.

Suggestions for improvement of the text or illustrations which can be incorporated by way of amendment or in any future revision of this book, will be welcomed and will receive careful consideration; they should be forwarded to the Secretary of the Admiralty through the usual channels

(SO 3083)

Components

11. In addition to carrying the relays, the following components are found on relay panels:—

ITEM	PURPOSE
(*a*) Supply fuses . .	Power supply for the A.F. system.
(*b*) Panel fuses . .	Panel relay power supply.
(*c*) Transformer, 230/50 volts.	Panel relay power supply.
(*d*) Full wave metal rectifier.	Panel relay power supply.
(*e*) Milliammeter . .	Used as a voltmeter across the 50 volt rectified supply.
(*f*) A.C. supply switch .	Closing of the 230 volt supply to the system.
(*g*) Switches, various .	As stated in paragraph 12.
(*h*) Resistors, various .	As stated in paragraph 13.

Note:—In the following paragraph the term " switch " includes both toggle and push operated circuit " makes " and " breaks ".

12. Switches are accommodated on the relay panels for the purposes shown:—

(*a*) For closing the operating circuits, for test purposes, of relays which operate when:—

(i) A " section call " is made from a control box to a control box of an associated A.F. system.

(ii) Any " press to speak " switch is closed at any microphone position.

(iii) Groups of loudspeakers are switched " in " or " out ".

(iv) Any " alarm " or " warning " tone is sounded over a system.

(*b*) For the isolation of 50 volt D.C. supply lines leading to individual control boxes.

(*c*) For the closing or opening of the A.C. power supply.

Switches mentioned under (*a*) and (*b*) above are all on the " test " deck and are not accessible until the front cover is removed.

13. The resistors which may be accommodated on the relay panels are:—

(*a*) Action damage safety resistors in each of the lines leading:—

(i) To indicating meters in all control boxes.

(ii) To " in use " lamps in all control boxes.

(iii) To section call buzzers and lamps.

(iv) From the alarm panel for conveying " alarm " and " warning " signals to sections.

(*b*) Amplifier load compensating resistors for groups of loudspeakers switched off.

(*c*) Current limiting resistors in the test circuits for certain relays.

(*d*) Sound volume reduction resistors, series and shunt, for certain loudspeaker groups.

(*e*) Panel meter series resistor.

Power Supply

14. An A.C. single phase supply at 230 volts, 50 or 60 c.p.s., is brought from the C.W.S. or similar source, enters by SKC and PLC connections Nos. 11 and 12, passes through a D.P. switch which is operated from the front of the panel, to a pair of 15 ampere fuses. From the load side of these fuses supplies are taken:—

(*a*) out by plug and socket connections Nos. 3 and 4 to the other rack units of the system, and

(*b*) through a pair of 1 ampere fuses to the primary of a transformer.

Both pairs of fuses are accessible from the front of the panel.

15. The purpose of the transformer is to provide, in connection with a rectifier, a D.C. supply independent of any other source, for the operation of the relays. The transformer secondary has a centre tap which forms one pole of the supply, and with a metal rectifier placed in each of the lines to the end terminals, a full wave rectified supply at 50 volts is provided. Details of the transformer windings are given in Appendix 1.

16. For some A.F. systems which require a 50 volt A.C. supply for lamp call up or other purposes a pair of lines are taken from one half of the secondary, independent of the rectifier. Connections Nos. 7 and 8 of PLC are used for these lines when required.

17. The Meter. A milliammeter arranged in series with a suitable resistor to act as a voltmeter, is connected across the 50 volt supply and mounted with the dial in the centre of the front of the panel. The meter is the same pattern as is used in other rack units. A midscale reading of 5 represents a measured voltage of 50 V. The inscribed mark at 3·16 on the scale has no significance on this panel.

18. Distribution. The 50 volt supply is distributed as required inside the panel and externally to individual control boxes or other microphone positions. Fuses are fitted in the " in use " lamp supply in later relay panels.

19. Isolation of Control Boxes. Where several control boxes are fitted in an A.F. system the power supply to each is taken through an isolating switch in the relay panel. The primary purpose of the switch is for the isolation of action damage but it may also be used for switching off power temporarily from any box while not required for use or when under repair. In the original system the switch does not cut off the supply to the " in use " lamps.

Mounting of Relays

20. Relays are mounted on the main vertical member of the panel with all contacts visible from the front and the connection tags from the rear. In accordance with established practice the relays are mounted with the contact surfaces in the vertical plane, that is, contact movement is in the horizontal plane.

Relay Identification

21. The letters appearing on the front of the relay armatures are in accordance with a functional code which is followed throughout the A.F. 100 systems. The code enables any relay or junction panel terminal to be identified at sight. Where one or more letters is preceded by a figure the latter identifies one relay of a series bearing the same letter or letters. The actual employment of the contacts on any relay bearing a letter or combination of letters, which may be common to two or more A.F. systems, is necessarily varied to meet the requirements of the system in which it is employed.

22. The code is as follows:—

TERMINAL OR RELAY LETTER	USED SINGLY INDICATING OPERATION	USED AS SECOND LETTER INDICATING SERVICE
A	Alarm control	Armament
B	Buzzer	Box (control)
C	Common	Ship's company
D	—	Day cabin
E	Earth	Entertainment
F	Fault	Flight deck
G	General (master)	Armament (aft)
H	High tension	Hangar
I	Input	—
J	—	—
K	Buzzer call	—
L	Lamp control	Lower hangar
M	Microphone	Machinery
N	Indicator	Action information
O	—	Officers
P	Press to speak	—
Q	Note (alarm or warning)	—
R	Return (supply)	Ready rooms
S	Loudspeaker	Main Bc.
T	Transfer control	Reply outstation
U	Muting (S.R.E.)	Upper deck
V	Volume	—
W	Warning control	—
X	Loudspeaker group control	—
Y	Remote control	—
Z	Priority switch	—

Note:—Control boxes in each A.F. system are numbered from 1 upwards.

RELAYS

23. All the relays used in the A.F. 100 systems are of the standard Post Office 3,000 type. Four patterns only are employed in the relay panels, the objects being:—

(*a*) To simplify maintenance work.

(*b*) For the simplification of the "spares" question.

24. Particulars of the relays used are:—

I.S. CAT. NO.	A.P. NO.	TYPE	COIL RESISTANCE (OHMS)	OPERATING CURRENT MA	OPERATING VOLTAGE (VOLTS)	CONTACTS LEFT	CONTACTS RIGHT
Z 530046	52189	SM3-LV-26	1,000	14	24	C	C
Z 530058	—	SM3-LV-45	2,000	14	48	2C	2C
Z 530060	—	SM3-LV-48	1,000	25	48	3C	3C
Z 530145	52215	SM3-LV-14	200	30	12	C	C

All coil resistances have a tolerance of + or − 10 per cent. Contacts shown underlined are made of platinum.

All the above-mentioned relays have:—

(*a*) Armature travel of 31 mils. (*b*) Residual stud length of 12 mils. (*c*) Spring thickness of 14 mils.

Representation on Drawings

25. Relays are shown on the drawings in this series of books as rectangles (the resistance values being omitted). Each relay is identified by a fractional representation consisting of letters and figures. The numerator of the fraction is composed of the identification letters and figures according to the code explained in paragraphs 21 and 22, the fraction denominator is a single figure indicating the number of contacts which open or close when the relay operates. For example, $\frac{FZ}{4}$ would indicate relay FZ having four contacts.

26. The circuit contacts which are closed or opened by the relays are shown in circuit diagrams detached from their relay, and situated at the point in the circuit which most clearly displays their function. All such detached contacts are identified by the code letters or letters and figures of the numerator of the relay fraction followed by

one or more figures. The figures indicate the actual contacts of the relay; thus FX 1/2 would indicate contacts Nos. 1 and 2 of relay FX.

Relay Description

27. The description given here of the Post Office type 3,000 relays applies only to those patterns which are employed in the A.F. 100 series equipments and scheduled in paragraph 24.

Note:—In the description which follows, and in the maintenance instructions later, any prepositional terms such as " above " or " lower ", refer only to the view of the relay as seen in Figure 1, and not to its position when mounted for use.

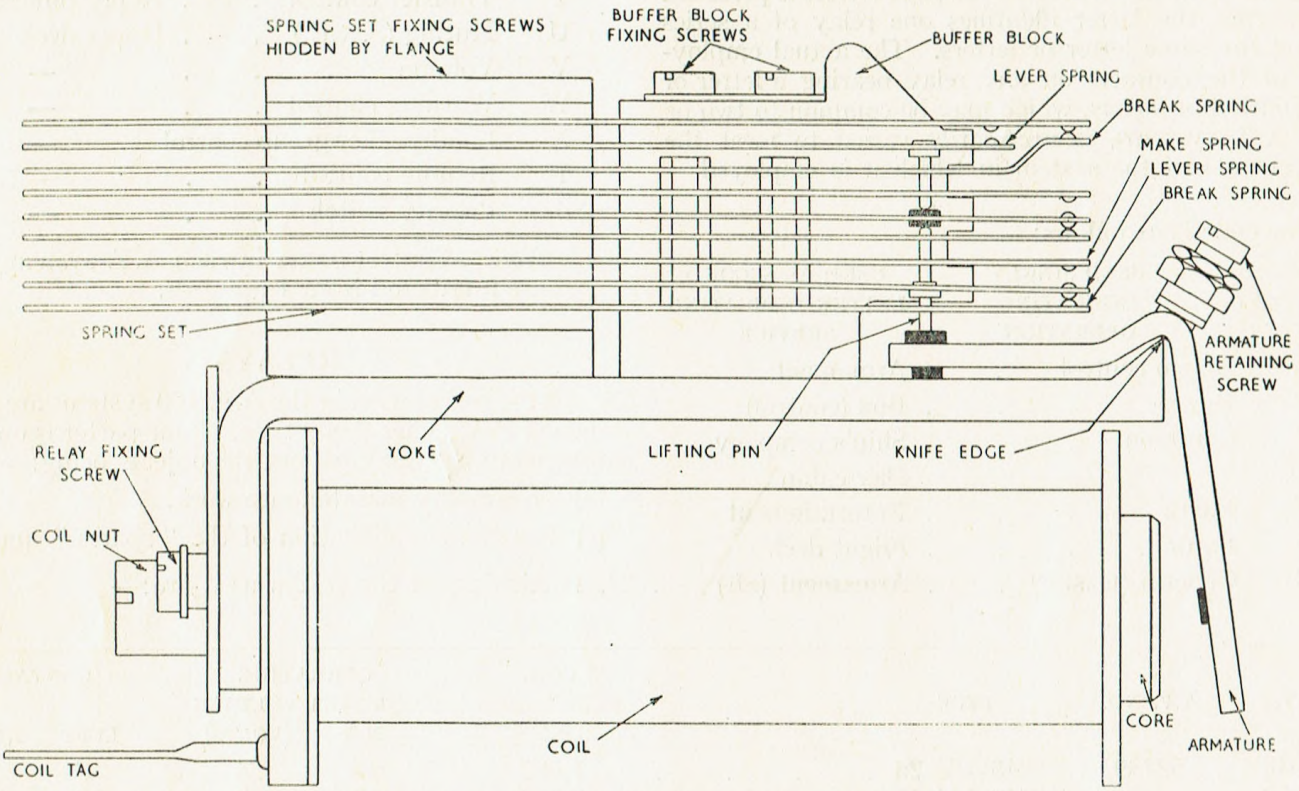

Figure 1. A typical 3,000 type relay. Side view

28. Figure 1 illustrates a typical relay. The principal parts are a coil, an iron core, an L-shaped yoke, an L-shaped armature and a spring-set. The core, carrying the coil, is clamped to the short arm of the yoke by a coil nut. Coil tags protrude from the rear end of the coil for making connections to the winding. The armature is pivoted in its angle on a knife edge formed on the long arm of the yoke, and retained in place by an armature retaining screw. Pressure on the armature pivot is maintained by a spring and washer, the pressure on the spring being adjustable by an adjusting nut travelling on the retaining screw. After adjustment the adjusting nut is locked by a lock nut.

29. The core, yoke and the armature are manufactured from specially annealed Swedish iron and have very high permeability, low reluctance, and for practical purposes no residual flux. The metal parts are given a thin coating of non-corrosive protective material which has little or no magnetic property.

30. When the coil is energised one leg of the armature is drawn towards the free end of the core; the other leg of the armature acts as a lever and moves outwards from the yoke. This movement is employed to actuate lifting pins which cause the contacts to " make " or " break ".

Residual Studs

31. In the centre line of the free leg of the armature a " Residual Stud " is fitted. This is made of bronze and therefore is non-magnetic. Its purpose is to fix an air gap in the magnetic circuit through the core, yoke and armature, and so to control the release current. The residual stud length is made to a very fine limit and must not be altered; the standard length of stud is as stated in paragraph 24. Directions for checking this length are given in the maintenance instructions. A second bronze stud is fitted in the spring-operating leg of the armature to prevent a magnetic closure at that point.

The Spring-Sets

32. The relay contact fingers or springs are supplied assembled in sets. A spring-set consists of an insulated anchorage carrying the required number and description of contact spring fingers. The assembly is secured to the

long arm of the yoke near the angle of the " L ", and the spring fingers project from it along the yoke so that their free ends lie over the lever portion of the armature. Backward projections of the fingers from the anchorage form tags to which lines may be soldered. The lever finger tags are offset towards the centre line of the yoke for the improvement of accessibility. A relay operates a pair of spring-sets, mounted side by side and known as " left " and " right ". The left and right sets may or may not be matched or balanced.

33. The springs in the set are allocated numbers for identification purposes. When viewed from the tag (or coil nut) end of the relay with the spring sets uppermost, the springs of the set on the right hand are numbered in sequence from 1 to 9 from the yoke upwards; those of the left hand set are numbered from 21 to 29 in the same direction. These numbers, when used on circuit diagrams, indicate to which spring of the relay the connection is made.

34. There are three types of contact or spring fingers, namely, " make ", " break " and " lever ". The lever fingers are operated by the armature through the medium of " lifting pins ". Movement of the armature causes its lever end to lift the lifting pins, which in turn lift the lever fingers, causing them to open from the " break " fingers and to close on the " make " fingers.

35. The arrangement of the lifting pins depends upon the position of the lever finger or fingers in the spring-set and the number of lever fingers fitted. The lowest lever finger in a set carries a lifting pin which bears on an insulated stud on the lever portion of the armature. If there is a second or upper lever finger in the set it is operated by a lifting pin attached to the lower one and which takes against an insulated stud on the upper one. If there is a third lever finger a lifting pin projects downwards from it and bears on the insulated stud on the second lever finger. The lever fingers lie between the " make " and " break " fingers, and the lifting pins pass through holes cut in these.

36. There are four different switching arrangements of fingers. They are:—

TYPE	DENOTED BY
Make	M
Break	B
Change-over	C
Make before break change-over	K

37. *Make.* In a " make " arrangement the make finger is above the lever finger. Movement of the latter by a lifting pin causes it to close on the make finger.

38. *Break.* In a " break " arrangement a lever finger is normally closed on a break finger; movement of the armature causes the lever finger to be lifted clear.

39. *Change-over.* In a " change-over " arrangement the lever finger is moved to open from a " break " finger and to close on a " make " finger.

40. *Make before break change-over.* In this arrangement the make and break fingers are normally closed on each other, the break finger being bent up and the lever finger shortened to effect this. Movement of the " lever " finger causes it first to close on the " make " finger and then to lift the latter clear of the " break " finger.

Buffer Block

41. When the lifting pins cause the lever fingers to move, the " break " fingers will follow the movement of the lever fingers for a short distance before the break is effected. Conversely, when, on release, the lever finger moves away from a " make " finger the latter will follow it for a short travel before contact is opened. This movement is intentional and desirable both in the matter of providing the correct contact pressure and in introducing a slight sliding movement into the contact points helping to keep them clean. In order to limit this travel to the extent desired, relays are fitted with buffer blocks.

42. A buffer block is a block of moulded insulating material, mounted on the yoke between the left and right hand spring-sets. Slots are cut horizontally across its front face leaving a number of " steps ". Projecting lugs, one of which is a part of every make and every break finger, work in the slots. When a lever finger bears against either a make or a break finger it holds that finger with its lug just clear of the step in the buffer block. When the lever finger moves the make or break finger follows the movement until its lug bears on the step. In the case of a make finger at rest, the lug bears against the upper face of the step; in the case of a break finger, contact is broken when the lug bears against the under face of the step.

43. In the case of suspected defect in relay operation no attempt must ever be made to correct it by adjustment to, or filing or scraping of, the buffer block.

Contacts

44. Electrical contact between fingers is obtained by means of twin hemispherical contacts fitted near the ends. The end of each finger is split by a slot which terminates in a hole cut in the finger, thus forming two tongues. On each tongue a contact is fitted. By this arrangement each make and each break finger has two contacts on one face. Each lever finger in change-over arrangements (except those of " make before break ") makes contact in turn on both of its faces, therefore it has four contacts, two on the upper and two on the lower face. In " make before break " arrangements the lever finger and the make finger have two and four contacts respectively, on one face.

45. The contact metal is generally silver; that metal being chosen on account of its good conducting and self cleaning properties. Where heavy current is carried platinum contacts are used. A small V groove cut in the end of each tongue of a finger indicates that platinum contacts are fitted.

RELAY MAINTENANCE

46. The relays are designed to have maximum reliability under Service conditions, and before installation are carefully adjusted and tested. Gross mal-adjustments are not likely to develop during normal service, and, unless there is convincing evidence of faulty operation, the adjustments should not be touched.

47. Owing to the standardisation of relay types used in the A.F. 100 systems, and to the small number of patterns employed, some relays will be found with unemployed contacts. In the event of defective contacts it may at times be found possible and expedient simply to transfer the connections at the spring-set tags from a defective pair of fingers to a spare pair.

48. If and when relay failure does occur the most likely causes are dust and grease. Under Service conditions a completely dust free atmosphere is unlikely, and the relay covers should not therefore be removed unless absolutely necessary. To eliminate, as far as possible, trouble from dust, relays are normally mounted with spring-sets to the side, that is, the contact units, when operated, move in a horizontal direction. Thus, any dust present tends to work off the contacts rather than to settle on them.

49. Should evidence exist of faulty relay operation, either mechanical, for example, sluggishness, or by producing a specific circuit condition, such as apparent failure to close or open its contacts, check as follows:

(*a*) There should be no dust on any part of the armature, or on the contacts. Particular attention should be paid to the knife edge, the core face, and to the operating pins of the spring-sets.

(*b*) The relay should be completely free from oil or grease.

50. The remedies for the above possible conditions are:—

(*a*) Remove any dust by blowing sharply or by using a small, medium stiff brush, lightly applied.

(*b*) Clean dirty contacts using only a special contact cleaner. *Do not use a file.*

(*c*) Remove grease with a clean rag or by using chemically pure carbon tetrachloride, sparingly applied, and then a clean lint free rag.

Tools

51. The tools listed here are available as Naval Stores for maintenance work on relays —

PATTERN	DESCRIPTION	USE
0276/5840	Screwdriver, instrument P.O. No. 1	General use.
0277/910-6179	Spanner, flat, P.O. No. 2	Adjusting nut and lock nut on armature retaining screw.
0277/910-6180	Spanner, flat, P.O. No. 2	
0276/2260	Screwdriver, instrument P.O. No. 2	Buffer block and spring-set fixing screw.
0276/2265	Screwdriver, instrument P.O. No. 6	Core fixing nut.
0274/910-5003	Gauges, feeler P.O. No. 1	General use.
0274/910-5005	Gauges, feeler P.O. No. 3	General use.
0274/9436	Gauge, tension, (4-24 gms) P.O. No. 1	Spring-set fixing screws.
0274/9437	Gauge, tension, (10-80 gms) P.O. No. 2	Measurement of spring tension.
0273/910-4539	Cleaner, contact P.O. No. 1	Measurement of spring tension.
0274/9440	Guide P.O. No. 1	Contact points.
0273/9431	Adjuster, armature P.O. No. 2	Contact points.
0276/910-5497	Pliers, adjusting P.O. No. 2	Armature shoe-horn for replacing armatures.
0273/9433	Adjuster, spring P.O. No. 1	Tool for armature bending.
0273/9434	Adjuster, spring P.O. No. 2	Bent duckbill pliers for spring adjustments.

(Change No. 2.)

45. The contact metal is generally silver; that metal being chosen on account of its good conducting and self cleaning properties. Where heavy current is carried platinum contacts are used. A small V groove cut in the end of each tongue of a finger indicates that platinum contacts are fitted.

RELAY MAINTENANCE

46. The relays are designed to have maximum reliability under Service conditions, and before installation are carefully adjusted and tested. Gross mal-adjustments are not likely to develop during normal service, and, unless there is convincing evidence of faulty operation, the adjustments should not be touched.

47. Owing to the standardisation of relay types used in the A.F. 100 systems, and to the small number of patterns employed, some relays will be found with unemployed contacts. In the event of defective contacts it may at times be found possible and expedient simply to transfer the connections at the spring-set tags from a defective pair of fingers to a spare pair.

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49. Should evidence exist of faulty relay operation, either mechanical, for example, sluggishness, or by producing a specific circuit condition, such as apparent failure to close or open its contacts, check as follows:—

(*a*) There should be no dust on any part of the armature, or on the contacts. Particular attention should be paid to the knife edge, the core face, and to the operating pins of the spring-sets.

(*b*) The relay should be completely free from oil or grease.

50. The remedies for the above possible conditions are:—

(*a*) Remove any dust by blowing sharply or by using a small, medium stiff brush, lightly applied.

(*b*) Clean dirty contacts using only a special contact cleaner. *Do not use a file.*

(*e*) Remove grease with a clean rag or by using chemically pure carbon tetrachloride, sparingly applied, and then a clean lint free rag.

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0277/910-6179	Spanner, flat, P.O. No. 2	Adjusting nut and lock nut on armature retaining screw.
0277/910-6180	Spanner, flat, P.O. No. 2	
0276/2260	Screwdriver, instrument P.O. No. 2	Buffer block and spring-set fixing screws.
0276/2265	Screwdriver, instrument P.O. No. 6	Core fixing nut.
0274/910-5203	Gauges, feeler P.O. No. 1	General use.
0274/910-5205	Gauges, feeler P.O.	General use.

Adjustments

52. Should evidence of faulty operation persist after a relay has been cleaned as described in paragraph 50, check the following adjustments:—

	PARAGRAPH REFERENCE
(*a*) Residual stud length	53
(*b*) The residual air gap	53
(*c*) The armature:—	
(i) the retaining screw	54
(ii) the travel	55, 56
(*d*) The spring-sets:—	
(i) Straightness of springs	61
(ii) Twin contact tongues	62
(iii) Overlap of contacts	63
(iv) Spring tension	64–71
(v) Block pressures and contact pressures	64
(vi) Lever spring pressure	65
(vii) Total lever spring pressure	66
(ix) Contact clearance	72
(x) Contact operation sequence	73
(xi) Spring lift	74
(xii) Lifting pin clearance	75

53. Residual Studs, Residual Gap. The residual stud should be firmly fixed in the armature. Its length is 12 mils. but for maintenance adjustments it is not necessary to gauge the length, but to measure the gap known as the residual gap which exists between the nearest parts of the core face and the armature when the latter is closed as far as the stud will allow. The minimum acceptable gap for a 12 mil. stud is 5 mils. Care must be taken when gauging to see that the actual minimum gap is measured. The gap is gauged by the holed feeler gauge; the hole accommodates the stud while the armature is closed by hand. If the specified minimum clearance is not obtained the armature should be changed.

The Armature

54. Retaining Screw. All the relays are fitted with the later type of retaining screw which is designed to be shock and vibration proof and with adjustable spring compression. With the nuts free the screw must be screwed right home, and the spring compression adjustment made by means of the adjusting nut and locked by the lock nut. The spring should have sufficient compression to ensure that the armature is securely pivoted along the knife edge. If the nuts are screwed down too far the armature movement is restricted or may even be prevented.

55. Travel. This is the distance between the striking face of the residual stud and the core face. The standard is 31 mils., with a test tolerance of + or — 3 mils. To test, insert a 28 mils. feeler gauge, and when an attempt is made to close the armature by hand a slight movement should be felt. When a gauge of 34 mils. is inserted no movement should be possible. When making these tests the gauge must not be inserted so far as to reach the residual gap where the residual measurements are made.

56. Travel Adjustments. If the armature travel needs adjustment it should be done by bending by means of the armature adjuster. This should rarely be necessary. The armature must be removed from the relay and bent inwards to decrease or outwards to increase the travel. The armature must be placed over the tool knife edge and clamped firmly. By operating the tool the armature can be bent in either direction without altering the angle of the V groove which works on the knife edge. An allowance must be made however in the tool lever movement for the elasticity of the armature material.

Adjustments of Spring-Sets

57. Since all the contact arrangements of fingers of relays used in the A.F. 100 systems are all of the " change-over " type, instructions are given here for that arrangement only.

58. If a spring-set is found to be out of adjustment it is advisable to readjust in all respects, otherwise, while rectifying the adjustment of one detail others may be upset and require further adjustment later. If the relay is in an awkward position or bad light it is desirable to remove it to the workshop when ever possible.

59. When readjusting a spring-set each contact unit, that is, each set of three springs in a " change-over " unit, should be treated as an entirely independent unit, commencing with the one nearest to the yoke and working successively to the top contact unit in the spring-set. Each spring-set should be adjusted separately. The spring adjustments for the " change-over " type of contact unit are given in the following paragraphs.

60. **Change-over contact adjustment:—**

	PARAGRAPH REFERENCE
(*a*) Straighten springs if necessary . .	61
(*b*) Tension the " make " spring against the block step	64
(*c*) Operate the armature and tension the " break " spring against the block step . .	64
(*d*) Release the armature and tension the lever spring so that the " break " spring leaves the block step, and, in addition, is tensioned against the lifting pin or stud below it . .	65
(*e*) Check the contact clearances, sequence of " make " and " break ", and the spring lift, correcting where necessary	72–74

61. Straightness of springs. Every spring, including the lug which rests on the buffer block step, must appear straight and flat when the relay is midway between the operated and unoperated positions, that is, when all buffered springs are in contact with the buffer block, and all lever springs are midway between the break and the make springs.

62. Twin contact tongues. Twin contact points should " make " or " break " simultaneously so far as can be judged by eye. Each contact is on an independent tongue and these tongues should be adjusted when necessary to obtain simultaneous closing. The spring tongue adjusting tool should be used.

63. Overlap of contact points. Pairs of contact points which make contact one with the other (one in one spring and one in an adjacent spring) should not overlap each other by more than one third of the diameter of a contact, as judged by the eye. If faulty the spring-set should be changed.

Spring Tension

64. Block pressures and contact pressures. Contact pressures are not measured directly but the correct pressure is ensured by tensioning the spring fingers so that their lugs rest against the steps of the block with a certain " block pressure ". A " block pressure " is the pressure required at the tip of the spring to lift the lug away from the block. The standard pressure for the

type of relays under discussion is from 16 grammes to 20 grammes. The springs should resist a pressure of 16 grammes and the lugs should move away from the block at 20 grammes. The gauge should be applied to the tip of the spring and not to the lug. Block pressures of " make " springs should be measured with the armature unoperated; those of " break " springs must be measured with the armature operated.

65. LEVER SPRING PRESSURES. " BREAK " CONTACTS. A lever spring associated with a break spring should be tensioned so that, with the armature unoperated, and the break spring adjusted to the correct block pressure, the pressure of the lever spring towards the armature is within the limits of 5 to 8 grammes. The pressure should be measured by applying the gauge to the tip of each lever spring of the set. Any lever springs above that under test must be held clear by the tip of a small screwdriver. It should be noted that it is the *resultant* pressure of the lever spring and its associated " break " spring that is being measured. The lifting pin of the lever spring should lift from the armature stud when a pressure of 8 grammes is applied, but should not leave the stud when a pressure of 5 grammes is applied, to the tip of the lever spring.

66. GROSS OR TOTAL LEVER SPRING PRESSURE. If a spring-set has more than one lever spring, to find the gross lever spring pressure it will be sufficient to measure the pressure of the lowest lever spring. This pressure value should be within the limits of " n " times the figures given in the preceding paragraph, where " n " equals the number of lever springs in the set. Whenever gross lever spring pressure is measured at the lowest lever spring it is essential to check the inward tension of the extreme upper lever spring in the set in addition to the total lever spring pressure. This should be the same as for a single contact lever spring. To verify that all the other lever springs are finally tensioned towards the armature the pressure due to the upper lever springs must be relieved, and, under these conditions the lever spring being checked should not show any tendency to leave the lifting pin or stud of the lever spring immediately below it.

Spring Tension Adjustment (*Figure* 2)

67. Spring fingers should be tensioned either with the special adjuster provided (see Figure 2), or with the duck bill pliers. The instructions which follow refer to the special tool, but the principles apply to both. If the duck bill pliers are used it is important that the spring be gripped *lightly*, otherwise the required tension will not be obtained.

68. The tension of a spring should not be increased by merely giving a bend or " set " to the back end. If this were done the pressure at the lifting pin or stud (or at the buffer block step) would be increased, but the extra pressure would cause the spring to sag and upset the contact clearances. The correct method, therefore, is first to form a uniform " hump " or " bow " in the spring by the process known as " stroking ", so that when finally, a " set " is put on the back end of the spring to increase the pressure at the contact point, the tendency to sag is counteracted by the " hump " and the spring remains straight.

Stroking (*Figure* 3)

69. The following example shows the details of this method as applied to the tensioning of a " make " spring on to the buffer block step. For simplicity the directions are given assuming that the relay is mounted with its spring-sets uppermost, but once the principle is understood there should not be any difficulty in carrying out the operation while the relay is mounted on its side, either left hand or right hand.

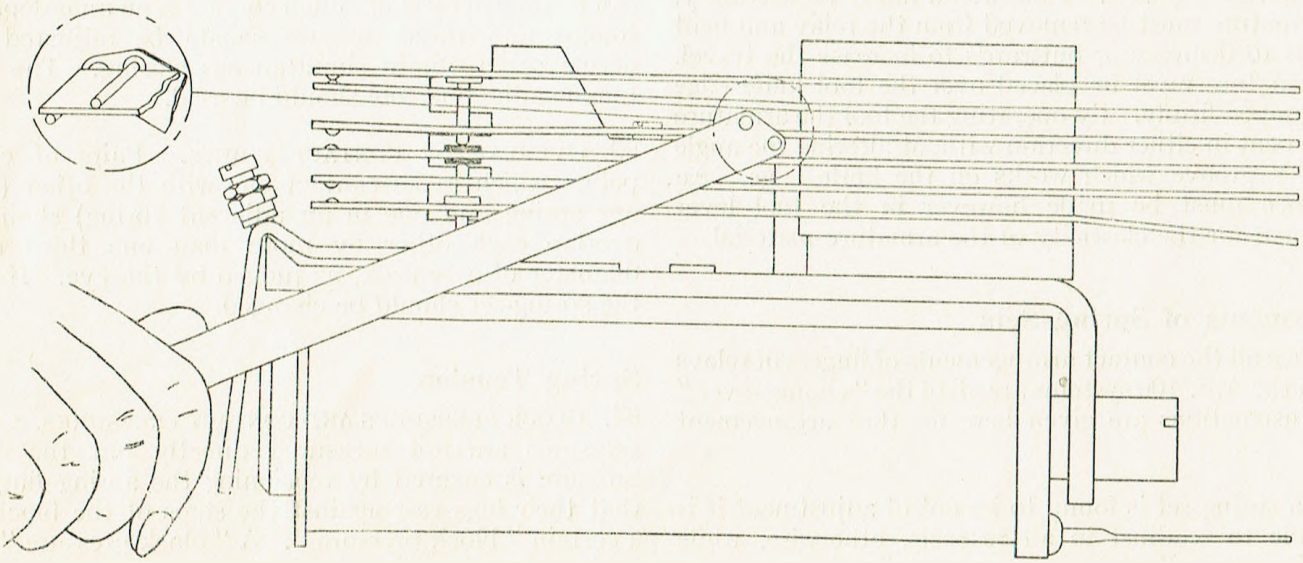

Figure 2. Tensioning a spring

type of relays under discussion is from 16 grammes to 20 grammes. The springs should resist a pressure of 16 grammes and the lugs should move away from the block at 20 grammes. The gauge should be applied to the tip of the spring and not to the lug. Block pressures of " make " springs should be measured with the armature unoperated; those of " break " springs must be measured with the armature operated.

65. LEVER SPRING PRESSURES. " BREAK " CONTACTS. A lever spring associated with a break spring should be tensioned so that, with the armature unoperated, and the break spring adjusted to the correct block pressure, the pressure of the lever spring towards the armature is within the limits of 5 to 8 grammes. The pressure should be measured by applying the gauge to the tip of each lever spring of the set. Any lever springs above that under test must be held clear by the tip of a small screwdriver. It should be noted that it is the *resultant* pressure of the lever spring and its associated " break " spring that is being measured. The lifting pin of the lever spring should lift from the armature stud when a pressure of 8 grammes is applied, but should not leave the stud when a pressure of 5 grammes is applied, to the tip of the lever spring.

66. GROSS OR TOTAL LEVER SPRING PRESSURE. If a spring-set has more than one lever spring, to find the gross lever spring pressure it will be sufficient to measure the pressure of the lowest lever spring. This pressure value should be within the limits of " n " times the figures given in the preceding paragraph, where " n " equals the number of lever springs in the set. Whenever gross lever spring pressure is measured at the lowest lever spring it is essential to check the inward tension of the extreme upper lever spring in the set in addition to the total lever spring pressure. This should be the same as for a single contact lever spring. To verify that all the other lever springs are finally tensioned towards the armature the pressure due to the upper lever springs must be relieved, and, under these conditions the lever spring being checked should not show any tendency to leave the lifting pin or stud of the lever spring immediately below it.

Spring Tension Adjustment (*Figure* 2)

67. Spring fingers should be tensioned either with the special adjuster provided (see Figure 2), or with the duck bill pliers. The instructions which follow refer to the special tool, but the principles apply to both. If the duck bill pliers are used it is important that the spring be gripped *lightly*, otherwise the required tension will not be obtained.

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Stroking (*Figure* 3)

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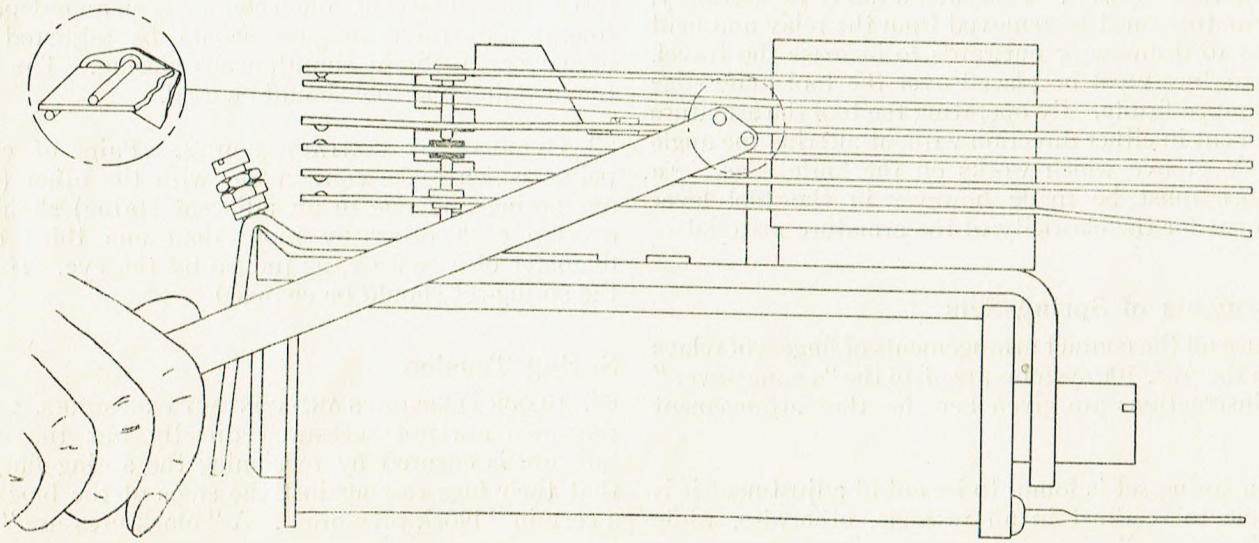

Figure 2. Tensioning a spring

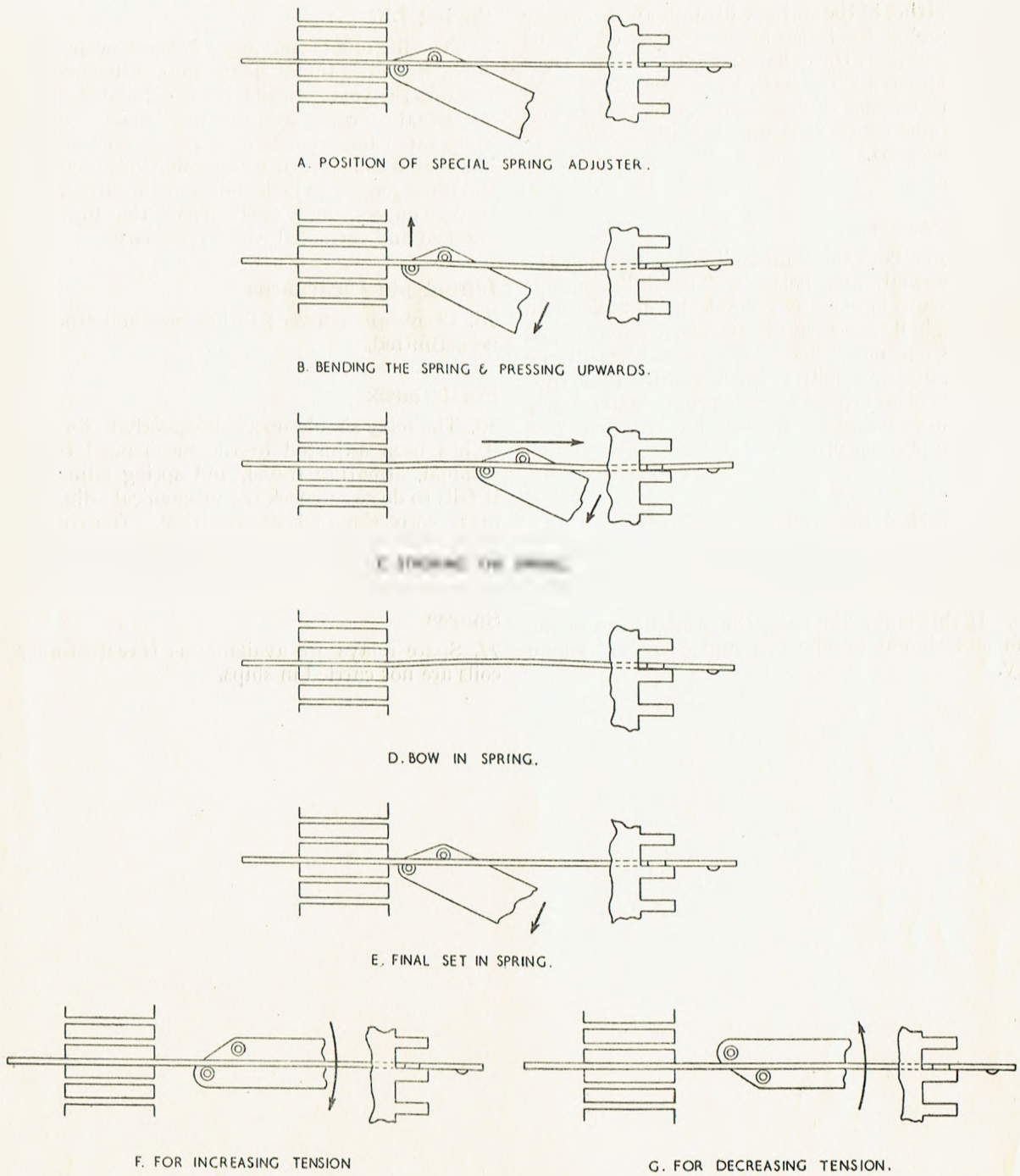

Figure 3. Spring Pressure Adjustment

70. **Procedure :—**

(*a*) Place the tool over the spring with the prongs as shown, at the back end of the spring. (Figure 3A.)

(*b*) Use the tool as a lever to exert a light pressure on the spring as shown, at the same time pressing the tip of the tool upwards. (Figure 3B.)

(*c*) Keeping the spring under pressure, draw the tool gently but firmly along the spring so that a " bow " is extended towards the buffer block step. (Figure 3C.)

(*d*) The shape of the spring after this " stroking " will be as shown, a uniform " bow " being formed along the length of the spring. (Figure 3D.)

(*e*) Replace the tool at the back end, and give a " set " to the spring to increase the pressure on the buffer block step until the spring becomes straight. (Figure 3E.)

71. The final setting of the spring will apply the necessary increased pressure at the buffer block, and yet the spring will be quite straight at the end of the adjustment. Once the principle of stroking and setting is understood, it can be applied to increasing or decreasing of tension in any spring without further explanation; the appropriate end of the tool being used.

Contact Clearances

72. The clearance between " make " contacts when the armature is normal, and between " break " contacts when the armature is operated, should be not less than 10 mils., that is, half the height of a standard dome-shaped contact point when new. The clearance can usually be judged by eye, and normally is much greater than this. If incorrect, the straightness of the springs, particularly the twin-contact tongues, should be checked and corrected where necessary.

Contact Operation Sequence

73. In a " change-over " contact arrangement it should be checked that the lever spring contacts leave the " break " contacts before they close on the " make " contacts. If this is not the case, the straightness of the spring fingers should be checked and corrected where necessary.

Spring Lift

74. The lift of a spring finger is the movement of its lug away from the buffer block step, either away from or towards the yoke. Spring lift should be checked by eye, the armature being operated for " make " contacts, and unoperated for " break " contacts. The nominal value is about 5 mils., with a minimum of about 2 mils. If the lift is judged to be insufficient the straightness of the spring fingers, and particularly the lugs should be checked and corrected where necessary.

Lifting pin Clearances

75. Clearances between lifting pins and studs must not be permitted.

Final Check

76. The relay should operate correctly in its circuit after it has been adjusted to the mechanical tolerances of residual, armature travel, and spring adjustments. If it fails to do so re-check the mechanical adjustments and make corrections where necessary. The coil should be balanced for resistance but even if correct may still be defective magnetically.

Spares

77. Spare relays are available as Naval Stores. Spare coils are not carried in ships.

APPENDIX 1

TRANSFORMER WINDING DATA

Notes on re-winding the transformer

1. It is not intended that the transformer should be re-wound in ships except in case of necessity.

2. In connection with the winding data given below it is assumed that the defective article will be available for study as to the manner of leading the ends of the windings in and out, it being impracticable to give full winding details in this book.

3. Particular care must be taken when re-winding the transformer to ensure that any overlap of the single turn of the screen is well insulated.

WINDING NO.	LEAD-OUT COLOUR	TERMINAL LETTER		
1	RED	B	(START)	PRIMARY
	WHITE	G	(FINISH)	
2	BLACK	H	(START)	PRIMARY
	YELLOW	C	(FINISH)	
3	BLACK	A		SCREEN
4	BLUE	D	(START)	SECONDARY
	YELLOW	E	(TAP)	
	GREEN	F	(FINISH)	

WINDING NO.	NO. OF TURNS	SIZE OF WIRE (S W G)	TAPPED AT TURN NO.	D.C. RESISTANCE (OHMS)
1	775	30	—	20
2	775	30	—	24
3	1	—	SCREEN	—
4	760	22	380	2·8

TRANSFORMER T1 PATT. 0513/12672

APPENDIX 1

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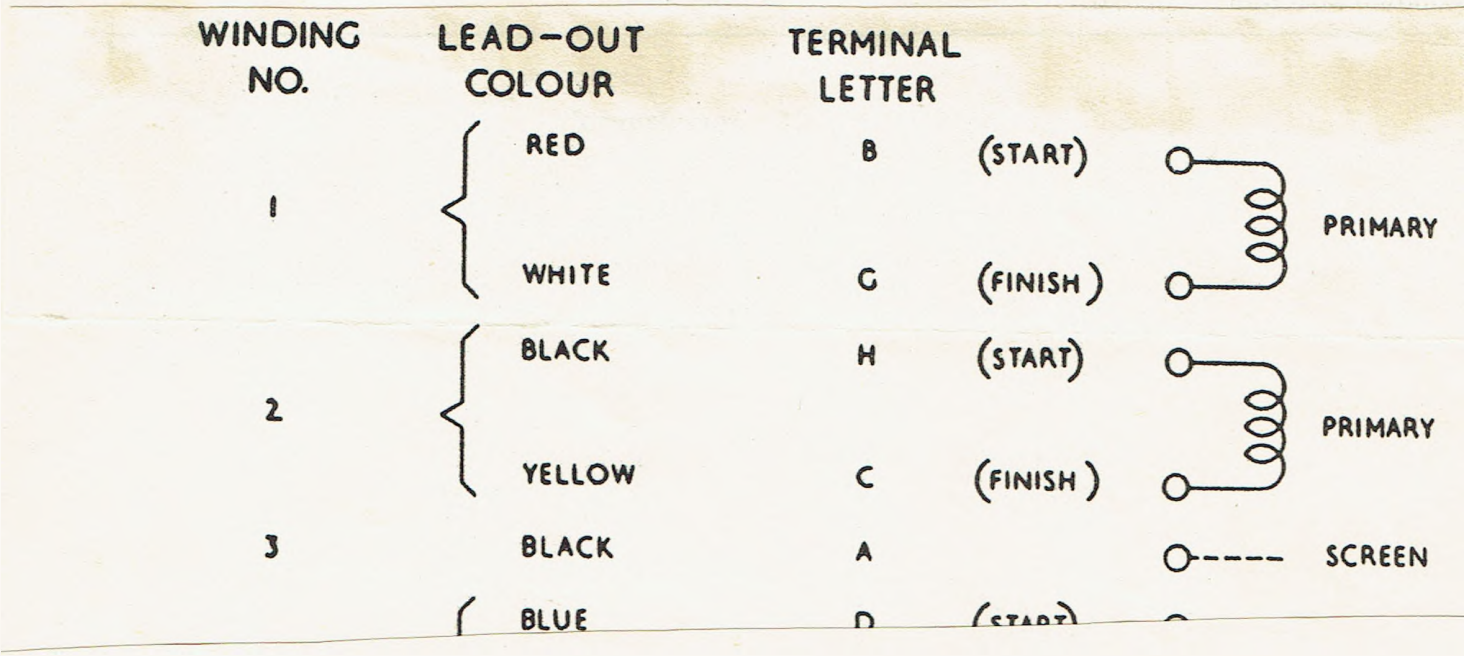

Wire insulation. Enamel covered.

Winding direction. All windings wound clockwise as viewed from the end of the former where the winding are brought out.

Adjacent layers of windings Nos. 1 and 3 are separated by one turn of manilla paper 3 mils. thick.

Insulation over windings. Two turns of insulating cloth.

Wire material. Copper.

Screen material. Tinned copper foil, 2 to 3 mils. thick.

APPENDIX 2

Summary of Structural and Electrical Details

	A.P. 12653	A.P. 12597
STRUCTURAL:—		
Dimensions:—		
Height (in.)	15¾ (9E)	12¼ (7E)
Width, overall (in.)	19	19
Depth, front to back (in.)	17	17
Projection, front, from mounting rack (in.)	9	—
Withdrawal clearance (in.)	18	18
Weight (maximum) (lb.)	70	60
Type of mounting	Rack	Rack
Fixing particulars	Slide rails and clamps	Slide rails and clamps
Cable entry:—		
(*a*) 24 way plug (Painton Cat. No. 500489)	6 in No.	3 in No.
(*b*) 10 way plug. I.S. Cat. No. Z 560118	1 in No.	1 in No.
Position	(*a*) Top front (*b*) Side (right)	(*a*) Top front (*b*) Side (right)
Casing material	Mild steel sheet	Mild steel sheet
Type of enclosure	Protected	Protected

	A.P. 12653	A.P. 12597
ELECTRICAL:—		
Supply	A.C.	A.C.
Voltage (volts)	230	230
Frequency	50–60 c.p.s.	50–60 c.p.s.
Power consumption (secondary)	200 VA	100 VA
Small components:—		
Switches:—		
D.P. A.C. supply:—		
Number	1	1
Pattern (see Note)	*	*
S.P. Isolating and relay test:—		
Number	as req.	as req.
Pattern. I.S. Cat. No.	Z 510300	Z 510300
Fuses:—		
Supply to System:—		
Number and capacity	2 15A	2 15A
Pattern (see Note)	†	†
Relay panel supply:—		
Number and capacity	2 2A	2 1A
Pattern	A.P. 19246	A.P. 19246
Pilot lamps	6000	6000

* "Arrow" type. Cat. No. S0093B.

† With A. P. 19349 or I.S. Cat. No. Z590123.

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1. All the switching necessary for bringing microphones, amplifiers, alarms and loudspeakers into use, and for all inter-connection between the numbered A.F. systems is relay operated. The reasons for the adoption of this method are:—

(*a*) In a system of this complexity any other method would be impracticable.

(*b*) Economy of cable and therefore of weight.

(*c*) The switch contacts of all sensitive switching, such as that of the extremely low voltage currents from microphones, are sited in a well protected and ventilated housing.

(*d*) Reduction of interference, since microphone cables are switched near the amplifier instead of opening the circuit at the microphone end of the cable.

(*e*) Action damage risk can be reduced. For example, if the switches in microphone circuits were situated at the speaking positions the liability of those circuits becoming short circuited by action damage, thereby rendering all microphones inoperative, would greatly be increased. Further, in certain circuits, for example, in alarm and warning push lines, by the use of suitable relays in conjunction with line resistors it has been made possible to discriminate between the closing of the circuit by normal process and its being closed by short circuit from action or other damage, and so to avoid false signals being given by damage operation.

(*f*) Convenience of maintenance, in that the relays mounted on their panels are all located in the amplifier compartment and therefore, when required, attention can be given and adjustments made under favourable conditions.

Relay Panel Circuits

2. The circuits of relay panels are designed individually to meet the needs of the A.F. systems or sections of which they form parts. Therefore the descriptive and explanatory matter in this book is confined to general applications and no particular circuit is described. Full details of the methods of employing the relays, and of their circuits and operation are given in the books describing the A.F. systems concerned.

3. Relay panels are made in two sizes:—

A.P. NO.	POSSIBLE NO. OF RELAYS
12653	25
12597	10

The particular needs of individual A.F. systems in the matters of:—

(*a*) the number and type of relay required, and

(*b*) the number, type and purpose of switches required are met from these two general A.P. Nos., variations in each pattern being identified by the addition of a reference letter suffix, thus, A.P. 12653 (*ref. a*).

Mounting, Weight and Dimensions

4. Both patterns of panel are rack mounted. Weight and dimensions are as follows:—

	A.P. NO. 12653	A.P. NO. 12597
Weight, maximum (lb.)	70	60
Height (in.)	$15\frac{3}{4}$ (9 E)	$12\frac{1}{4}$ (7 E)
Depth, front to back (in.)	17	17
Width overall (in.)	19	19

DESCRIPTION

Connections

5. All connections to the panels are made by plugs and sockets of the multi-pin type. These are of two sizes, 24 way for carrying the lines leading to the relay coils and contacts, and 10 way for " control " purposes.

6. The larger panel has provision for six 24 way plugs, giving connections for a total of 144 lines. The smaller size panel has provision for three such plugs, affording a total of 72 line connections. The plugs and sockets are identified by letters on each panel in order to assist in correct engagement. The number of lines and plugs fitted to any one panel is varied to suit the needs of the A.F. system in which it is fitted.

7. In some early panels the sockets are secured against the loosening effect of vibration by flat steel spring clips engaging in slots at the sides of the plugs. For release the spring clips must be squeezed inwards. The sockets on later panels have no such clips but are held in place by the design of the panel front cover.

8. Each panel has one 10 way plug and socket, PLC and SKC (late JC) for " control " purposes. It is fitted at the side of the panel and the socket is retained in a manner similar to that on the amplifiers. The lines carried are the A.C. supply lines (4), lines for a 50 volt A.C. indicator lamp circuit and, in panels of later manufacture, an earthing line. In early panels the earth connection is by a single line and separate plug and socket.

Design Considerations

9. The relay panel forms the centre and switchboard of the A.F. system in which it is fitted. That being so, special consideration has been given to the design of the panel and circuits with a view to the elimination as far as is possible, of the effects of action damage on the operation of the A.F. system and circuits.

10. To this end, resistors have been placed in all the outgoing lines where advisable, in order to reduce the risk of a complete short circuit of these lines by action damage.

Mounting of Relays

20. Relays are mounted on the main vertical member of the panel with all contacts visible from the front and the connection tags from the rear. In accordance with established practice the relays are mounted with the contact surfaces in the vertical plane, that is, contact movement is in the horizontal plane.

Relay Identification

21. The letters appearing on the front of the relay armatures are in accordance with a functional code which is followed throughout the A.F. 100 systems. The code enables any relay or junction panel terminal to be identified at sight. Where one or more letters is preceded by a figure the latter identifies one relay of a series bearing the same letter or letters. The actual employment of the contacts on any relay bearing a letter or combination of letters, which may be common to two or more A.F. systems, is necessarily varied to meet the requirements of the system in which it is employed.

22. The code is as follows:—

TERMINAL OR RELAY LETTER	USED SINGLY INDICATING OPERATION	USED AS SECOND LETTER INDICATING SERVICE
A	Alarm control	Armament
B	Buzzer	Box (control)
C	Common	Ship's company
D	—	Day cabin
E	Earth	Entertainment
F	Fault	Flight deck
G	General (master)	Armament (aft)
H	High tension	Hangar
I	Input	—
J	—	—
K	Buzzer call	—
L	Lamp control	Lower hangar
M	Microphone	Machinery
N	Indicator	Action information
O	—	Officers
P	Press to speak	—
Q	Note (alarm or warning)	—
R	Return (supply)	Ready rooms
S	Loudspeaker	Main Bc.
T	Transfer control	Reply outstation
U	Muting (S.R.E.)	Upper deck
V	Volume	—
W	Warning control	—
X	Loudspeaker group control	—
Y	Remote control	—
Z	Priority switch	—

Note:—Control boxes in each A.F. system are numbered from 1 upwards.

RELAYS

23. All the relays used in the A.F. 100 systems are of the standard Post Office 3,000 type. Four patterns only are employed in the relay panels, the objects being:—

(*a*) To simplify maintenance work.

(*b*) For the simplification of the "spares" question.

24. Particulars of the relays used are:—

I.S. CAT. NO.	A.P. NO.	TYPE	COIL RESISTANCE (OHMS)	OPERATING CURRENT mA	OPERATING VOLTAGE (VOLTS)	CONTACTS LEFT	CONTACTS RIGHT
Z 530046	52189	SM3-LV-26	1,000	14	24	C	C
Z 530058	—	SM3-LV-45	2,000	14	48	2C	2C
Z 530060	—	SM3-LV-48	1,000	25	48	$\overline{3C}$	3C
Z 530145	52215	SM3-LV-14	200	30	12	C	C

All coil resistances have a tolerance of + or − 10 per cent. Contacts shown underlined are made of platinum.

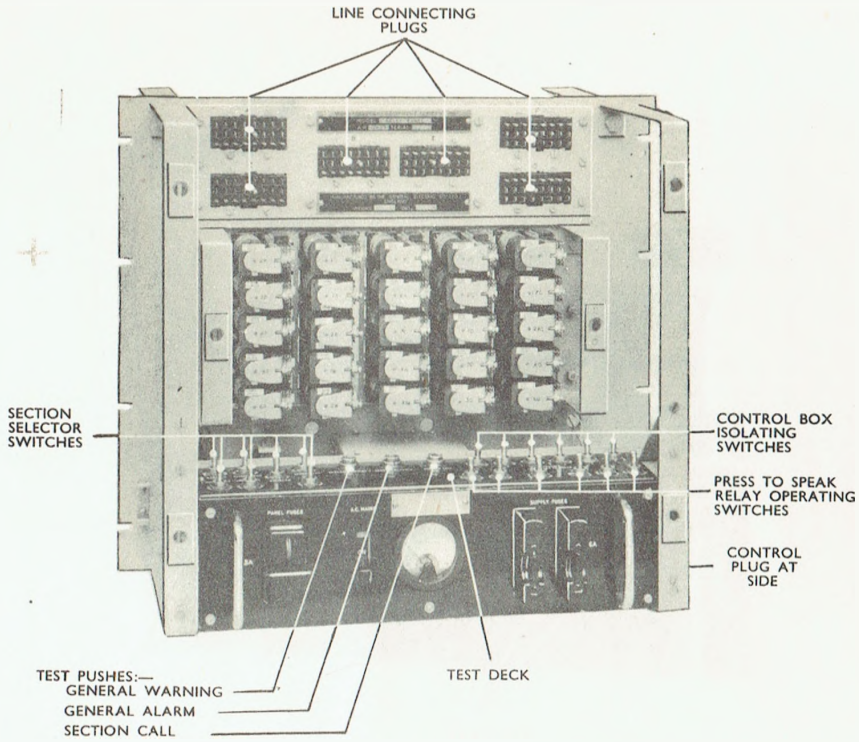
All the above-mentioned relays have:—

(*a*) Armature travel of 31 mils. (*b*) Residual stud length of 12 mils. (*c*) Spring thickness of 14 mils.

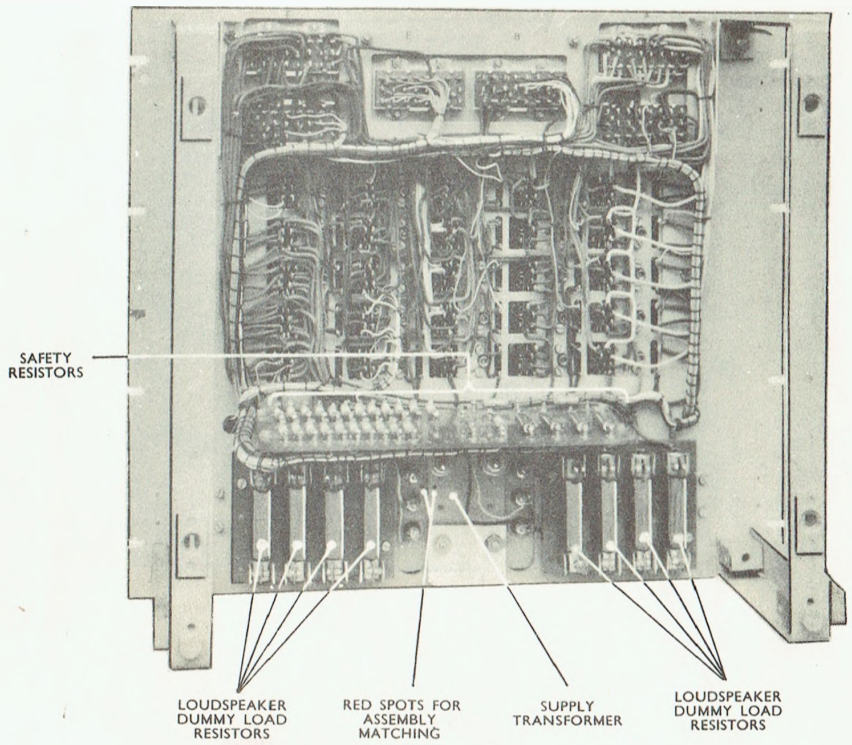
Representation on Drawings

25. Relays are shown on the drawings in this series of books as rectangles (the resistance values being omitted). Each relay is identified by a fractional representation consisting of letters and figures. The numerator of the fraction is composed of the identification letters and figures according to the code explained in paragraphs 21 and 22, the fraction denominator is a single figure indicating the number of contacts which open or close when the relay operates. For example, $\frac{FZ}{4}$ would indicate relay FZ having four contacts.

26. The circuit contacts which are closed or opened by the relays are shown in circuit diagrams detached from their relay, and situated at the point in the circuit which most clearly displays their function. All such detached contacts are identified by the code letters or letters and figures of the numerator of the relay fraction followed by



(a) A TYPICAL LARGE RELAY PANEL
FRONT VIEW



(b) A TYPICAL LARGE RELAY PANEL
REAR VIEW

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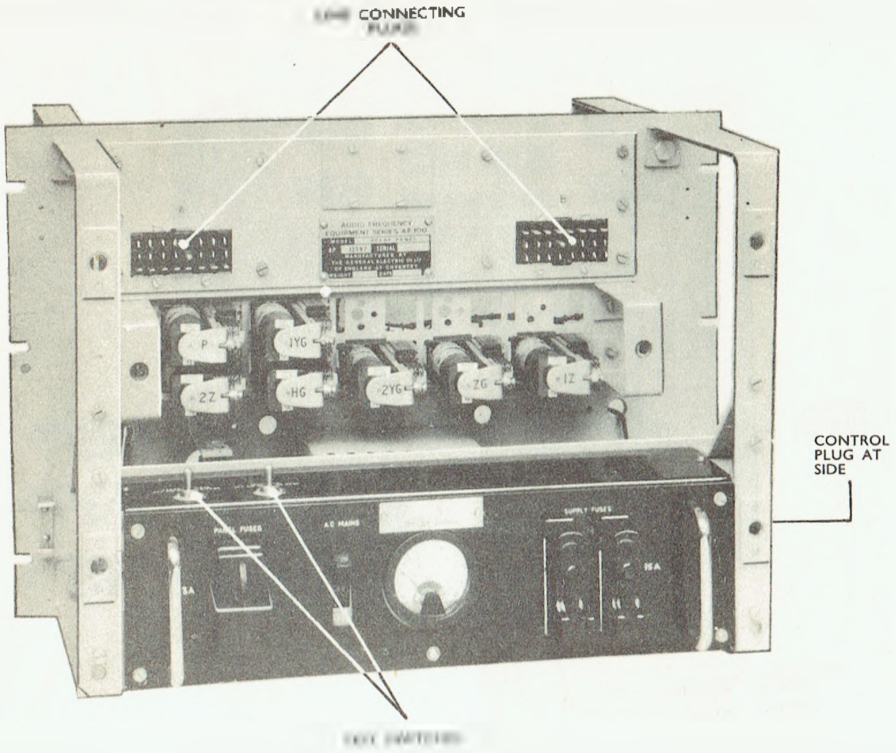
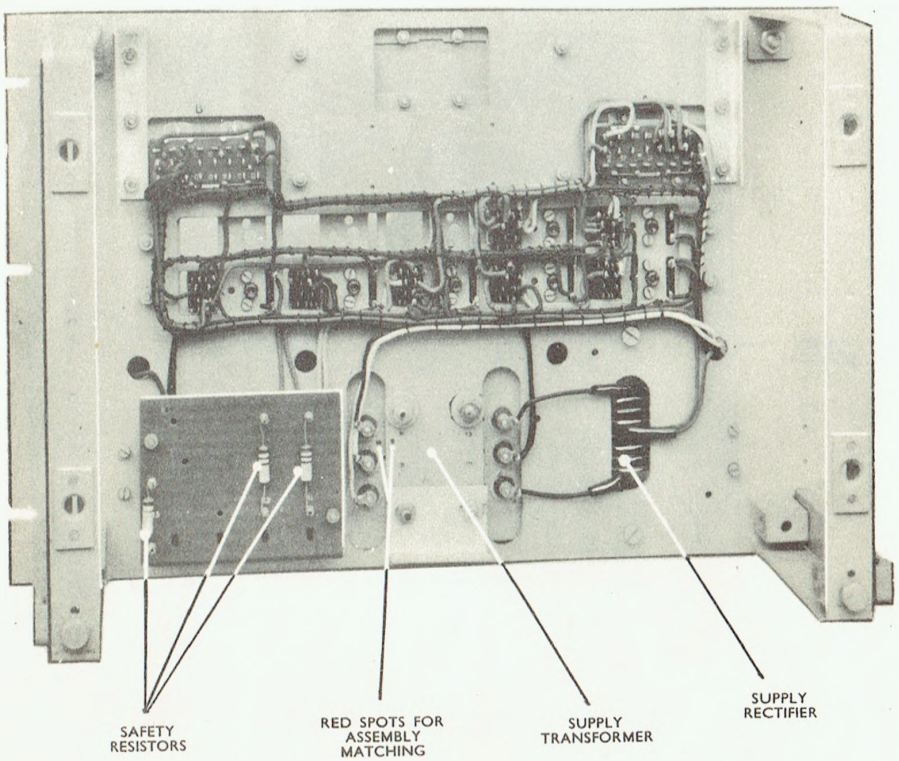
PLATE 1.



(a) A TYPICAL SMALL RELAY PANEL
FRONT VIEW



(b) A TYPICAL SMALL RELAY PANEL
REAR VIEW

PLATE 2.

one or more figures. The figures indicate the actual contacts of the relay; thus FX 1/2 would indicate contacts Nos. 1 and 2 of relay FX.

Relay Description

27. The description given here of the Post Office type 3,000 relays applies only to those patterns which are employed in the A.F. 100 series equipments and scheduled in paragraph 24.

> *Note:*—In the description which follows, and in the maintenance instructions later, any prepositional terms such as " above " or " lower ", refer only to the view of the relay as seen in Figure 1, and not to its position when mounted for use.

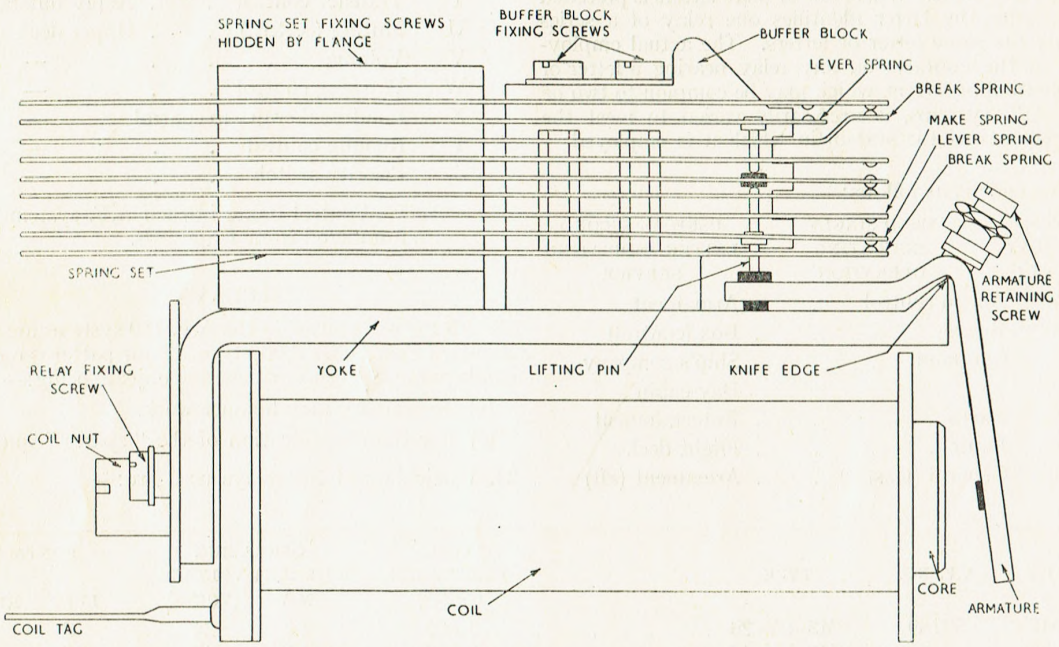


Figure 1. A typical 3,000 type relay. Side view

28. Figure 1 illustrates a typical relay. The principal parts are a coil, an iron core, an L-shaped yoke, an L-shaped armature and a spring-set. The core, carrying the coil, is clamped to the short arm of the yoke by a coil nut. Coil tags protrude from the rear end of the coil for making connections to the winding. The armature is pivoted in its angle on a knife edge formed on the long arm of the yoke, and retained in place by an armature retaining screw. Pressure on the armature pivot is maintained by a spring and washer, the pressure on the spring being adjustable by an adjusting nut travelling on the retaining screw. After adjustment the adjusting nut is locked by a lock nut.

29. The core, yoke and the armature are manufactured from specially annealed Swedish iron and have very high permeability, low reluctance, and for practical purposes no residual flux. The metal parts are given a thin coating of non-corrosive protective material which has little or no magnetic property.

30. When the coil is energised one leg of the armature is drawn towards the free end of the core; the other leg of the armature acts as a lever and moves outwards from the yoke. This movement is employed to actuate lifting pins which cause the contacts to " make " or " break ".

Residual Studs

31. In the centre line of the free leg of the armature a " Residual Stud " is fitted. This is made of bronze and therefore is non-magnetic. Its purpose is to fix an air gap in the magnetic circuit through the core, yoke and armature, and so to control the release current. The residual stud length is made to a very fine limit and must not be altered; the standard length of stud is as stated in paragraph 24. Directions for checking this length are given in the maintenance instructions. A second bronze stud is fitted in the spring-operating leg of the armature to prevent a magnetic closure at that point.

The Spring-Sets

32. The relay contact fingers or springs are supplied assembled in sets. A spring-set consists of an insulated anchorage carrying the required number and description of contact spring fingers. The assembly is secured to the

Components

11. In addition to carrying the relays, the following components are found on relay panels:—

ITEM	PURPOSE
(*a*) Supply fuses . .	Power supply for the A.F. system.
(*b*) Panel fuses . .	Panel relay power supply.
(*c*) Transformer, 230/50 volts.	Panel relay power supply.
(*d*) Full wave metal rectifier.	Panel relay power supply.
(*e*) Milliammeter . .	Used as a voltmeter across the 50 volt rectified supply.
(*f*) A.C. supply switch .	Closing of the 230 volt supply to the system.
(*g*) Switches, various .	As stated in paragraph 12.
(*h*) Resistors, various .	As stated in paragraph 13.

Note:—In the following paragraph the term " switch " includes both toggle and push operated circuit " makes " and " breaks ".

12. Switches are accommodated on the relay panels for the purposes shown:—

(*a*) For closing the operating circuits, for test purposes, of relays which operate when:—

(i) A " section call " is made from a control box to a control box of an associated A.F. system.

(ii) Any " press to speak " switch is closed at any microphone position.

(iii) Groups of loudspeakers are switched " in " or " out ".

(iv) Any " alarm " or " warning " tone is sounded over a system.

(*b*) For the isolation of 50 volt D.C. supply lines leading to individual control boxes.

(*c*) For the closing or opening of the A.C. power supply.

Switches mentioned under (*a*) and (*b*) above are all on the " test " deck and are not accessible until the front cover is removed.

13. The resistors which may be accommodated on the relay panels are:—

(*a*) Action damage safety resistors in each of the lines leading:—

(i) To indicating meters in all control boxes.

(ii) To " in use " lamps in all control boxes.

(iii) To section call buzzers and lamps.

(iv) From the alarm panel for conveying " alarm " and " warning " signals to sections.

(*b*) Amplifier load compensating resistors for groups of loudspeakers switched off.

(*c*) Current limiting resistors in the test circuits for certain relays.

(*d*) Sound volume reduction resistors, series and shunt, for certain loudspeaker groups.

(*e*) Panel meter series resistor.

Power Supply

14. An A.C. single phase supply at 230 volts, 50 or 60 c.p.s., is brought from the C.W.S. or similar source, enters by SKC and PLC connections Nos. 11 and 12, passes through a D.P. switch which is operated from the front of the panel, to a pair of 15 ampere fuses. From the load side of these fuses supplies are taken:—

(*a*) out by plug and socket connections Nos. 3 and 4 to the other rack units of the system, and

(*b*) through a pair of 1 ampere fuses to the primary of a transformer.

Both pairs of fuses are accessible from the front of the panel.

15. The purpose of the transformer is to provide, in connection with a rectifier, a D.C. supply independent of any other source, for the operation of the relays. The transformer secondary has a centre tap which forms one pole of the supply, and with a metal rectifier placed in each of the lines to the end terminals, a full wave rectified supply at 50 volts is provided. Details of the transformer windings are given in Appendix 1.

16. For some A.F. systems which require a 50 volt A.C. supply for lamp call up or other purposes a pair of lines are taken from one half of the secondary, independent of the rectifier. Connections Nos. 7 and 8 of PLC are used for these lines when required.

17. The Meter. A milliammeter arranged in series with a suitable resistor to act as a voltmeter, is connected across the 50 volt supply and mounted with the dial in the centre of the front of the panel. The meter is the same pattern as is used in other rack units. A midscale reading of 5 represents a measured voltage of 50 V. The inscribed mark at 3·16 on the scale has no significance on this panel.

18. Distribution. The 50 volt supply is distributed as required inside the panel and externally to individual control boxes or other microphone positions. Fuses are fitted in the " in use " lamp supply in later relay panels.

19. Isolation of Control Boxes. Where several control boxes are fitted in an A.F. system the power supply to each is taken through an isolating switch in the relay panel. The primary purpose of the switch is for the isolation of action damage but it may also be used for switching off power temporarily from any box while not required for use or when under repair. In the original system the switch does not cut off the supply to the " in use " lamps.

CONTENTS

ILLUSTRATIONS

CHANGES
~~AMENDMENTS~~

~~Amendment~~ No. Change	A.F.O. "P" No.	Date of insertion in this copy	Initials
1	489/63	13-3-66	
2	50/64	13-3-66	

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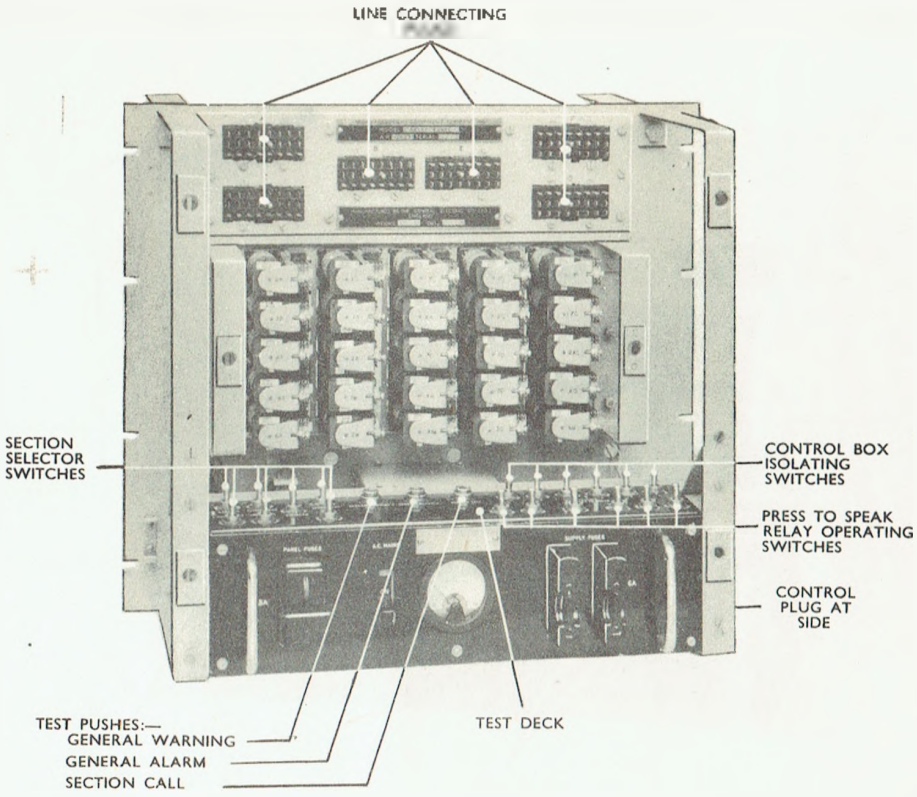
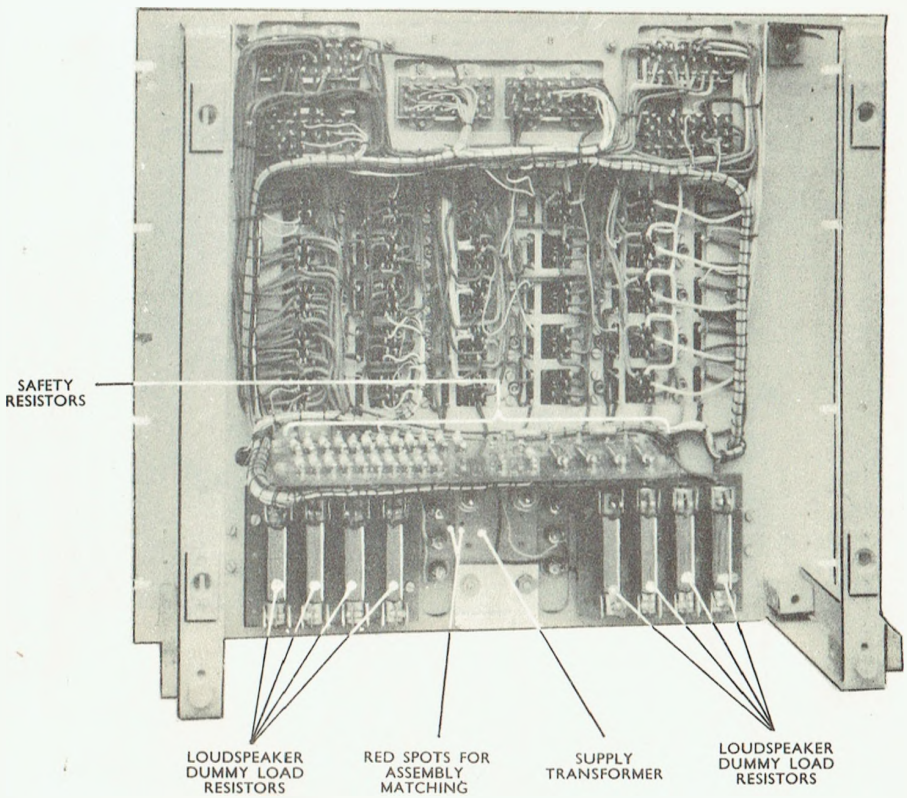
ILLUSTRATIONS

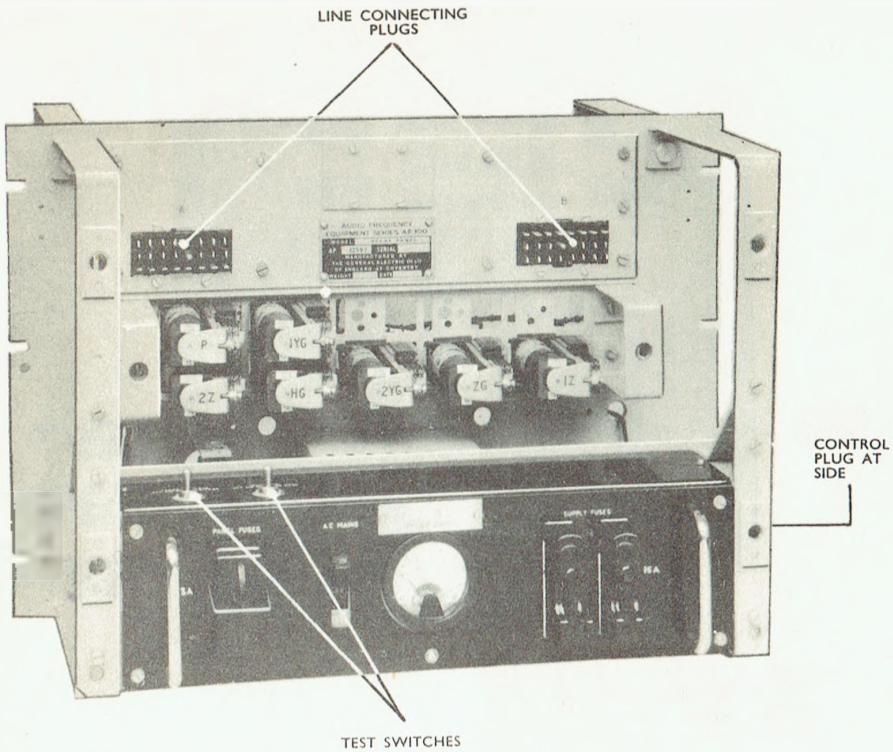


(a) A TYPICAL LARGE RELAY PANEL
FRONT VIEW

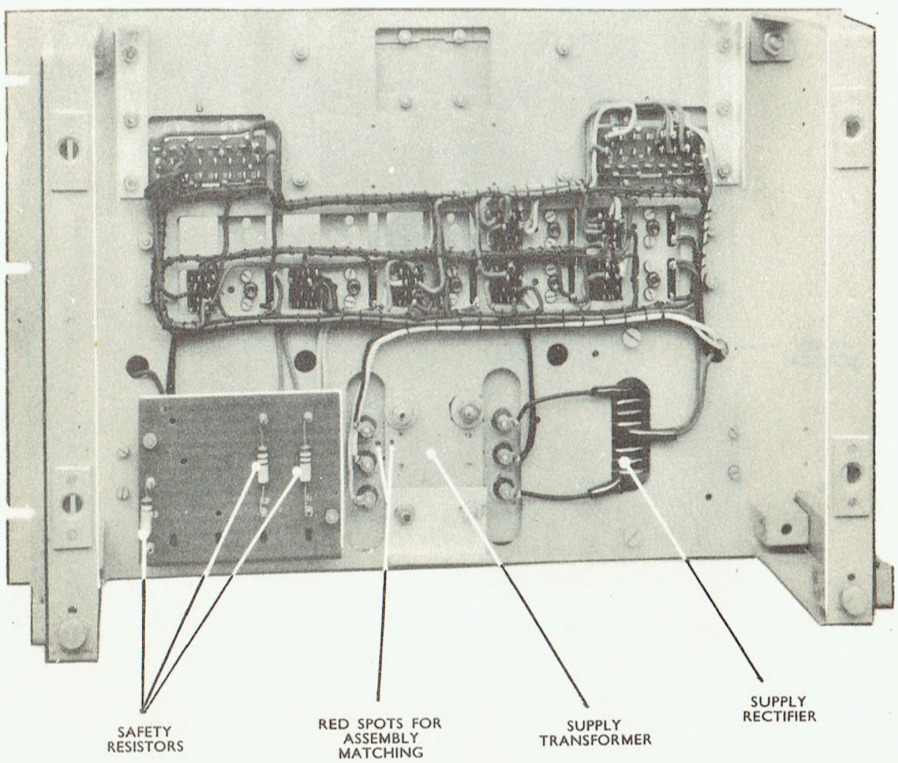


(b) A TYPICAL LARGE RELAY PANEL
REAR VIEW

PLATE 1.



(a) A TYPICAL SMALL RELAY PANEL
FRONT VIEW



(b) A TYPICAL SMALL RELAY PANEL
REAR VIEW

PLATE 2.