COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF CIVIL AVIATION

HANDBOOK FOR MF/HF RECEIVER AND CODAN UNIT

D.C.A. TYPE NO. R20 (RECEIVER)
D.C.A. TYPE NO. CD3 (CODAN)

EQUIPMENT IDENT. NO. Y5/13

MANUFACTURERS TYPE NO. C55184 (RECEIVER)
C55183 (CODAN)

AMALGAMATED WIRELESS AUSTRALASIA LTD.

CRYSTAL LOCKED COMMUNICATION RECEIVER

HANDBOOK IDENT NO. Y5/HB138

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This is the 2nd Edition of the handbook for the R20 Receiver and includes full details of the equipment in service at the time of printing.

The technical description takes into consideration all modifications and amendments carried out in accordance with the following Airways Engineerings Instructions.

7.5271	dated	April 1955
7.5274	"	April 1958
7.5277	"	June 1962
7.5282	"	January 1963
7.5284	"	August 1964

Table of Contents (cont'd)

1. BRIEF DESCRIPTION:

1.1. Receiver

The DCA type R20 Crystal Locked Communications Receiver provides reception facilities for R.T., or M.C.W. service at any one crystal-locked frequency in the ranges 200-400 kc. and 1.7 to 30 Mc. A Codan Unit DCA type CD3, is fitted to the receiver for automatic muting under unusable signal conditions.

Frequency Coverage

Any one spot frequency within the ranges of 200 to 400 kc and 1.7 to 30 Mc. may be selected. These ranges are divided into five bands for each of which a separate coil unit is available. Changing these coil units is fully described in Section 3.17. later.

Range A	200 kc. - 400 kc.
Range B	1.7 Mc. - 4 Mc.
Range C	4 Mc. - 7.5 Mc.
Range D	7.5 Mc. - 15 Mc.
Range E	15 Mc. - 30 Mc.

Determination of Oscillator Crystal Frequency

The frequency of the local oscillator crystal bears a direct relationship to the desired receiving frequency and is determined in the following manner -

Let f = Carrier frequency in kilocycles

Fo = Mixing frequency in kilocycles

Fx = Crystal frequency in kilocycles

Then Fo = f + 455 kc.

Where Fo is less than 8,500 kc $Fx = Fo$

Where Fo lies between 8,500 & 16,000kc. $Fx = \frac{Fo}{2}$

Where Fo lies between 16,000 & 24,000kc. $Fx = \frac{Fo}{3}$

Where Fo lies between 24,000 & 30,455Kc. $Fx = \frac{Fo}{4}$

Note that Fx should always be selected within the range 2 to 8.0 Mc. Two stages of H.F. amplification are provided on the H.F. range and one on the L.F. range. These feed into a pentagrid mixer with signal from the local oscillator. The oscillator is crystal locked and is isolated from the mixer by a buffer amplifier.

There are three I.F. stages and the selectivity of the I.F. channel may be varied by means of a selectivity switch inside the chassis. This switch provides four positions, "A, B, C & D" of increasing bandwidth, the "A" position bringing into circuit a narrow band mechanical filter, if fitted.

The output of the second detector is fed to the audio stages via a noise limiter that may be switched out of circuit. The audio stages comprise essentially a limiting amplifier, the gain of which is controlled by a bias voltage applied to the first stage of the amplifier and derived from the output of a side-chain amplifier. The output of this side-chain amplifier and thus the bias voltage applied to the audio chain will vary in proportion to the level of the input signal. An audio volume control is fitted that does not affect the action of the limiting amplifier, and three audio outputs are available, these being -

600 ohms at 300 milliwatts
600 ohms at 30 milliwatts
15000 ohms at 1 milliwatt.

A.G.C. voltages are applied from the output of the A.G.C. rectifier to the R.F. stages, the mixer and the first two I.F. stages. The input to the A.G.C. amplifier is taken from the input to the third I.F. stage, amplified and fed to the diode rectifier circuit that produces a D.C. voltage, varying with the I.F. level, for application as A.G.C. bias. A connection to the A.G.C. line is provided that enables the receiver to be used in diversity reception. The R.F. gain (sensitivity) control voltage is applied directly to the A.G.C. line. An output of I.F. signal is provided from the A.G.C. amplifier circuit as input to the codan unit.

A variable frequency oscillator is incorporated, the output of which can be fed into the I.F. channel to produce audio beat frequencies.

A local remote switch enables the transfer of control of receiver sensitivity, codan on/off and call indicator functions which can be used with either short or long line control systems. When set for remote control the local A.G.C. switch becomes inoperative and A.G.C. voltages are permanently applied. The B.F.O. cannot be remotely controlled.

A solid state conventional full-wave rectifier circuit feeding a capacitance input filter is employed to provide H.T. and bias voltages and a gaseous regulator is connected across the rectifier output to stabilise critical voltages.

Codan Unit

The word codan is derived from the intial letters "carrier operated device anti-noise".

The unit contains circuits that determine whether a carrier signal is present in the I.F. channel of the receiver, and depending on the signal to noise ratio, either mutes or unmutes the receiver. The opening sensitivity is controlled by the R.F. gain control.

The signal for analysis from the I.F. channel of the receiver is passed through a delay line and mixed with the output of a crystal oscillator. The sum frequency is then fed to another mixer where it is mixed with a signal derived from the I.F. channel of the receiver; there is no delay introduced into this latter frequency. The difference frequency is then fed to two circuits; one passing a narrow band and the other passing a broad band of frequencies about the centre frequency. The relative amount of energy passed by the narrow and wide passband circuits depends on whether signal or noise predominates in the I.F. channel of the receiver.

Rectifiers are connected in the outputs of these two circuits, the D.C. outputs then being fed to a pair of balanced D.C. amplifiers which in turn drive a second pair of D.C. amplifiers in the plate circuit of which is the muting relay.

1.2. Mechanical Description

1.2.1 Receiver

The receiver is of recessed chassis construction, with the small components and wiring inside the chassis, and the valves, transformers and other larger components projecting rearwards horizontally.

The chassis is fabricated of spot-welded sheet steel and is bright-alloy plated on cadmium to provide maximum protection against corrosion. A dust cover fits over the rear of the chassis and is spring located for ease in removal and replacement.

A front panel is secured by a captive screw at the top of the unit and on the removal of this screw, the panel hinges forward to provide access to the inside of the chassis.

The receiver is designed to mount in a standard 19" equipment rack and is secured by eight $\frac{1}{4}$" B.S.W. countersunk head screws. These become accessible on opening the front cover panel.

1.2.2 Codan

The codan unit is constructed on a small chassis that fits to the rear of the receiver chassis. A flexible cable and octal plug provide electrical inter-connection to the receiver.

Two bollards on the ends of the codan chassis locate the unit in the two slotted support posts projecting from the rear of the receiver chassis. Spring retaining clips fit over the bollards when in position and permit the codan chassis to hinge in the supports. The rear set of holes (as per AEI 7.5274) in the retaining springs allows the codan to be lowered almost horizontally for servicing in situ. A 2BA captive screw at the top of the chassis secures the codan in position. A carrying handle is fitted to each end of the codan chassis and may be used to support the chassis during servicing.

1.3. Specification

Dimensions:	Front Panel 19" x 14" high. (8 Rack units) Depth 12½" including dust cover.
Weight:	68 lb., including valves, dust cover and codan unit.
Power Requirements:	Approx. 120 watts from 200-260 volts, 40-60 cycles supply. The codan unit derives its power requirements from the receiver.
Frequency Range:	200-400 kc and 1.7 to 30 Mc covered in five bands for each of which a separate coil unit is available.

Range A	200 kc - 400 kc
Range B	1.7 Mc - 4 Mc
Range C	4 Mc - 7.5 Mc
Range D	7.5 Mc - 15 Mc
Range E	15 Mc - 30 Mc

Input Impedance:

200 - 400 kc	High impedance
1.7 - 30 Mc	100 ohm, balanced or unbalanced. (electrostatic shield)

Frequency Control:

200-400 kc 1.7-30 Mc	HC3B crystal HC7 oven fitted with HC6 crystal may be fitted for close frequency tolerance operation.

Sensitivity: All figures are for 300 milliwatts output.

200 - 400 kc	2uV., modulated 30% at 400 cycles.
1.7 - 30 Mc	1uV., " " " " "

Signal to Noise Ratio:

200 - 400 kc	12db down on removal of modulation from a 2uV., signal modulated to 30% at 400 cycles.
1.7 - 30 Mc	12db down on removal of modulation from a 1uV., signal modulated to 30% at 400 cycles.

Codan Sensitivity: 0.25uV from a signal generator unmutes the receiver.

A.G.C. Characteristics: (Measured at Det. diode current socket CF5).

Within 3 db for inputs of 1.0uV to 0.5V., frequency up to 20Mc.

Within 3 db for inputs of 2.0uV to 0.5V., frequency 20-30 Mc.

Image Frequency Rejection:

Up to 9 Mc.	Better than 70 db.
9.0 to 15 Mc.	" " 50 db.
15 to 30 Mc.	" " 40 db.

Selectivity: Listed below are typical figures. See appendix 2b for typical response curves relating also to equipment fitted with a mechanical filter as per appendix.

Switch Position	Input Gain	Total Bandwidth
A	Use mechanical filter	See appendix 2b
B	+6db	4.0 kc.
	+20db	8.0 kc.
	+40db	11.0 kc.
	+60 db	13.5 kc.
C	+6db	6.6 kc.
	+20db	11.0 kc.
	+40db	14.5 kc.
	+60db	18.5 kc.
D	+6db	15 kc.
	+20db	19 kc.
	+40db	22.5 kc.
	+60db	25.5 kc.

Overall Frequency Response (For modulated carrier input)

With selectivity switch in position B

200 c/s 3 db down on 1,000 c/s
3000 c/s 9 db down on 1,000 c/s

Constancy of Output (Measured at Audio output with AGC characteristics within tolerance).

Within 3 db for input levels of from 10uV. to 2.0V., modulation from 20% to 80%.

Distortion: Not greater than 20% rms (or -14 db) at 400 cycles for input levels of from 10uV. to 2.0uV., modulation from 20% to 80%.

Output Impedance:
(i) 600 ohm - 30 milliwatts.
(ii) 600 ohm - 300 milliwatts.
(iii) 15,000 ohm - 1 milliwatt.

Remote Control: Receiver sensitivity, codan on/off and call indicator functions can be used with either short or long line control systems.

Electron Tubes and Diodes:

Receiver	V1	1st R.F. amplifier	6BA6
	V2	2nd " "	6BA6
	V3	Mixer	6BE6
	V4	Local oscillator - Buffer Amplifier	6J6
	V5	1st I.F. amplifier	6BA6
	V6	2nd " "	6BA6
	V7	A.G.C. amplifier	6AU6
	V8	A.G.C. rectifier - Noise Limiter	6AL5
	V9	BFO - reactance tuner	6J6
	V10	3rd I.F. amplifier	6AU6
	V11	BFO Buffer amplifier	6BA6
	V12	Limiter amplifier	6BA6
	V13	Audio amplifier	6AU6
	V14	Output	6AQ5
	V15	Bias amplifier	6AU6
	V16	Bias rectifier	6AL5
	V17	Gaseous regulator	OC3/ VR105
	W1	2nd detector	GE X 34
	W2	Long line control diode (Sensitivity)	OA202
	W3	Long line control diode (Codan on/off)	OA202
	W4	Long line control diode (Call Indicator)	OA202

	W5	H.T. rectifier	IN2358
	W6	" "	IN2358
Codan Unit	9V1	Crystal oscillator	6AU6
	9V2	1st Mixer	6BE6
	9V3	2nd Mixer	6BE6
	9V4	D.C. amplifier	6SN7-GT
	9V5	D.C. amplifier	6SN7-GT
	9W1	Signal diode	GEX34
	9W2	Noise diode	GEX34

Crystal Complement:

Receiver	X1	DCA type HC3B Tol. ± 0.005% operating into shunt capacitance of 30uu fd. temp. range 0-70°C.

An HC7 oven fitted with HC6 crystal may be fitted for close frequency tolerance operation.

Codan	9X1	Oscillator crystal DCA type HC9 Freq. 300 kc. ± 20 PPM @ 25°C ± 120 PPM 10-70°C in oscillator with shunt capacity of 40 uu fd.
	9X2	Filter crystal DCA type HC9 Freq. 300 kc ± 20 PPM @ 25°C ± 120 PPM 10-70°C with filter operating into a resistive load of not less than 1000 ohms.

NOTE: 9X1 and 9X2 were formerly type HC5. (See para 2.5)

2. TECHNICAL DESCRIPTION:

2.1. Receiver R20:

2.1.1 R.F. Amplifier

On frequency ranges B, C, D & E, the aerial input is connected directly to a wide band matching transformer T1 which is provided with an electrostatic shield between primary and secondary. The signal is then fed to the grid coil T2 via an impedance matching network C94 and C1. Two wide-band matching transformers are required to cover the frequency range 1.7 to 30 Mc.

For the low frequency range (Band A), the wide band transformer and first R.F. stage are dispensed with but the tuned circuit T3 associated with V1 is used to give additional selectivity and so reduce cross and inter-modulation.

Two stages of R.F. amplification are provided on the high frequency ranges, the output of the final amplifier V2 being fed to the signal grid of the mixer V3. Note that on the low frequency range, the first R.F. amplifier valve V1 is not used, although it need not be moved from its socket. To keep the gain to the desired level when using frequency range B 1000 ohm damping resistors have been wired in parallel with the primaries of T3 and T4.

2.1.2 Local Oscillator-Mixer

The local oscillator consists of one section of a twin-triode V4 operating in a crystal controlled "Pierce" circuit. The output is fed to the second section of this triode which acts as a buffer amplifier. The anode circuit of the buffer amplifier is tuned to the fundamental crystal frequency or the second, third or fourth harmonic of it depending on the frequency to which the receiver has been tuned. The oscillator signal is coupled, via C22, to the injector grid of the mixer valve V3, grid current of which is measured at CF2 (OSC GRID CURRENT). The anode circuit of V3 is tuned to the intermediate frequency of 455 kc by means of the first I.F. transformer T6.

2.1.3 I.F. Amplifiers

Three stages of amplification at 455 kc follow the mixer, the coupling between the first and second amplifier consisting of two transformers connected back to back, the same arrangement being used between the second and third amplifiers. This provides greater selectivity than with conventional coupling.

2.1.4 I.F. Selectivity

The selectivity switch S1 provides four positions of varying selectivity. To do this, tertiary windings are provided on the I.F. transformers that are connected back to back (T7 to T10 inclusive) and these are switched into circuit to increase the pass band of the I.F. transformers in the following sequence:-

Position A - No tertiary windings connected.

Position B - No tertiary windings connected.

Position C - Tertiary windings of T7 and T8 connected in series with the secondaries of their respective transformers.

Position D - Tertiary windings of T7, T8, T9 and T10 connected in series with the secondary windings of their respective transformers.

Using the originally arranged crystal (was X2) with switch position A selectivity was too narrow for AM use, and on other switch positions was too wide to reject adjacent frequency interference in some instances.

At appendices 2a to 2d is detail of the incorporation of a "mechanical" filter in lieu of the crystal. The bandwidth is determined by the selection of mechanical filter unit. The mechanical filter has not been included on the main drawing as the equipment should not be modified unless for a specific requirement.

2.1.5 Second Detector

The third I.F. amplifier V10 is coupled via the transformer T11 to the second detector. This is a germanium diode W1, and the load is connected in series with the secondary of the I.F. transformer T11, and takes the form of a voltage divider composed of R45, R46 and R47. A metering point CF5 is connected in series with this load and may be used in conjunction with a micro-ammeter to provide relative indication of the gain of the preceding stages.

If the noise limiter is not in circuit the audio voltage developed across R47 is applied to coupling capacitor C74 for application to the audio circuits.

2.1.6 Noise Limiter

The noise limiter uses a diode in a conventional arrangement to "clip" sudden peaks of signal such as produced by ignition interference, etc. Under conditions of normal reception, the voltage appearing across the detector diode load is negative with respect to earth and varies with the modulation envelope. When the A.N.L. switch S3 is switched

ON portion of this voltage (i.e. that appearing across R47 and R87) is applied to the anode of V8B. The cathode of this diode is maintained at a more negative potential by connecting it via R49 and R48 to the tap on R45 in the detector diode load. The capacitor C72 is decoupled from the load resistor R48 and maintains the cathode at a steady potential. Thus the series diode is normally conducting, and the voltage developed across its load circuit R75 and R62 varies in amplitude with the modulation envelope and is applied to the following audio amplifier stages.

Noise produced by electrical discharge is of a short transient nature and forms "spikes" on the modulation envelope. The negative "spikes" pass the second detector and appear across the load resistors. For the duration of each "spike" the negative voltage applied to the anode of the series diode will increase and as the cathode is stabilised by C72, the diode V8B will be cut off for the period that the noise spike exceeds a level determined by the setting of the NOISE LIMITER control R45.

It can then be seen that the series diode will pass the audio frequency components of the detector diode output, but will block any signal above the level determined by the setting of R45. This control is normally set so that clipping occurs for all impulses above the normal peaks of speech encountered on the circuit; distortion will be introduced if the control is set to commence clipping before this point.

[illegible].1.7 Audio Amplifier-Compressor

The audio signal from the second detector and noise limiter circuits is split and applied to two amplifier chains. These combine to produce a constant output for all input levels above a predetermined fixed value. One of the amplifier chains, consisting of V15 and V16, is fed with portion of the input signal and its output is applied as a D.C. bias voltage to the control grid of V12 in the other amplifier chain. This bias voltage will be directly dependent on the level of the audio input signal to the amplifiers and will produce an inverse effect on the gain of the first stage of the main audio chain since the valve employed in this position has a variable mu characteristic.

Conventional audio circuits follow the first or compression stage in the main amplifier chain, a pre-set volume control R55 being provided in the input circuit to the second amplifier V13. This control is independent of the limiting action of the amplifier and is used to adjust the level of the speaker or headphones as desired. The audio output valve V14 is a pentode and is loaded into the matching transformer T16 that will normally load to 600 ohms and provide 300 milliwatts. of output. Two pad networks are also connected across the secondary of this transformer and provide additional outputs of 30 milliwatts in 600 ohms and 1 milliwatt in 15,000 ohms.

2.1.8 A.G.C. Circuits

A signal from the I.F. channel is amplified by the pentode V7 before being applied to the diode V8A to produce the A.G.C. voltage. In normal operation this diode is provided with a positive delay bias at its cathode and the anode swing provided from the driving stage (V7) must be sufficient to overcome this before the diode will conduct and produce the A.G.C. voltage across its load. The load circuit is formed by the series of resistors R35, R85, R69 and R70. A negative bias voltage is applied to this network via R69 and R68 and may be controlled by R69 which functions as the R.F. GAIN control when the LOCAL-REMOTE switch S4 is set to LOCAL. Under remote control R69 is replaced in the load circuit by R73 and the negative bias is applied via R72 and R115 from the remote control circuits. The A.G.C. circuits may be paralysed by removing the earth from the voltage divider in the cathode circuit of V8A. This increases the bias on the valve further past cut-off so that the valve will not conduct irrespective of the magnitude of the input signal.

2.1.9 Beat Frequency Oscillator

Provision for remote CW reception has been removed and the BFO connection to the IF has been disconnected to increase the IF sensitivity. The BFO may, however, be required to assist in the identification of received signals, in which case it will be necessary to temporarily reconnect the coupling capacitor (C108) to the IF strip at T11/3 thus enabling the BFO to be used on local control only. The beat frequency oscillator circuit consists of a twin-triode V9. One section of this also operates as a reactance valve to control feedback and also to provide frequency variation. The characteristics of the reactance section are determined by the bias voltage applied to its grid. The controlling element is the potentiometer R65 in series with the -12 volt supply from the power section. To switch off the BFO, the grid return circuit of the reactance valve is disconnected from earth by switch S6. The frequency generated by the oscillator is cathode loaded into the isolating amplifier V11 then (if connected) to the primary of T11 and there beats with the intermediate frequency to produce the audio beat note.

2.2. Remote Control:

A local remote switch S4 is provided and allows the facilities of receiver sensitivity and codan on/off to be remotely controlled. In addition remote presentation of the codan operation is now available. DCA circuitry also provides for remote on/off switching of a.c. power to the equipment.

For short line operation negative potentials on individual wires are used to remotely control power ON/OFF, Receiver Sensitivity, Codan ON-OFF and provide remote channel indication.

For long wire operation, positive and negative potentials are used on a pair of wires to provide the above functions. Application of 50V positive to the R.F. Gain Line switches the receiver OFF via a relay operated micro-switch in the P.D.U., negative voltage determines the receiver sensitivity. On the codan line positive voltage switches the Codan OFF and negative voltage is used for channel indication via the back contact of the Codan relay. To convert from short line to long line operation, it is necessary for diodes W2, W3 and W4 to be placed in the respective control lines in addition to small wiring changes in the equipment.

Reference should be made to appendices 1a and 1b for details of short and long line control circuitry.

Control of Receiver and Codan Sensitivity:

Circuitry has been included in the receiver to remotely control the sensitivity of the receiver. This circuitry restricts the range of the R.F. gain control, enables a variable negative D.C. voltage to be applied between the grid and earth of the noise side of the first D.C. amplifier in the codan and provides for both the R.F. gain bias and the negative voltage in the codan to be varied remotely by a "Receiver Sensitivity Control" which is the existing R.F. gain control.

The codan operation depends on the balance of rectified IF voltages through two channels, one representing signal and the other noise. The difference of these is fed through D.C. amplifiers to operate the codan relay. The sensitivity control is effected by means of adjustments on the noise channel of the codan. The variable negative D.C. voltage applied to the noise channel of the codan is additive to the normal noise input and controls the signal channel level and thus the signal input to the receiver at which the codan will open. Increase the negative D.C. voltage means a higher signal input is required to open the codan. This applies up to the point where the A.G.C. in the receiver is operative, which is approximately 1 uV at maximum R.F. gain. Using the negative voltage to mute signals above the A.G.C. operating point would result in no signals opening the codan.

By increasing the R.F. gain bias voltage the commencement of A.G.C. action can be delayed to any desired signal input level. Thus, by using variation of R.F. gain control and a variable D.C. negative voltage in the noise channel of the codan, the opening point of the codan can be controlled over a wide range of signal inputs to the receiver. This is the method employed in the receiver for "Receiver Sensitivity Control". The maximum values of R.F. gain bias and applied negative voltages have been selected to provide maximum muting point of approximately 30 uV signal input for an average receiver.

2.4. Power Supply:

HT and bias power requirements for the receiver and codan are met by using two silicon rectifiers operating into a capacitor input filter. Resistors are placed in series with each rectifier to reduce the H.T. voltage to the desired level. Across the output of the filter is connected a gaseous regulator V17 in series with a dropping resistor R82 to provide two H.T. levels of 250 volts and 150 volts regulated. Use is made of the internal "jumper" of the regulator V17 to break the H.T. return circuit of the power supply should V17 be removed from its socket. The bias supplies are provided by a voltage divider R83 connected in series with the H.T. return to the power transformer centre tap.

2.5. Codan Unit:

The unit contains circuits that determine whether a carrier signal is present in the IF channel of the receiver, and depending on the signal to noise ratio, either mutes or unmutes the receiver. To do this two comparator circuits are involved; one receives, via a crystal type band-pass filter, energy from a narrow range of frequencies that are representative of the carrier level present; the other receives energy representative of all signals that may be present in the IF channel, including noise and modulation sideband.

The bandwidth of the narrow-pass filter is however, approximately 100 cycles and as variations of up to 500 cycles may be expected in the I.F. of the receiver, a system of double mixing in conjunction with a stable local oscillator (300 kc.) is used in the codan to produce a carrier whose frequency is independent of I.F. variation. The frequency of this carrier is 300 kc. and the examples given below indicate how the method compensates for I.F. drift.

(i) Receiver I.F. 455 kc mixed with 300 kc gives 755 kc which when mixed with 455 kc gives 300 kc.

(ii) Receiver I.F. 455.5 kc mixed with 300 kc gives 755.5 which when mixed with 455.5 kc gives 300 kc.

(iii) Receiver I.F. 454.5 kc mixed with 300 kc gives 754.5 kc which when mixed with 454.5 kc gives 300 kc.

As these examples show, this double mixing would have the disadvantage of producing false centre-frequency components from all noise frequencies of the signal spectrum as fed from the I.F. channel of the receiver. These false 300 kc. carriers, being in phase, would produce a relatively large amplitude 300 kc. carrier.

The production of this false 300 kc. carrier is avoided by introducing a delay line in the input to the first mixer. Signals passing through this delay line would undergo a phase change, the angle of which would vary with frequency. The characteristics of the line are such that the phase change varies over approximately 360 degrees from one extreme frequency of the I.F. band to the other. This results in the phase of the false carriers being spread over the full 360 degrees phase range, the resultant being thus reduced to a negligible level.

The 300 kc. oscillator is crystal controlled and uses a triode-connected 6AU6 (9V1) with the crystal between anode and grid and is anode circuit tuned by 9L1, 9C5 and 9C6 to a slightly lower frequency than the crystal. The oscillator frequency may be caried over a small range by means of the trimmer capacitor 9C1. Grid leak bias is used and resistor 9R2, in series with the grid leak 9R1, provides metering facilities.

Output from the oscillator is fed to the first mixer stage employing a 6BE6 (9V2). The other mixing frequency is taken from the 455 kc I.F. channel of the receiver and fed to the mixer via the delay line. The delay line consists of a series of double-tuned transformers 9T3 to 9T7 inclusive with top capacitance coupling from one transformer to the next.

The sum frequency (755 kc) is selected in the anode circuit and coupled to the second mixer 9V3 (6BE6). The second mixing frequency is again 455 kc. from the receiver IF channel but no delay is introduced and the difference frequency is selected in the anode circuit. Thus if a carrier component is present in the signal fed from the receiver I.F. channel then the output of the second mixer will also contain a carrier component with a frequency of 300 kc.

The output of the second mixer, under no signal conditions, consists of a band of noise, equal in width to that of the receiver I.F. pass band symmetrically spaced about a central frequency of 300 kc. The crystal filter accepts only the noise within its narrow pass band, the remainder of the noise being accepted by the wide band circuit in parallel with the filter. The outputs of each circuit are rectified to give D.C. voltages of negative polarity with respect to earth.

Due to the finite width of the carrier filter pass band, the ratio of noise passing through the filter to the noise passing through the wide band circuit is approximately 1:5, the exact ratio depending on the characteristics of the filter. This ratio remains virtually constant at all levels of noise. By dividing the noise voltage from the wideband circuit by a factor of 5, it is thus possible to make the noise voltages from both circuits equal. This is achieved by potentiometer 9R17. The voltages from the two circuits thus remain virtually equal irrespective of the level of the noise. Resistor 9R30 is shorted out during the adjustment of the codan. The function of this resistor is disucssed later in this sub-section.

When a signal is received from the second mixer, it divides between the carrier side and the noise side in a ratio of approximately 1:1 and is added to the currents already existing as a result of noise. The ratio of the increment in carrier current to that of noise current resulting from signal approximates unity in practice. Thus, with 9R17 adjusted to give a balance for all values of noise, the additional voltage developed due to signal on the noise side is attenuated by a factor of approximately 1/5. The D.C. voltages developed across the two diode loads are applied to a pair of balanced D.C. amplifiers which in turn drive a second pair of balanced cathode coupled D.C. amplifiers in the plate circuits of which is the muting relay.

The D.C. amplifier balance is adjusted by means of 9R19 so that in the absence of noise, the relay rests in a closed condition, i.e., 9R19 is adjusted so that the codan just mutes. Thus for all noise levels the input to the D.C. amplifier is balanced and the relay will remain in the muted condition. Hence the sensitivity of the codan is a function of the relay sensitivity and the signal level reaching the input to the filters, i.e. the gain of the receiver from aerial to input of filter.

Theordtically, it would appear that the codan sensitivity could be adjusted so that it would open on the smallest signal capable of operating the relay and remain closed in the absence of signal. In practice, however, it has been observed that, as this ideal condition is approached, the codan becomes prone to flick open in a transient fashion and that this flicking can be correlated with flicks in the carrier and noise currents. These effects are produced by "false carriers" which are possibly produced by noise bursts causing the crystal filter or perhaps the tuned circuits to ring. It is because of these false carriers that resistor 9R30 is used. During the adjustment of the codan this resistor is shorted out and the sensitivity is adjusted so that the codan just mutes with a flicking open every 3 or 4 seconds. The codan is purposely de-sensitised beyond the point at which the false carriers will open it by removing the short on 9R30, thus giving the codan a small fixed bias in favour of noise. In this condition, the signal required to open the codan will be a function of the prevailing noise. The effective magnitude of these false carriers have been reduced somewhat by the filter network 9R31, 9R32, 9C42 and 9C43 and tests have shown the codan can be adjusted to open on signals as low as 0.2 uV.

It should be noted that a matched pair of type HC5 crystals were initially used in 9X1 and 9X2 but are now replaced with closer toleranced type HC9. Should either 9X1 or 9X2 type HC5 crystal require replacement both crystals must be replaced with type HC9. Thereafter, it is not necessary to replace in pairs and individual crystals should then be ordered as required. Adaptors (ident No. V8/1278) are necessary and should be ordered when initially changing to the new crystals.

2.6. Codan Sensitivity Control: (See also 2.3 Control of Receiver and Codan Sensitivity).

This control can prevent low level signals from unmuting the receiver by reducing the gain of the receiver and thus the level of signal into the codan, as well as adding a proportionate bias voltage to the noise side of the codan.

Actually the "RF gain control" performs the gain controlling function but on "Remote" its range is specifically limited by R115/R72/R73, to provide a usable discrimination between low signal levels. The proportionate bias added to the codan reduces the difference in the receiver audio output level between the "just unmute" level and that level which AGC holds constant. This bias, adjustable at 9R36 in the codan, being proportionate should be set only when the Remote Sensitivity Control is set to minimum, as described in the section under "Adjustments - Control of Receiver Sensitivity".

Judicious use of this control can mask slight drifts in the DC amplifier bias adjustment and small changes in noise levels which would otherwise require readjustment of these controls.

3. ALIGNMENT AND ADJUSTMENT OF RECEIVER:

General:

Check that all valves and crystals are in their correct sockets, the codan is in place and the plug fitted to the interconnecting cable is securely located in its mating socket on the receiver chassis. Check also that input connections to the power transformer T17 corresponds to the mains voltage.

The receiver will normally be aligned accurately to the correct operating frequency. However, alignment may be disturbed during transport or the circuit frequency altered subsequently so a sensitivity check should be made to determine whether re-alignment is necessary.

Procedure for Sensitivity Check:

Connect the receiver to the mains supply and switch on the power switch. Set the R.F. GAIN control to maximum clockwise, LOCAL-REMOTE switch to LOCAL, B.F.O., A.G.C., A.N.L & CODAN switches to OFF, and the I.F. selectivity switch S1 to the "B" position.

Connect the output of a signal generator, accurately set to the required frequency and modulated 30% at 400 c/s, to the aerial input connector.

Plug a 100 uA 1,600 ohm test meter into the detector diode current test jack CF5.

If the receiver is tuned to a frequency in the 1.7 to 30 Mc range the input from the signal generator should be approximately 1 uV for a deflection of 15 uA on the test meter.

If the frequency is between 200 and 400 Kc then an input of not more than 2uV should be required for a deflection of 15 uA.

Alignment of R.F. Stages:

Set all controls as for sensitivity check.

(a) With a local oscillator crystal of the correct frequency fitted in its socket and the test meter connected to CF2 adjust C20 and the plug L4 to give a meter reading of between 40 and 80 uA. Note that this corresponds to the actual current of 200 to 400 uA.

(b) Connect the output of the signal generator to the input connector of the receiver. Note that one side of the input should be earthed at the receiver and the generator.

(c) Set the signal generator as accurately as possible to the desired operating frequency and adjust the output so as to obtain an indication on the test meter when connected in CF5 in the detector diode load circuit.

(d) If the alignment frequency is toward the lower end of the range covered by the coil assembly fitted, screw the slugs in the aerial and two R.F. coils (T2, T3 and T4) right into the coil former to increase inductance and conversely if the frequency is toward the upper limit the slugs should be unscrewed to about $\frac{1}{8}$" out of the formers.

(e) Using a non-metallic screwdriver, adjust the trimmer capacitors C1, C7 and C13 for maximum output as indicated on the test meter.

(f) Re-set the slugs in the aerial and R.F. coils for a maximum deflection. Reduce as necessary the output of the signal generator so as to obtain workable readings on the microammeter.

(g) Adjust the slug and trimmer capacitor C20 associated with the oscillator coil L4 for maximum sensitivity consistent with optimum signal to noise ratio.

(h) Reseal the tuning cores with the sealing paste provided.

3.4. Alignment of Aerial Circuit to 100 ohm Input:

A simple and accurate method of obtaining matching between the aerial feeder and the receiver aerial coil is as follows -

> Feed a signal into the receiver in a manner such that the aerial input impedance will not be affected, the aerial being connected to the receiver in the normal manner. This may be done by a radiated signal from the signal generator or by a signal coupled to the aerial by means of a small capacitance of, say, 5uuF. When an external aerial coupling device (e.g. multicoupler) is used the signal should be injected into the "aerial" side.
>
> Set the coupling capacitor C94 to about half in and tune the first grid circuit by means of C1. The output or signal diode current should be noted.
>
> Re-set the coupling capacitor and retune C1. The output will increase or decrease. The adjustment of these two capacitors which gives maximum signal output for minimum input from the signal generator is optimum aerial circuit tuning.

The receiver is now aligned to the operational frequency and may be placed into service. While in operation slight readjustments may be made to the tuned circuits to set the receiver exactly to the carrier frequency and these adjustments are to be made in the same manner as indicated in steps (e) to (g) alignment of R.F. stages with the input from the aerial substituted for the signal generator.

.5. Alignment of I.F. Stages:

It is important that the I.F. amplifier stages be aligned exactly to the centre frequency of 455 Kc. Thus, when re-alignment becomes necessary, an accurately calibrated signal generator must be used or a frequency meter used to check the generator calibration. Set the A.N.L., CODAN, A.G.C., and B.F.O. switches to OFF and switch on the mains power to the receiver. Allow sufficient time for the equipment to reach stable operating temperature.

Set the I.F. selectivity switch S1 to position B and connect the test meter to the detector diode current metering point CF5.

Adjust the signal generator accurately to 455 kc. and connect its output to the signal grid of the mixer V3 by removing the green lead from tag 1 of R.F. transformer T4 and connecting the output of the generator between this lead and earth.

Adjust the output level of the generator so that a reading of approximately 15 uA is obtained on the test meter.

Adjust first the secondary and then the primary of each of the I.F. transformers in the following order : T11, T10, T9, T8, T7 and T6. Reduce the output of the generator as necessary to maintain constant meter reading as tuning proceeds.

Repeat the above until maximum sensitivity has been obtained. A generator output of about 100uV should be required for a meter reading of 15uA (Note that this corresponds to an actual current of 75uA).

Check the bandwidth for a 6db increase of generator level. The points at which the standard test meter readings are obtained should be approximately 4kc. apart and symmetrically disposed about the centre frequency.

Check the bandwidth on switch positions C and D for the same generator increase. These points should be approximately 6.6 and 15 kc. apart respectively. Note that sensitivity will reduce slightly on these two positions.

Replace the lead to the signal grid of V3.

3.6. Alignment of Automatic Gain Control:

The A.G.C. alignment is covered in Adjustment of Delay Line (including 755 kc. Transformer and A.G.C. Amplifier.) However, the A.G.C. may be tested by placing a test meter in metering point CF4 and with the A.G.C. switched "ON" connect the output of an accurately set signal generator to the signal grid of V7.

An input of 100 - 150 mV should give a meter reading of 15 uA.

Transfer the signal generator, tuned to frequency, to the aerial terminals, connect the test meter to the metering point CF5 and with the A.G.C. switched on, check that the A.G.C. characteristics fall within the limits of 3db for inputs of 1uV to 0.5V for frequencies up to 20 Mc and 3db for inputs of 2uV to 0.5V for frequencies 20 to 30 Mc.

Should any re-alignment be considered necessary the equipment should be aligned in accordance with the instructions for adjustment of Delay Line (including 755 kv. Transformer and A.G.C. Amplifier) and re-check as above.

3.7. Adjustment of Compression Limiter:

Connect a signal generator, tuned to the signal frequency of the receiver, to the aerial terminals and check that the A.G.C. characteristics are within tolerance.

Set the output of the signal generator to 10uV and switch on the modulation.

Connect a 600 ohm 1 watt resistor across terminals TSA1 and TSA2 and across this an output meter.

Set the signal generator modulation depth at 30%.

Adjust the "Limiter" control R62 until limiting action is just operative. To ensure this, the control should be turned off i.e. completely anticlockwise and then turned up to where the output is reduced by 0.5db.

The limiter is now correctly set.

To check the limiter operation, the modulation depth of the signal generator should be increased to 80% and the change in output level of the receiver should be observed.

Limiter operation is satisfactory if the receiver output varies not more than 3 db for input modulation depth changes from 30% to 80%.

Adjustment of B.F.O.:

Connect coupling capacitor (C108) to the I.F. strip at T11/3 thus enabling the B.F.O. to be used.

With the B.F.O. switch ON, and a signal of 455 kc. applied to the signal grid of V3, set the B.F.O. control (R65) to the mid-position of its range and adjust the slug of L6 for zero beat.

Check that rotation of R65 tunes the audible note over the required range. Unless required for immediate use remove the B.F.O. from circuit by disconnecting the coupling capacitor (C108) from T11/3.

4. CHECKING AND ADJUSTMENT OF CODAN:

4.1. General

Bring the receiver into operation and set the Codan switch to "ON".

4.2. Checking Crystal Oscillator

Plus a test meter into test socket 9CF1.

Tolerance: The meter deflection should be between 30 and 50 microamperes indicating a grid current of between 60 and 100 microamperes.

4.3. Adjustment of Crystal Filter

(i) Connect the test meter into each of the test sockets 9CF2 and 9CF3. The former measures the noise current and the latter the output of the carrier filter.

(ii) Reduce the R.F. gain to a minimum and apply an unmodulated 300 kc. signal to the oscillator grid (pin 1) of 9V3. Adjust the frequency for maximum deflection in the carrier meter. Tune both cores of transformer 9T2 for maximum at this frequency.

Note - Allow sufficient time for the signal generator to reach temperature stability.

(iii) Set the signal generator to approximately 310 kc. and adjust 9C19 for a minimum on the carrier meter.

(iv) Reset the signal generator to the centre of the filter pass band and after temporarily disabling the crystal oscillator by earthing the oscillator tube grid (pin 1), note carefully the ratio of carrier current to the noiser current. Disabling the oscillator ensures that no beating or phasing effect occurs between the oscillators.

Tolerance: The ratio should not be less than 2:1.

(v) Connect the signal grids (pins 7) of 9V2 and 9V3 by means of a 100pF capacitor. This couples some of the output of the 300 kc. crystal oscillator to the second mixer.

(vi) Ensure that the signal generator frequency is still in the centre of the filter pass band and quickly adjust 9C1 until a beat is observed in the carrier meter. Adjust the beat as near as possible to zero frequency. If a visible beat cannot be obtained on the carrier meter, disconnect the signal generator and adjust 9C1 for a maximum reading on the meter.

(vii) Disconnect the signal generator and note the ratio of carrier current to noise current resulting from the 300 kc. crystal oscillator frequency.

Tolerance: This ratio should not be less than 85% of the ratio obtained in section (iv) above.

(viii) Remove the 100 pF coupling capacitor.

Adjustment of Delay Line (including 755 kc. Transformer and AGC Amplifier):

Note - Because of their close coupling, the A.G.C. amplifier and Codan Delay Line should be tuned together.

(i) Feed an accurately set frequency of 455 kc to the grid (pin 1) of the A.G.C. Amplifier V7. Ensure that the R.F. gain is at minimum and increase the signal from the signal generator until the codan carrier meter indicates approximately 20 microamperes.

(ii) Adjust transformer 9T1 for a maximum deflection on the carrier meter.

(iii) Adjust 9T3, 9T4, 9T5, 9T6 and 9T7 respectively, secondary first, then primary to give maximum deflection on the carrier meter, reducing the signal generator output as necessary to maintain the carrier meter reading at approximately 20 microamperes.

(iv) Adjust the A.G.C. amplifier tuning L5 to give a maximum carrier meter current. Repeat steps (ii), (iii) and (iv) until no further increase is obtained.

Tolerance: With the carrier meter reading adjusted to 50 microamperes, the noise meter should not exceed 25 microamperes.

Check that the signal generator frequency has not changed.

Adjustment of Relay

A test set as shown in Appendix 3A (at rear of this handbook) could be used to accurately set the Carpenter Relay.

Attach the test set to a 100V D.C. supply and plug a codan test meter and an ohmmeter into the appropriate sockets in the test set. A convenient voltage source for the test set is the 100V regulated supply in the R20 receiver. Vary the relative currents in the relay coils by means of the potentiometer until the relay operates. Note the reading. Readjust the potentiometer until the relay operates in the other direction, reversing the connections to the meter if necessary.

Note the reading. Adjust the relay contact adjustment screws until the readings are within the following limits.

Tolerance - The difference in current, as read on the meter, required to operate the relay in opposite directions should not be greater than 80 microamperes and not less than 40. The average of the two readings taking due account of polarity should be within 70 microamperes of the meter zero. For example, if the readings are - 15 microamperes and + 35 microamperes, the difference in reading is 50 microamperes and the centre of the range is +10 microamperes which is also within the limit of 70 microamperes.

Replace and screw down the cover of the relay. Tap the frame of the relay and recheck the readings to ensure that the relay is mechanically stable.

Replace the relay in the receiver.

4.6. Adjustment of D.C. Amplifier

(i) Short circuit the input to the codan at pin 3 of transformer 9T7 or at pin 1 of socket CF3 in receiver. (Note - A short length of wire terminated in alligator clips is most convenient for this purpose).

(ii) Turn 9R17 fully anticlockwise, i.e. towards the high potential end.

(iii) Turn 9R36 fully anticlockwise to remove any "noise bias".

(iv) While listening to the output of the receiver, adjust 9R19 until the codan just unmutes the receiver.

Tolerance - The relay should operate to mute the receiver when a 20,000 ohm resistor is connected between the cathode (pin 3) of 9V4 and earth.

(v) Readjustment 9R19 until the codan just mutes the receiver.

Tolerance - The relay should operate to unmute the receiver when a 20,000 ohm resistor is connected between the other cathode (pin 6) of 9V4 and earth and should not operate to unmute when a 40K is used. Seal 9R19 with a suitable sealing compound.

(vi) Remove the short circuit from the input to the codan and ensure that RF gain is at maximum and that the aerial is connected.

(vii) Short out margin resistor 9R30 and in the absence of a signal adjust 9R17 so that the codan just mutes with a flicking open once every 3 or 4 seconds. Reduce the gain of the receiver towards the minimum and note whether the codan becomes more prone to open. If so repeat steps (i), (ii) and (v) and recheck.

NOTE: In low noise conditions (below 30-40 microamperes on the noise meter) it may be found that the adjustment of 9R17 is not positive and hence this adjustment should be carried out, where practical, at a time when the ambient noise is relatively high. If this is not practical 9R17 should be carefully set so that it just prevents the flicking open of the codan.

(viii) Remove the short circuit on the margin resistor 9R30. This should stop the occasional flicking open of the codan. If not, check whether it is caused by received signals by using the B.F.O. If the flicking open is not being caused by signals repeat (vii) above.

(ix) Seal 9R17 with the locknut.

(x) 9R36 will require adjusting as detailed in Adjustment of Receiver Sensitivity Control when the codan is placed in service.

Caution: Any attempt to alter the sensitivity of the codan by varying the setting of 9R19 determined above will result in unsatisfactory performance.

5. OVERALL SENSITIVITY:

5.1. Provided that the adjustments in paras 4.1 to 4.6 have been carefully carried out the codan will be ready for service. The following check on the sensitivity of the codan can then be applied.

With the aerial disconnected and the R.F. gain at a maximum 5 microvolts at the intermediate frequency applied across a 100 ohm resistor to the grid of the receiver mixer should cause the codan to operate.

When operational behaviour of the codan indicates that its performance has deteriorated, the adjustments in paragraph (vi) should be carried out and the above sensitivity check applied. If the performance is still unsatisfactory, the complete adjustment in paras 4.1to4.6 should be made.

The sensitivity check is a satisfactory check of codan performance only immediately after the above adjustments have been carried out as it is possible that, due to a slight unbalance occurring in the D.C. amplifier or a drift in the setting of 9R17, that the small bias in favour of noise may be reduced.

Under these conditions, a sensitivity figure equal to or better than normal could be obtained whereas, in fact, the codan adjustments have deteriorated. The useful sensitivity of the codan is limited by certain spurious carriers, generated internally, whose precise nature is not known. However, their magnitude is sufficiently small as to permit reliable operation of the codan on a signal input of 0.25 microvolts at the receiver aerial terminals in the presence of external noise.

5.2. Adjustment of Receiver Sensitivity Control:

The following is the adjustment procedure for the "Receiver Sensitivity Control".

Control of Receiver Sensitivity:

These adjustments based on a maximum muting point of 30uV provide an operationally determined compromise between audio level difference (just unmute to large signal) on the one hand and threshold discrimination on the other hand.

(a) Switch receiver to remote. Plug meter into 9CF3 socket in codan. Switch A.G.C. "ON".

(b) Apply the normal maximum voltage obtained from the remote R.F. gain control to receiver terminal TSB2 either by turning the remote potentiometer to minimum gain or by using a local -50 volt supply.

If a local supply is used the voltage at TSB2 should be accurately adjusted to the same voltage experienced with the remote control (within 5%).

(c) Adjust R115 to give approximately -4 volts, from CF4 to earth, as measured with a V.T.V.M.

(d) Apply a 30% modulated signal to the receiver aerial terminals.

(e) Increase the signal input to the receiver until 9CF3 reaches a maximum value. Calculate 30% of this maximum and adjust the signal input until 9CF3 reaches this value.

(f) Carefully adjust potentiometer 9R36 until the codan just mutes the receiver.

(g) Check that the receiver now requires between 25-35uV signal input to open the codan with maximum voltage still applied to the R.F. gain line. If not and the receiver and codan performance are above the low performance level, adjust R115 to obtain the correct maximum muting point. To increase the muting point decrease the value of R115. To decrease the muting point increase the value of R115.

(h) Check that after the signal has just opened the codan at 25-35uV a signal reduction of 2 to 3uV will close the codan again.

6. CHANGING COIL ASSEMBLY:

6.1. (a) Remove the wide band coupling coil on the rear of the chassis by unsoldering the two conductors to the terminating connector and the lead to the stator plates of the trimmer capacitor and then loosening the two 5BA screws adjacent to the trimmer adjustment. The coil may now be removed.

(b) The wiring connecting the R.F. and oscillator coils into the receiver circuit should first be unsoldered at the terminating points remote from the coil terminals. This is done so that the trolitul bases that carry the coil terminals will not become damaged by excessive soldering heat. Note that there are three leads connecting from each R.F. coil, T3 and T4, two from the oscillator L4, three from the wide band-pass coil T1 and one from the aerial coil T2 (on ranges B, C, D and E). On range A, T1 is not fitted and there are three leads from the aerial coil; otherwise the wiring is identical with other ranges.

Note that the coverage of the wide band matching transformer is approximately twice that of the individual ranges. Coil V35 may be used for frequencies up to 7.5 Mc. and V36 up to 30 Mc. Thus it may not be necessary to change this coil when changing ranges.

(c) Remove the 5BA half filister head screws that secure the assembly to the sectional screens. The complete assembly may now be lifted clear of the receiver chassis and replaced by that covering the frequency required. The aerial coil should be removed from the replacement assembly before this is fitted into position and the aerial coil may then be used to replace that removed previously.

(d) Following the circuit diagram wire the new coil assembly and aerial coil into the receiver noting that the wiring terminating points have been so arranged that none of this wiring should cross and that the leads are colour coded for easy identification. The code is given by initial letters against the appropriate connections on the circuit diagram.

Determination of Oscillator Crystal Frequency

The frequency of the local oscillator crystal bears a direct relationship to the desired receiving frequency and is determined in the following manner.

Let F = Carrier frequency in kilocycles.

Fo = Mixing frequency in kilocycles.

Fx = Crystal frequency in kilocycles.

Then Fo = F + 455 Kc.

Where Fo is less than 8,500 kc Fx = Fo

" Fo lies between 8,500 kc & 16,000 kc. Fx = Fo/2

" Fo lies between 16,000 kc & 24,000 kc. Fx = Fo/3

" Fo lies between 24,000kc & 30,455 kc. Fx = Fo/4

Note that Fx should always be selected within the range 2 to 8.0 Mc.

7. TYPICAL VOLTAGE ANALYSIS:

Receiver

As measured on a 1,000 ohm/V set to the highest convenient range. Controls set as follows:-

B.F.O. - OFF
A.G.C. - ON
R.F. gain - Maximum clockwise
Input - 240V, 50 cycles (on 240V tap)
H.T. - 280V D.C. to centre tap of transformer
250V D.C. to earth
105V D.C. regulated.
R.F. bias (Max. gain) - 1.6V.
Bias at R83 28V D.C. Total
- 12V D.C. tap 1
- 1.8V D.C. tap 2
- 1.4V D.C. tap 3
Filaments - 6.3V a.c. all valves.

Individual Electrodes

Function	Valve type	Electrode	Pin No.	Voltage
R.F. Amp. 1 (vi)	6BA6	Anode	5	240V
		Screen	6	100V
R.F. Amp. 2 (V2)	6BA6	Anode	5	240V
		Screen	6	100V
Mixer (V3)	6BE6	Anode	5	250V
		Screen	6	105V
		Cathode	2	1.0V
R.F. Oscillator (V4)	6J6	Anode	1	100V
		Anode	2	105V
		Cathode	7	1.1V
I.F. Amp. 1 (V5)	6BA6	Anode	5	240V
		Screen	6	100V
		Cathode	7	1.0V
I.F. Amp. 2 (V6)	6BA6	Anode	5	240V
		Screen	6	100V
		Cathode	7	1.0V
A.G.C. Amp. (V7)	6AU6	Anode	5	245V
		Screen	6	155V
		Cathode	7	2V
A.G.C. Rectifier (V8)	6AL5	Cathode	5	20V
I.F. Amp. 3 (V10)	6AU6	Anode	5	245V
		Screen	6	220V
		Cathode	7	5V
B.F.O. (V9)	6J6	Anode	1	65V
		Anode	2	70V
		Cathode	7	1V

Function	Valve type	Electrode	Pin No.	Voltage
B.F.O. Amp (V11)	6BA6	Anode	5	155V
		Screen	6	120V
		Cathode	7	5V
Limiter (V12)	6BA6	Anode	5	200V
		Screen	6	35V
		Cathode	7	-0.5V
Audio Amp. (V13)	6AU6	Anode	5	100V
		Screen	6	35V
		Cathode	7	1.2V
Audio Output (V14)	6AQ5	Anode	5	145V
		Screen	6	150V
Bias Amp. (V15)	6AU6	Anode	5	245V
		Cathode	7	5V
Codan				
Crystal Osc. (9V1)	6AU6	Anode	5	60V
		Screen	6	60V
1st Mixer (9V2)	6BE6	Anode	5	250V
		Screen	6	115V
		Cathode	2	3V
2nd Mixer (9V3)	6BE6	Anode	5	250V
		Screen	6	110V
		Cathode	2	3V
D.C. Amp. (9V4)	6SN7GT	Anode	2	60V
		Anode	5	60V
		Cathode	3	1.5V
		Cathode	6	1.5V
D.C. Amp. (9V5)	6SN7GT	Anode	2	240V
		Anode	5	240V
		Cathode	3	65V
		Cathode	6	65V
		Grid	1	40V
		Grid	4	40V

8. STAGE GAIN:

Definition of Stage Gain

Stage gain has been taken as the voltage ratio $\frac{E2}{E1}$ where E2 is the voltage applied to the grid of valve V2 and E1 is the voltage applied to the grid of valve V1 in the previous stage in order to produce the same detector current. Typical stage gain figures are given for a receiver on the H.F. range.

Measuring Procedure

Set the receiver as follows:

(a) A.G.C., B.F.O., A.N.L. and codan switches "OFF".

(b) Limiter "OFF" (control fully anti-clockwise).

(c) A.N.L. control full anti-clockwise.

(d) R.F. and Audio gain controls full clockwise (maximum output).

(e) Selectivity switch in position "B".

(f) Termination of 600 ohms on 300mW output when 30mW output is in use.

(g) H.T. should be 250-260V, measured at terminal 3 of R.F. transformer T3 or T4.

(h) H.F. oscillator injection approximately 325 uA at CF2 (meter reading 65uA x 5).

(j) With 400 ohm shunt removed from CF5 check that a detector current of 12-14 uA is obtained for an input of 1 volt I.F. to terminal 3 of transformer T11. This measurement establishes the correct diode back resistance.

(k) Signal to noise ratio of 14-16 db for 1 uV into aerial terminals (CF1).

Using a Metrix type 931 signal generator feed a signal modulated 30% at 400 cps into each stage using a 0.1uF capacitor in series with the "active" wire in the unattenuated lead. Connect into the stages as follows:

R.F. Stages

Stage	Point of Connection	Freq.	Frequency Range					
			B 1.7-4 Mc		C 4-7.5 Mc		D 7.5-15 Mc	
			Input	Stage Gain	Input	Stage Gain	Input	Stage Gain
Aerial Coupling	Aerial Input CF1	Mod. R.F.	0.8uV Approx	20 App.	0.8uV	10 App.	0.5uV	6 App.
1st RF	Terminal 1 of Trans. T2	"	14uV Approx	6-9	8uV	6-8	3uV App.	15 App.
2nd RF	Terminal 1 of Trans. T3	"	110uV Approx	4-6	55uV App.	9-11	40uV App.	12-17

At each of the above points the signal gen. was adjusted to produce with the 400 ohm shunt on CF5, a detector current of 200uS. (meter reading 40uA x 5).

Mixer and IF Stages

Stage	Point of Connection	Freq.	Input required to produce 200uA Detector Current	Stage Gain
Mixer	Terminal T1 of T4	Mod. RF	550 uV	4-10
1st IF	Grid side of C29	" IF	4mV approx.	10-15
2nd IF	Terminal 5 of T8	" IF	50 mV "	8-12
3rd IF	Terminal 5 of T10	" IF	0.5 - 0.7 volts	-

Audio Stages

Stage	Point of Connection	Freq.	Input for +10dbm level from 300mW output	Stage Gain
Limiting Amp.	Grid of V12	400 cps	5 mV	9
Audio Amp.	Grid of V13	"	45 mV	12
Output	Grid of V14	"	500 mV	-

9. MAINTENANCE:

The equipment should be periodically checked to ensure that the performance is above the low performance level as specified in Airways Engineering Instructions. The Line Up and Low Performance Level for R20 receivers used on H.F. are listed below.

Line Up Level

R.F. Receiver Input for 10db Signal to Noise ratio	R.F. Receiver Input to Operate Codan.
1uV	0.3uV

Low Performance Level

R.F. Receiver Input for 10db Signal to Noise Ratio	R.F. Receiver Input to Operate Codan.
5uV	1uV

The above performance figures are based on the use of the H.F. Signal Generator Metrix type 931.

Heat conducting liners have been fitted inside the valve shields of R20 receivers and care should be taken that these are always replaced after maintenance. The use of these liners reduces the bulb temperature and minimises the incidence of failure due to reverse grid current in valves.

10. PLACING INTO OPERATION:

(a) Check that the codan is in position and connected to the receiver.

(b) Switch on the power switch S7.

(c) Set the R.F. gain to maximum clockwise, the local/remote switch to LOCAL, BFO, AGC noise limiter and codan switches to OFF and the IF selectivity switch S1 to the "B" position.

(d) Connect the output of a signal generator accurately set to the operating frequency and modulated 30% at 400 c/s to the aerial input connector.

(e) Plug a 100 uA 1,600 ohm test meter into the detector diode current CF5 and check that a meter deflection of 15 uA is achieved for 1 uV input to the receiver (2 uV in MF band).

(f) Disconnect any external line connected to the receiver and terminate the 300 mW output in a 600 ohm resistance. Connect an output indicator across the terminating resistance.

(g) Adjust the audio gain control to give an output of 300 milliwatts for an input signal of 1uV (2uV on MF) modulated 30% at 400 cycles.

(h) The signal to noise can now be measured by noticing the reduction in audio output when the modulation is switched off. This ratio should be approximately 12 db,

(j) Switch on the codan, allow to warm up and check that the codan operates when the receiver input from the signal generator is approximately 0.3uV.

(k) If the receiver is to be used on remote control the receiver sensitivity control should be checked as follows ..

Switch local/remote switch to remote.
Plug test meter into 9CF3 socket in codan.
Switch AGC on.
Set the remote R.F. gain control for minimum gain (max. voltage). Adjust R115 to give approximately - 4 volts from CF4 to earth as measured with a V.T.V.M.
Apply a 30% modulated signal to the receiver aerial terminals.

Increase the signal input to the receiver until 9CF3 reaches maximum value. Calculate 30% of this maximum and adjust the signal input until 9CF3 reaches this value.

Carefully adjust potentiometer 9R36 until the codan just mutes the receiver.

Check that the receiver now requires between 25-35 uV signal input to open the codan with minimum gain (max. voltage) still applied to the RF gain line. If not adjust R115 to obtain the correct maximum muting point.

With the muting point adjusted disconnect the signal generator and connect the aerial to the receiver.

The receiver is now ready to be placed into operation.

11. INSTALLATION:

The receiver should be mounted in a standard 19" rack by means of four ¼" B.S.W. countersunk head screws on each side of the front panel.

Ensure that the codan is in position and connected to the receiver.

Check that all valves and crystals are in their appropriate sockets and the power transformer tap corresponds to the mains voltage.

Connect the control lines as follows -

Call Indicator to TSB1
Remote Receiver Sensitivity to TSB2
Remote Codan ON/OFF to TSB3
Audio lines to TSA 4 and 5.

Power from the A.C. mains should be connected with three core flex, this cable passing through the second grommet hole in the chassis to the mains connector.

The receiver is now ready for testing as per section (Alignment and Adjustment).

This component schedule which forms part of the R20 Receiver Handbook is produced in two parts.

PART 1:

(a) The manufacturers circuit reference numbers.

(b) The CA170 reference number, which is to be recorded in columns 30-38 of the Equipment Fault and Inspection Report form;

(c) The D.C.A. Ident No. to be recorded in columns 39-47 of the Equipment Fault and Inspection Report form.

PART 2:

The D.C.A. Ident numbers together with a component description for each number shown.

Where Vocab. numbers are not available, an NIV number has been provided to facilitate location of the component description.

The D.C.A. Ident numbers in column 3 of Part 1 do not necessarily coincide with those contained in the original component schedule. This is because the Department has standardised on the supply of certain types of components which are not necessarily exactly the same, but can be substituted in place of the components originally used in the equipment. Consequently the Ident numbers of the new standardised components have been used in this schedule.

Whenrequisitioning for replacement components therefore, the Ident number shown on the schedule should be used, together with the component description shown in Part 2.

June 1966.

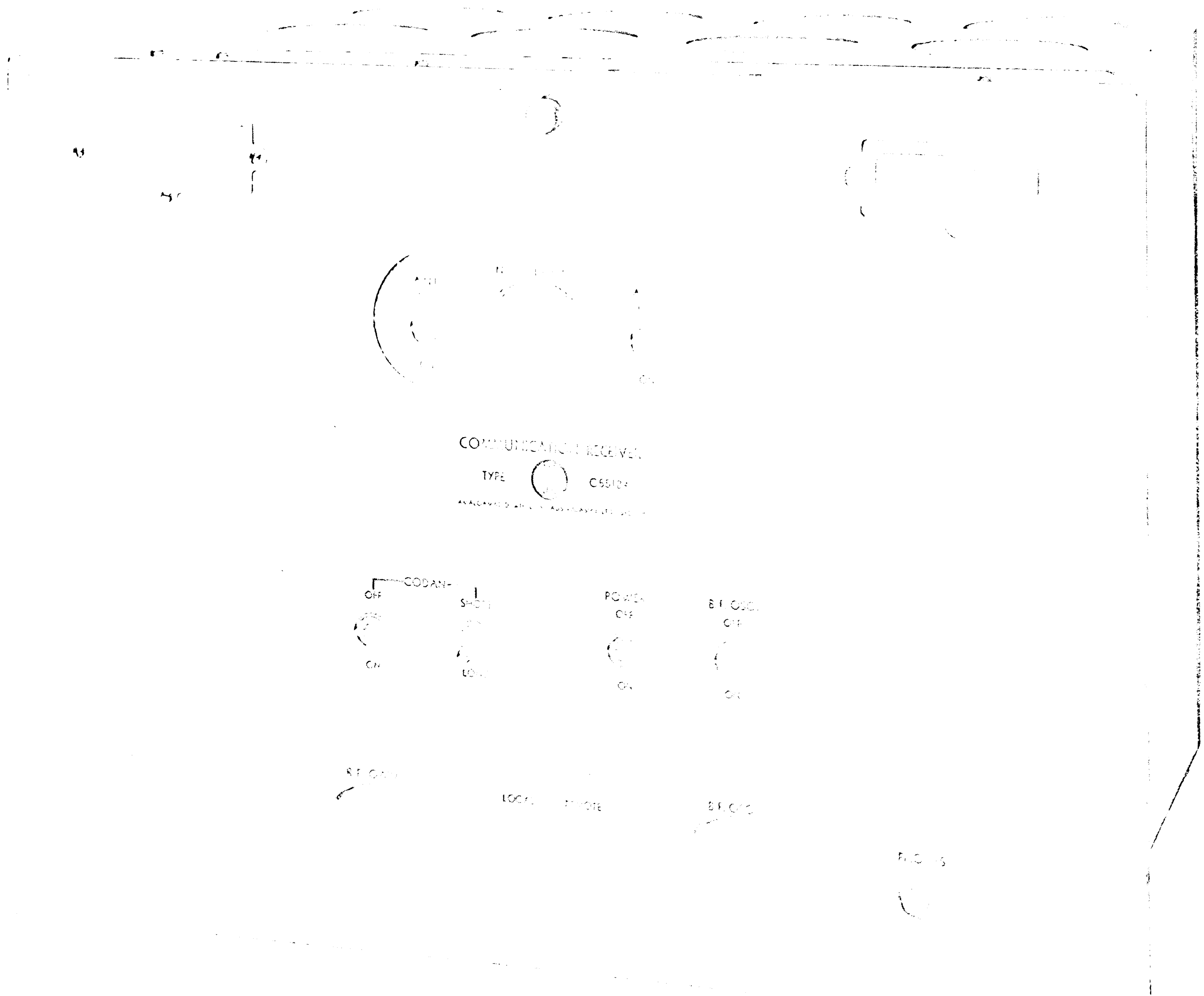
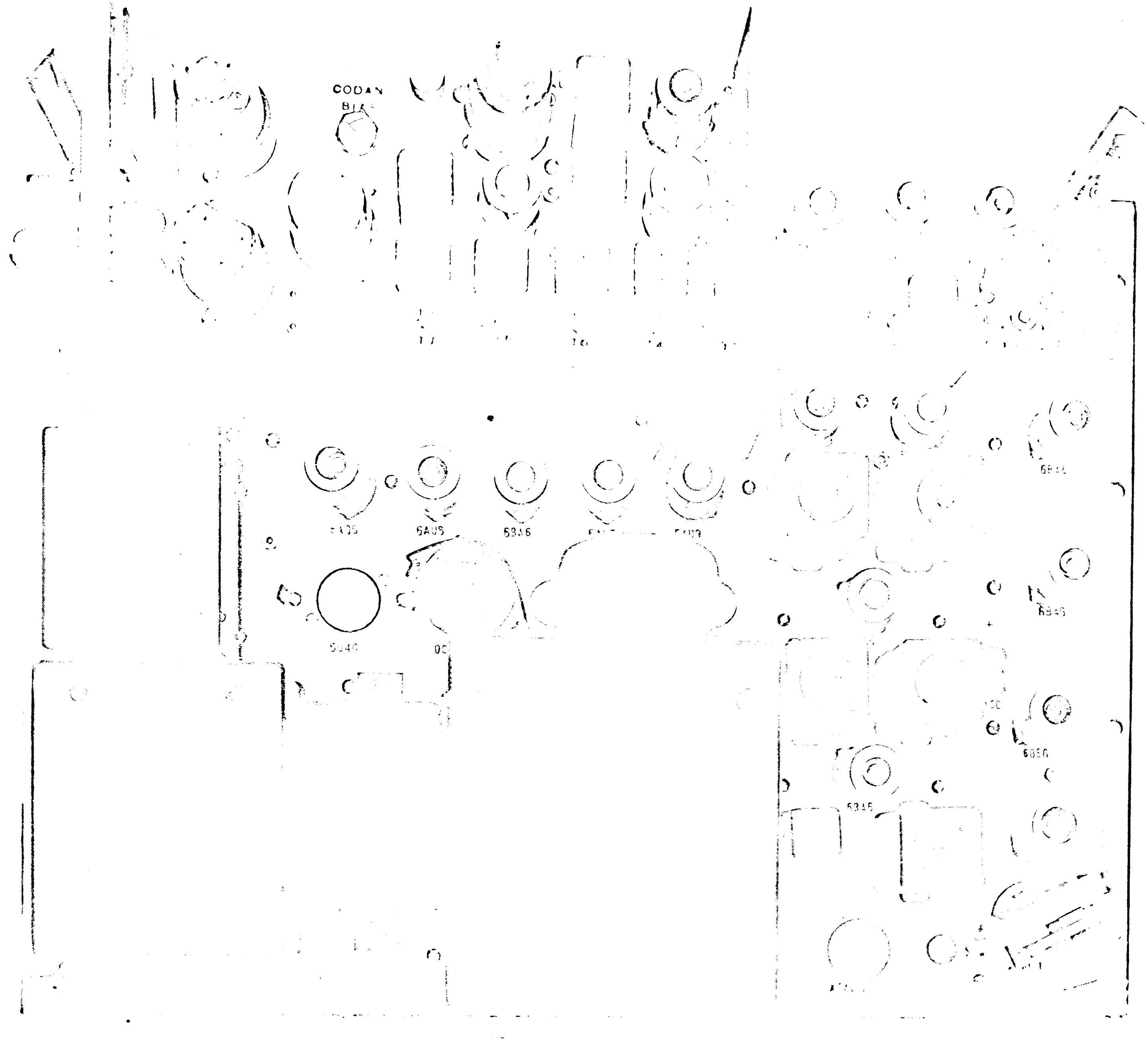


FIG. 1 R90 RECEIVER FRONT


CODAN
BIAS
6AQ5
6AU6
6BA6
5U4G
OC
6BA6
6BA6
6BE6
6BA6

R 20 RECEIVER COMPONENT LOCATION

CAPACITORS

C1	B-2B-3	C11	A-6	C21	A-8	C31	B-6	C41	see T8	C51	see T10	C61	see L6	C71	C-1	C81	H-4	C91	see L2	C101	C-2	C111	
C2	A-2	C12	B-5	C22	A-7	C32	A-3B-3	C42	D-6	C52	D-1	C62	B-1	C72	C-1	C82		C92	top side of chassis	C102	J-1K-1	C112	
C3	A-3	C13	B-5	C23	A-6	C33	C-6	C43	B-4B-5	C53	D-3	C63	A-1	C73	C-1	C83	E-4	C93		C103		C113	D-1
C4	A-4	C14	A-5	C24	A-6	C34	on L2	C44	C-5	C54	D-3	C64	B-1	C74	E-3	C84	G-4	C94		C104	B-8	C114	
C5	A-4	C15	A-7	C25	B-6	C35	C-7	C45	B-4	C55	see T5	C65	A-1B-1	C75	E-4	C85	E-3	C95	A-3	C105	B-8	C115	H-2H-3
C6	B-4	C16	A-8	C26	D-7	C36	B-5	C46	see T9	C56		C66	[illegible]	C76	E-1H-1	C86	J-8	C96	A-3	C106	E-9F-9	C116	G-3
C7	B-4	C17	A-8	C27	see T6	C37	see T7	C47		C57	C-1	C67	[illegible]	C77	F-1	C87	G-6G-7	C97	D-1	C107	H-4		
C8	A-4	C18	A-6	C28		C38		C48	D-3	C58	E-1	C68	C-2	C78	F-1	C88	C-3	C98	A-6	C108	C-1		
C9	A-4	C19	A-7	C29	D-8	C39	D-5	C49	D-4	C59	[illegible]	C69	see T11	C79	G-1	C89	J-4	C99	E-1	C109			
C10	A-5	C20	A-7B-7	C30	D-7	C40	[illegible]	C50	see T10	C60	C-1	C70		C80	[illegible]	C90		C100	C-2	C110			

RESISTORS

R1	[illegible]	R11	B-5	R21	C-6	R31	C-3	R41	B-1	R51	G-3	R61		R71	G-4	R81	K-5	R91	[illegible]	R101		R111	A-4
R2	A-3	R12	A-6	R22	D-7	R32	D-3	R42	C-3	R52	F-4	R62	E-1F-1	R72	G-8	R82	J-5J-6	R92		R102		R112	
R3	A-4	R13	B-5	R23	B-5	R33	D-3	R43	C-3	R53	F-4	R63	D-4	R73	G-8	R83	G-6G-8	R93	A-4	R103	D-1	R113	
R4	A-4	R14	A-5	R24	C-6	R34	D-3	R44	C-3	R54	E-4	R64		R74	G-4	R84	B-6	R94	A-5	R104	G-5H-5	R114	
R5	A-4	R15	B-7	R25	B-5	R35	D-2	R45	E-3F-3	R55	H-1H-2	R65	G-9H-9	R75	E-3	R85	E-1	R95	H-4J-4	R105	G-5H-5	R115	G-8
R6	A-6	R16	C-7	R26	D-5	R36	C-1	R46	D-1	R56	H-4	R66		R76	K-3	R86	B-1	R96		R106	G-8		
R7	A-7	R17	B-6	R27	D-4	R37	C-1	R47	D-1	R57	H-4	R67		R77	K-3	R87	B-1	R97		R107	H-3		
R8	B-7	R18	A-3	R28	C-3	R38	B-1	R48	D-1	R58	G-3	R68	H-8	R78	K-4	R88	K-1	R98		R108	H-3		
R9	A-7	R19	D-7	R29	B-1	R39	C-1	R49	D-1	R59	J-4	R69	C-8D-9	R79	K-4	R89	J-2K-2	R99		R109	J-5		
R10	A-6	R20	C-6	R30	D-2	R40	B-1	R50	G-4	R60	H-4	R70	H-8	R80	K-4	R90	F-3	R100		R110	A-3		

MISCELLANEOUS

VALVES AND DIODES

V1	A-3	V11	C-1	W4	H-3
V2	A-4	V12	F-4	W5	E-6
V3	A-6	V13	G-4	W6	F-6
V4	A-7	V14	H-4		
V5	C-6	V15	E-4		
V6	C-5	V16	E-4		
V7	C-3	V17	F-5		
V8	C-1	W1	C-2		
V9	B-1	W2	G-8		
V10	B-3	W3	H-3		

TRANSFORMERS

T1	REAR	T11	B-2C-2
T2	A-2	T12	
T3	A-4	T13	
T4	A-5	T14	
T5		T15	E-5
T6	B-7C-7	T16	J-4J-5
T7	B-5C-6	T17	E-6F-7
T8	C-5D-6		
T9	B-4C-4		
T10	C-4D-4		

INDUCTORS

L1	A-8
L2	C-7D-7
L3	H-7J-6
L4	A-6A-7
L5	C-2
L6	A-1

SOCKETS

CF1	AER.
CF2	B-5
CF3	J-2
CF4	D-1
CF5	B-1

SWITCHES

S1	C-4C-8
S2	P-3G-3
S3	D-3
S4	F-8
S5	C-10
S6	H-10
S7	F-9 G10
S8	D-10E-10

VARIOUS

LAMPS

P1	E-5

TERMINAL STRIPS

TSA	K-2K-4
TSB	K-2K-4

JACK

J1	J-9

FUSES

F1	E-9
F2	G-6

CRYSTAL

X1	A-8

FIG. 3

FIG. 4 R20 RECEIVER - INSIDE FRONT VIEW

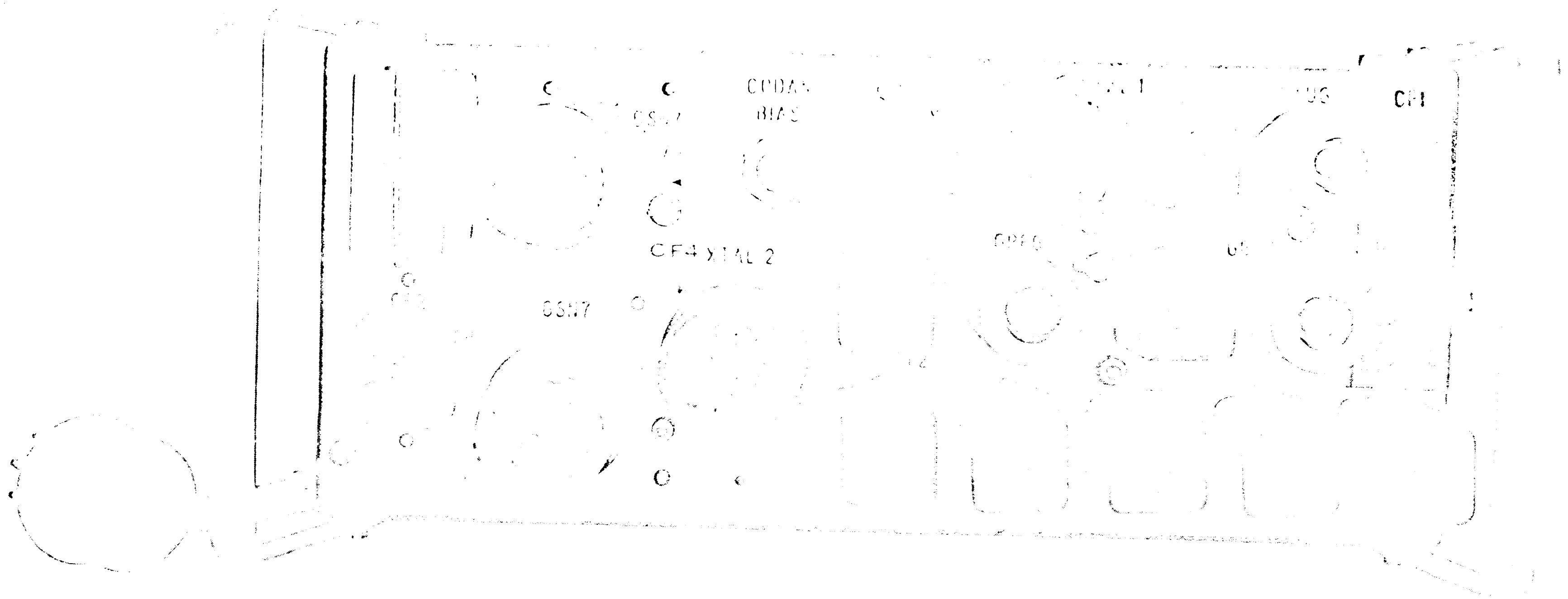


FIG 5 CODAN TYPE CD3 – TOP VIEW

CODAN COMPONENT LOCATION

CAPACITORS										RESISTORS								VALVES & DIODES		TRANSFORMERS		SOCKETS	
9C1	A-1B-1	9C11	see 9T1	9C21		9C31	C-4	9C41		9R1	A-1	9R11	D-2E-2	9B21		9R31	H-2H-3	9V1	B-1	9T1	C-2	9CF1	A-1
9C2	B-1	9C12		9C22		9C32	SEE	9C42	H-1K-1	9R2	A-1	9R12	H-3J-3	9B22	J-3	9R32	H-1	9V2	B-2B-3	9T2	E-2F-3	9CF2	K-3
9C3	C-1	9C13	D-2	9C23		9C33	9T5	9C43	H-2K-2	9R3	D-1	9R13	H-3J-3	9R23	H-2	9R33	F-3	9V3	D-2D-3	9T3	A-4	9CF3	K-3
9C4	B-1C-1	9C14	D-3E-3	9C24		9C34	D-4	9C44	H-3J-3	9R4	B-3	9R14	J-3K-3	9R24	J-1K-1	9R34	G-1H-1	9V4	H-1J-2	9T4	B-4	RELAY	
9C5	C-1	9C15	E-2	9C25		9C35	SEE	9C45	G-3H-3	9R5	A-2A-3	9R15	J-3K-3	9R25	J-4	9R35	H-1H-2	9V5	H-3J-4	9T5	C-4	9RELI	J-1K-2
9C6	C-1	9C16	E-2E-3	9C26	SEE	9C36	9T6			9R6	B-3C-3	9R16		9R26	J-1K-1	9R36	A-2A-3	9W1	G-4H-1	9T6	D-4		
9C7	B-2B-3	9C17	F-2F-3	9C27	9T3	9C37	E-4			9R7	C-2	9R17	F-1	9R27		9R37	B-3	9W2	G-3	9T7	E-4F-4		
9C8	B-2	9C18	G-3	9C28	A-4B-4	9C38	SEE			9R8		9R18		9R28	E-3					INDUCTORS		CRYSTALS	
9C9	C-3	9C19	G-4	9C29	SEE	9C39	9T7			9R9	D-2	9R19	F-1	9R29	G-2					9L1	C-1	9X1	D-1
9C10	see 9T1	9C20	F-2G-2	9C30	9T4	9C40	E-3			9R10	C-3D-3	9R20		9R30	G-1G-2							9X2	G-3

FIG. 6

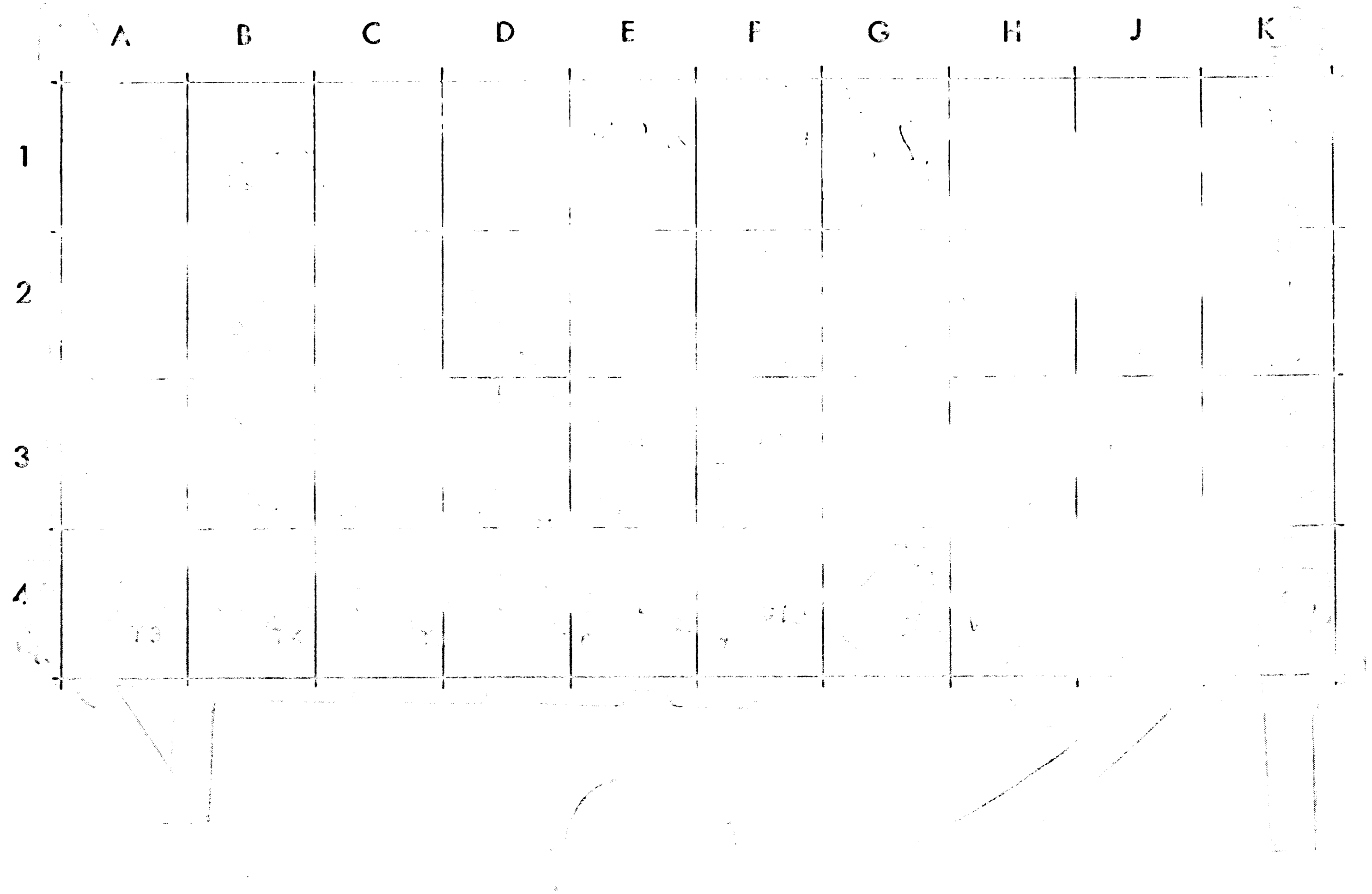


FIG. 7 CODAN TYPE CD3 – BOTTOM VIEW