FOREWORD

The Oscillator and Output-Meter method of alignment served its purpose well in the days of sets using single tuned circuits. The fact is well known, however, that from the first moment that modern superheterodynes using band-pass intermediate frequency or band-pass pre-selector circuits were introduced it became imperative to recourse to the visual method of alignment. Many years' experience in aligning modern sets in production has confirmed the necessity for this change.

Whilst the expensive laboratory Signal Generator and Output-Meter are still required in research work for point to point determination and absolute selectivity tests, the less ambitious service equivalents of these instruments which are generally used do not provide satisfactory results on production tests and service work. This is particularly the case when the work has to be done by other than highly technical personnel, when the time allowed is limited, and when the fullest possible information is required from the test. These limitations of the Output-Meter method obviously increased as radio development progressed, because technical improvements in commercial radio receivers quickly appeared with which this method could not cope in the light of the above-mentioned requirements.

The Cossor Research Department had pioneered the development of Cathode Ray Tubes as far back as 1902, and the increased complication of modern receiver technique coincided with the advent of an efficient Cossor sealed-off low voltage Cathode Ray Tube possessing the required rugged construction and long life. The recording versatility of this device was speedily applied to the solution of complex design problems, to production aligning and eventually to the service testing of receivers.

The Cossor Company was, in fact, the first to employ this method in these fields, a step which has been followed subsequently by many other manufacturers and is now general. After these many years of experience it has been found possible to design and construct an equivalent inexpensive equipment comprising the present-day Oscillograph Model 339 and Ganging Oscillator Model 343. These can be used with confidence by the Radio Service Engineer not only because they have been designed by a radio manufacturer who knows the real requirements of service work, but because they are a proven proposition and the outcome of years of commercial testing in the factory.

The equipment fulfils a greater purpose than ganging. It can be used for a variety of tests on radio sets, and above all, the instantaneous trace of the Cathode Ray Tube furnishes the Radio Engineer with the means of actually seeing what is happening in the electrical circuits he uses, thus providing the most satisfactory means of fault tracing in radio receivers. Furthermore, the new Double Beam Tube, by serving without additional expense or duplication of apparatus, as the means of investigating simultaneously two independent effects, has provided a considerable increase in the versatility of the combined equipment as now offered to the Radio Engineer.

1. INTRODUCTION.

1.1. THE ALIGNING PROBLEM.

The object of the test is to tune a series of circuits to resonance at a given frequency. Whilst it may appear at first sight that the choice of the procedure to be adopted may be made on the basis solely of obtaining a maximum response at certain test frequencies, the problem is, in practice, a little different. The true object is to secure from the pre-detector section of the receiver the best overall response characteristic of which these circuits are capable. A procedure based on the former statement is to an extent justified with single tuned circuits, but some method of alignment applicable to the overall characteristics is indispensable when tuning the coupled circuits which are general in modern superheterodyne receivers.

The alignment of a tuned circuit is strictly a voltage test. The Oscillator supplies a known radio frequency input voltage to the selective circuit and the voltage output from the last tuned stage is measured at various input frequencies and the response curve thus traced. The ratio between the input and output voltages indicates the sensitivity of the receiver, whilst the shape of the response curve determines the selectivity of the receiver and, to a large extent, the quality of reproduction of which it is capable.

There are two methods of obtaining the required results :—

(1) The Output-Meter method, which determines the input voltage which must be applied to the tuned circuit in order to give a constant output over the required frequency range. This method requires a calibrated variable input of high maximum value capable of adjustment over an amplitude range of from 10,000 to 1.

(2) The Visual method, which shows directly the output over the working frequency range when the receiver is provided with an input signal of constant amplitude, which is the minimum value required at resonance.

It is clear that both methods give essentially the same information.

1.2. OUTPUT-METER METHOD.

The Oscillator injects into the receiver a known radio frequency voltage which is normally modulated in amplitude to a depth of 30 per cent. by a standard 400 c.p.s. note. After detection and audio frequency amplification in the receiver, this alternating voltage is rectified by the Output-Meter, which measures the voltage across a constant load at the loudspeaker of the receiver. This meter is generally calibrated directly, either in decibels or power output in watts.

If the alignment of the tuned circuit is to be carried out correctly, the loudspeaker should be disconnected and replaced by a non-inductive load the resistance of which should equal the impedance of the speech coil measured at 400 c.p.s. The Output-Meter should be connected across this resistance, whilst the Oscillator output must then be varied so as to maintain a constant 50 milliwatts at this point. The use of a variable input and constant output will ensure that the results of the test be independent of the amplitude characteristics of the audio frequency section of the receiver. The equipment required is thus :—

(*a*) A means of determining the amplitude of the variable output of the Radio Frequency Oscillator.

(*b*) A calibrated attenuator.

(*c*) A suitable Output-Meter.

Two serious disadvantages of this system are immediately apparent. Firstly, the overall response curve can be obtained only by laborious point to point measurements plotted on a graph, and secondly, a high Oscillator output (having a maximum of the order of 1 volt) is necessary because when tracing the curve or making selectivity and A.V.C. tests a much greater output is required "off" resonance than "on" resonance in order to provide the required 50 milliwatts at the output of the receiver. The large signals which are therefore necessary in the Oscillator and attenuator call for extreme care in design and operation in order to avoid serious errors due to leakage. The performance necessary to enable this class of test to be carried out accurately and satisfactorily can only be found in expensive Standard Signal Generators and is unobtainable with inexpensive oscillators such as are used normally for Radio Service work.

1.3. VISUAL METHOD.

The input impedance of the Cathode Ray Tube used for indicating purposes is very high and the tube may therefore be used on radio frequency circuits or detector circuits without appreciably affecting the characteristics of these provided suitable precautions are taken. The output voltage from the circuits on test may thus be measured directly, and there is therefore no need to make any use of the audio frequency section of the receiver, so that a constant input voltage may be applied. The sensitivity may be determined quantitatively, if required, by measurement of the input and output voltages.

Provided the radio frequency output from the Oscillator is made to sweep over the required frequency range at constant amplitude and at a given rate, it is possible to obtain on the Cathode Ray Tube a stationary image of the response curve, either in the form of the amplified radio frequency envelope or, better still, as a single trace after detection. The advantages of this method are the following :—

(*a*) As only a constant radio frequency output is required, the exact voltage of the output from the Oscillator is not important.

(*b*) The attenuator is only required for adjustment of this voltage to a suitable value, and need not be calibrated.

(*c*) As a high output voltage is not necessary, some 50 millivolts being the maximum required, a low power Oscillator may be used, with consequent advantages in the direction of frequency stability and simplicity of screening. A low leakage is thus obtainable even when operating at the relatively low output impedance desirable for exciting receiver input circuits.

(*d*) The audio frequency section of the receiver under test is not used and no errors are therefore introduced as a result of non-linearity of the amplitude and frequency characteristics of these circuits.

Advantage may be taken of these facts to simplify the design of the Oscillator considerably, particularly in the mechanical direction. For this reason an inexpensive high grade instrument may be made which is more efficient for this class of work than the ordinary Service man's oscillator.

1.4. FEATURES AND ADVANTAGES.

Because the record obtained gives the overall pre-detector characteristics of the receiver the effect of any trimmer adjustment or circuit change is shown immediately. It is thus possible to obtain a symmetrical response curve with maximum sensitivity from band-pass circuits and avoid favouring one or other of the two natural circuit frequencies of the usual two cell band-pass assemblies of intermediate frequency couplings. The inability to ensure this condition without performing laborious point to point measurements after every trimming adjustment is the most characteristic drawback experienced when using an Oscillator and Output-Meter. Inaccuracies of alignment giving asymmetric response curves are responsible for the loss in selectivity and quality and the greater background noise frequently experienced when ganging by this method. Generally the asymmetric response curve obtained by the Output-Meter method leads to a slight increase in sensitivity, which often gives rise to instability. Once caused, this instability precludes the possibility of aligning correctly by this method, and obliges the Service Engineer to recourse to one or other of the following expedients to get out of his difficulties : the damping of the various circuits, alteration of the valve operating conditions to restrict gain, or more simply the deliberate staggering of the circuits or " ganging by ear," all of which affect both the sensitivity and selectivity of the receiver.

Therefore any departure by the trace from a symmetrical outline denotes distortion due to incorrect adjustment or design. The presence of circuits which will not tune to the desired frequency, and other coil and circuit faults, are readily detected, as are receiver faults of either a variational or intermittent character. All this information is obtained with the Visual method in as much time as it takes merely to align the receiver with the Output-Meter method, quite apart from the inaccurate results usually obtained with the alignment itself. Quantitative data on sensitivity and selectivity may be obtained by calibration, but this is rarely required and approximate values are readily estimated from the data given in the instrument specification.

The combination of the Oscillator with the Oscillograph for alignment provides at the same time the most effective method of performing functional tests on Radio Sets, and also fault tracing, by following the R.F. signal through the set stage by stage or by point to point testing. These additional tests are probably of equal practical importance to the Radio Service Engineer as the circuit alignment test for which the equipment was originally designed.

2. DESCRIPTION OF CIRCUIT.

2.1. FREQUENCY MODULATION.

The present Ganging Oscillator is characterized by the provision of frequency modulation. It is the absence of this feature which renders the usual type of Serviceman's oscillator unsuitable for visual work when a response curve is required.

The simplest interpretation of frequency modulation is that of the frequency of a given R.F. carrier being made to vary or " wobble " at a given rate over a given band on each side of its mean frequency whilst its amplitude is kept constant. For this reason the process is sometimes descriptively called " wobbulation."

To obtain a frequency modulated output from the Oscillator one or more of the elements of the tuned circuit must be varied, and this may be done electrically or mechanically. In the present instrument the variation is effected by electronic means, a valve modulated by the Oscillograph being used as the controlling element. This method is mechanically static, inherently synchronous and simple in operation, and can be used in portable instruments in addition to possessing great operational stability. It is much superior to the usual mechanical methods (the rotating condenser or vibrating reed, etc.), which, having moving parts, are subject to wear and can cause objectionable effects in the receiver.

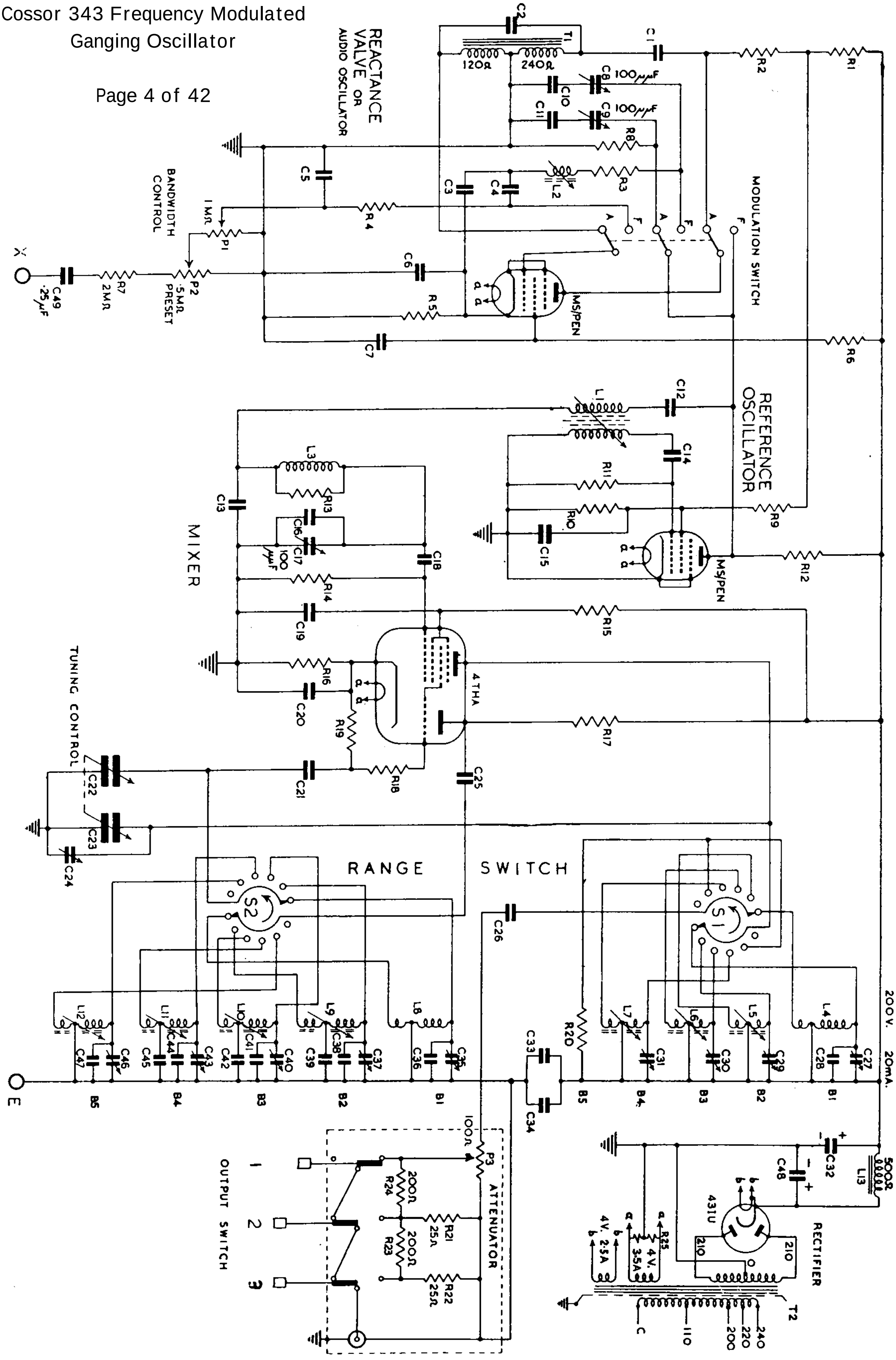


Fig. 2. Circuit diagram of Cossor Ganging Oscillator Model 343.

2.2. ELECTRONIC CAPACITY VARIATION.

The electronic method of frequency modulation used in this instrument is designed to produce a capacity variation and uses for the purpose a valve. The principle employed is the same as that frequently used for oscillator tuning correction in the Automatic Frequency Controlled (A.F.C.) circuits of radio receivers.

In the former editions of the instrument the Miller effect was used. By this method the input capacity of the valve, augmented for the purpose to the required value by an anode grid feedback capacity, varies as the amplification of the valve, this latter effect being brought about by a change of bias on a variable-mu valve used for the purpose.

Because of the requirement in practice of a greater range of frequency modulation, another method known as the reactance valve method has been used in the current version of the instrument. This method, though operationally the same as the Miller valve method, is in principle different, and is described herewith with the aid of Fig. 1.

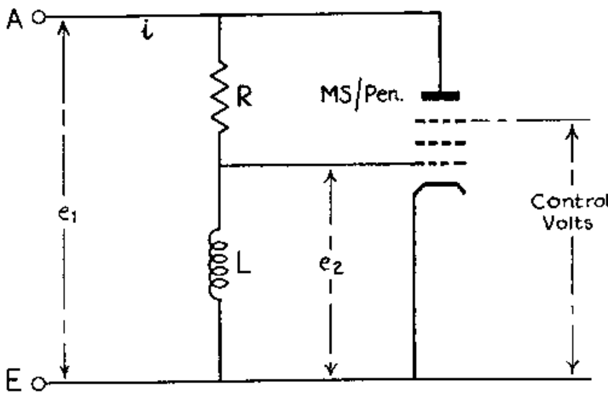


Fig. 1. Circuit diagram to illustrate principle of operation of "Reactance" valve.

For a given potential, e_1, applied between the anode of the valve and earth a current, *i*, will flow through the phase shifting network *R* and *L*, and if the reactance of ωL is small compared with *R*, *i* will be nearly in phase with e_1. A voltage, e_2, will appear across *L* leading the current, *i*, by 90°.

On the other hand, because of the normal conditions of operation of the valve, in the anode circuit will flow a current which is in phase with e_2 and leading e_1 by nearly 90°. With the current leading the applied voltage by nearly 90° the network between the anode and earth of the valve simulates almost a pure capacity and its value is controlled by changing the anode current of the valve, which is varied, as with the Miller valve method, by varying its bias. A further important difference resides in the fact that a variable-mu valve is not used, but a straight high frequency pentode, because the requirements here for linear change of capacity are a linear change of current. The valve is therefore used as a straightforward amplifier and is entirely a linear device.

The above description covers solely the principle involved. The actual circuit used in the instrument, as given in Fig. 2, is slightly different to meet other requirements.

The capacity variation is linear within the operating range of control voltage and the rate of variation fixes the frequency modulation rate, which should be kept low (say, 25 c.p.s.) to avoid spurious results such as "ringing" on high Q circuits. The method is free from amplitude modulation effects up to 25 c.p.s., which is sufficient for alignment purposes, and exhibits only a small amount over the rest of the range up to the 50 kcs. provided for other tests.

A suitable control voltage is obtained from the sawtooth output of the Oscillograph time base available at the XI terminal of the Oscillograph, which is equivalent to a continuously variable D.C. voltage starting from zero and falling negatively to a minimum, then returning rapidly to zero to repeat the sequence, thereby providing the required recurrent variation of the oscillator frequency. When the frequency modulated signal is fed into the receiver on test the output voltage of varying amplitude from the pre-detector stages over the frequency modulation range is rectified by the detector and applied via the Oscillograph Amplifier to the Y axis of the Cathode Ray Tube. By this means an inherently synchronous trace of the pre-detector response is obtained.

2.3. BEAT FREQUENCY OSCILLATOR.

If the Oscillator R.F. carrier is to be modulated in frequency by a constant controllable amount over the tuning range, as is necessary to avoid the scale of the trace varying with frequency, a Beat Frequency type of oscillator must be used. It is for this reason that an ordinary Serviceman's oscillator cannot be satisfactory when used with a separate Frequency Modulator or "Wobbulator" designed to control the frequency of the Oscillator itself, also because invariably it necessitates the modification of the calibration settings of the Oscillator and therefore makes for frequency inaccuracy and greater complexity of operation.

In Mod. 343 the reference oscillator is a M.S. Pen. valve operating as a oscillator at a fixed mean frequency of 380 kcs. It is modulated by the MS/Pen. reactance valve already discussed. The modulated output is fed to the modulator grid of a 4THA triode-hexode mixer valve through a band-pass filter to exclude harmonics. The triode section of this latter valve is employed as a variable oscillator and is tuned by one section of the two-gang condenser coupled to the large direct-calibrated dial. The variable oscillator beats with the frequency or amplitude modulated fixed oscillator to produce the required modulated R.F. carrier in the anode circuit of the mixer valve. At this point a tuned circuit is provided on Bands 1, 2, 3 and 4 in order to reduce the amplitude of the higher of the two beat frequencies produced. The response of these coils is sensibly flat over the band-spread required and they are tuned by the second section of the two-gang condenser. No tuned circuit is provided on Band 5 because the unwanted frequencies lie outside this band and a simple resistive anode load is sufficient. However, at very high frequencies, i.e., Band 1 of the instrument, the two beat frequencies lie rather close together. In order to avoid errors in calibration through selection of the wrong channel care should be taken on this range to select the lower frequency signal of the two, which corresponds in frequency to the dial calibration and will always be found to have the greater amplitude. The output signal passes from this circuit through the attenuator network to the screened output circuit.

A clear conception of the effects obtained is given in Fig. 3, showing the resulting frequency spectrum in the case when the resultant Oscillator output is 465 kcs. frequently used for I.F. ganging. The reference data is as follows :—

fv=variable Oscillator frequency.
fo=fixed Oscillator=380 kcs.
s =frequency modulation range=15 kcs.
f1=fo—s=365 kcs.
f2=fo+s=395 kcs.
f =fv—fo=wanted frequency=465 kcs.
(fv+f1) to (fv+f2)=upper Side-Band frequencies.
(fv—f1) to (fv—f2)=lower (wanted) Side-Band frequencies.

It may be added that the instrument operates only on fundamental frequencies.

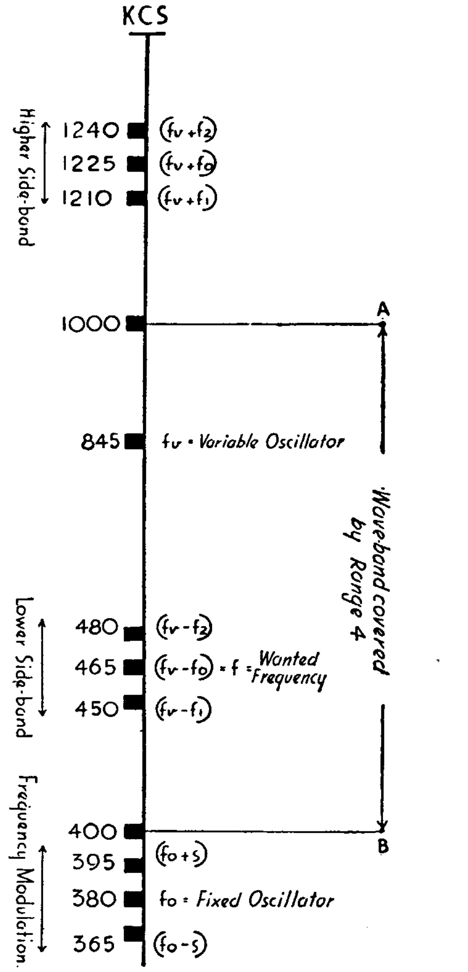


Fig. 3. Distribution of Frequency Modulation Spectrum for 465 Kcs. wanted frequency

3. INSTRUMENT CONTROLS.

3.1. FREQUENCY CONTROL.

The variable frequency control is fitted with a modern large fluted instrument knob and a 5-in. diameter circular nickel brass dial, engraved through an angle of 180° in five directly calibrated ranges, plus a 180° division scale. Two transparent hair-line indicators over-ride the dial and are sc marked as to indicate the scale corresponding to each position of the Wave Range switch. The dial itself is rigidly fixed to the condenser rotor through a 6 : 1 epicyclic reduction device. The mechanism is smooth and free from errors resulting from backlash. The scale readings are given in megacycles (or decimals of a megacycle) and each division for which a figure is given is subdivided into five. The subdivisions between the main calibrations on each range are as follows :—

Range 1	... ...	0·2 megacycle.
,, 2	... ...	0·1 ,,
,, 3 and 4	...	0·02 ,,
,, 5	... ...	0·01 ,,

These markings ensure accurate reading to the accepted R.M.A. standard reading accuracy of ±½ per cent. without the need for cumbersome external charts or graphs.

3.2. MODULATION SWITCH.

The top control on the escutcheon plate is a 2-position switch. The first position provides an unmodulated R.F. carrier if the X terminal if connected to E, or a frequency modulated signal, swept at a rate fixed by the time base frequency of the Oscillograph if the X and E terminals of the Oscillator and Oscillograph are joined together. The second position provides internal amplitude moduation to a depth of 30 per cent. at 400 c.p.s.

For Frequency Modulation up to ± 25 kcs. is required the equivalent of about 225 volts D.C. recurrent change of voltage applied to the X terminal of the instrument and obtained from the Model 339 Oscillograph Time Base.

3.3. RANGE SWITCH.

Beneath the frequency control is located the range change switch. This is a 5-position frequency selector covering the range from 20 megacycles to 80 kilocycles practically without gaps. A signal is thus available over all the normal wavebands of a modern commercial all-wave receiver. Certain ranges of Communication, and the requirements of Frequency Modulation, Television or other special receivers are not provided for.

3.4. BAND-WIDTH CONTROL.

The Swept Band-Width control is situated at the lower right-hand side of the panel and covers a frequency sweep up to 50 kcs. overall ; i.e., ± 25 kcs. relative to the mean carrier frequency when 10 cms. horizontal deflection is obtained on the screen of the cathode ray tube. This frequency range is covered by the horizontal amplitude of the response curve obtained. The scale is linear, and free from amplitude modulation effects up to at least 25 kcs. sweep. A maximum of 50 kcs. frequency spread can be obtained and measured by the sub-divisions on the transparent scale of the Oscillograph. The control is a continuous one and is marked off to an approximate overall calibration in steps of 5 kcs. Intermediate band-width frequencies can be read with sufficient accuracy for all practical purposes by proportional interpolation of the scale of this control.

3.5. ATTENUATOR.

3.5.1. OUTPUT SWITCH.

This is mounted above the output attenuator and has three positions, and is of the push-button type. Positions 1, 2 and 3 provide coarse control of the R.F. carrier output of the Oscillator. Position 1 provides the minimum attenuation, each lower step giving an additional reduction of approximately 10 : 1 with the output potentiometer at maximum. The output resistance is 20 ohms in position 2 and 3 of the attenuator pad and matches the impedance of the standard Dummy Aerial. Position 1 gives a maximum resistance of 69 ohms.

3.5.2. ATTENUATOR.

This 100 ohm linear variable resistance is graduated approximately in ten divisions. Whilst accurate attenuator calibration is not required for visual alignment, the approximate sub-divisions are useful for certain quantitative work and for comparative tests.

3.5.3. OUTPUT SOCKET.

This is placed at the lower end of the escutcheon plate and is completely screened. A suitable plug is provided, to which a screened lead is fitted and taken to the receiver. This connection is usually effected through a Dummy Aerial Model 393 for R.F. circuits or a 0·01 mfd. condenser for I.F. circuits.

3.6. TERMINALS.

Only two terminals are provided. That marked E is earth, X is for the purpose of connection to the X terminal of the Oscillograph for frequency modulation. A pilot lamp is fitted to the instrument and a mains switch is provided.

4. ACCESSORIES.

4.1. DUMMY AERIAL

This accessory is supplied with the instrument and is used when testing the R.F. section of radio sets, and has been designed to conform to the Radio Manufacturers' Association Standard Specification to represent the equivalent load of an aerial 4 metres high, of 25 ohms resistance, 20 μH inductance and 200 $\mu\mu$fd. capacity for medium and long wave bands. A 400 ohms non-inductive resistance is used for short wave bands. A screened lead is required to connect the plug and socket supplied with the Oscillator to the two plugs supplied with the Dummy Aerial (Fig. 5). The red plug should be fitted to the

Fig 5. Cossor Dummy Aerial.

H.F. lead and the black plug to its screening. This latter is inserted either in the Earth terminal of the set or, when the Dummy Aerial is used, in the socket marked E on this device. The red plug of the Oscillator lead can then be inserted either into the " B " socket of the Dummy Aerial when the tests are being carried out on the Broadcast range, or into the " S " socket when Short Wave ranges are being tested. A short screened lead protrudes from the other end of the Dummy Aerial, to which are fitted similar plugs, of which the black corresponds to the earthed screening. This plug is either inserted in the earth socket of the set or, capped by a detachable crocodile clip, attached to the chassis of the set, whilst the red wander plug is similarly applied to the aerial terminal of the set. This Dummy Aerial is cylindrical in shape, made of nickelled brass and completely screened.

4.2. ALIGNMENT TOOLS.

No special alignment tools have been made for this instrument as different types of tools are required for different makes of sets, and these are obtainable either from the makers of the sets themselves or in kit form from manufacturers who specialize in this type of Radio Service accessory.

4.3. SERVICE RACKS. (Fig. 7).

The " rack and panel " mounting of apparatus is now a well established practice in telegraph, telephone and radio engineering. It offers various important advantages, such as the vertical disposition of the instruments, with consequent saving in space, and the standardization of dimensions and parts, thus affording convenient interchangeability. It was with the object of making use of these advantages that Cossor's have planned their range of Instruments, whether for the Laboratory or Radio Service, for Rack mounting and have made suitable Racks available for the purpose. (See Section 9).

The instruments are permanently fixed and thus the risk of damage due to excessive moving about is avoided. An important point is that the instruments can be permanently connected up ready for use, a fact which ensures greater use being made of the gear with quicker results.

The Racks have been designed in such a manner that two or more can be mounted together so that an expanding Instrument Panel is ensured. For this purpose detachable interchangeable feet, brackets and panels are used, this being made possible by the standard spacing of the fixing-screw drillings on the frame (see Fig. 7).

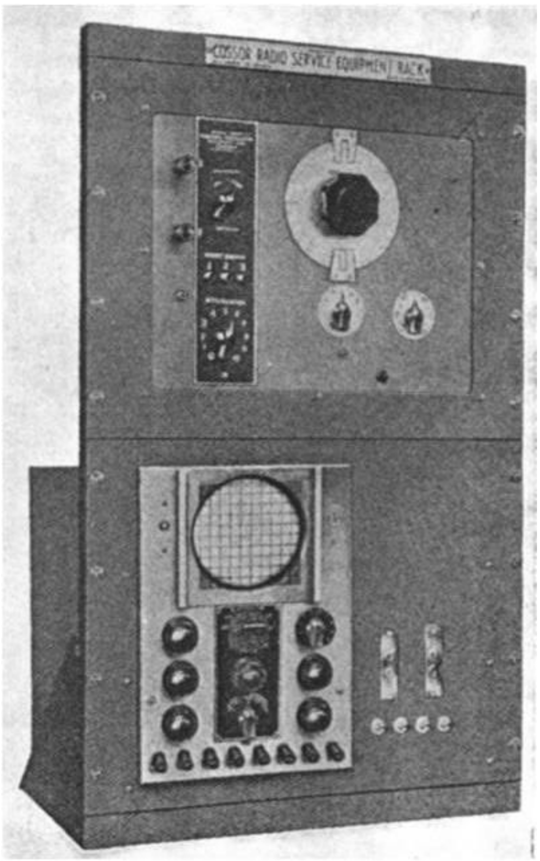


Fig. 7.

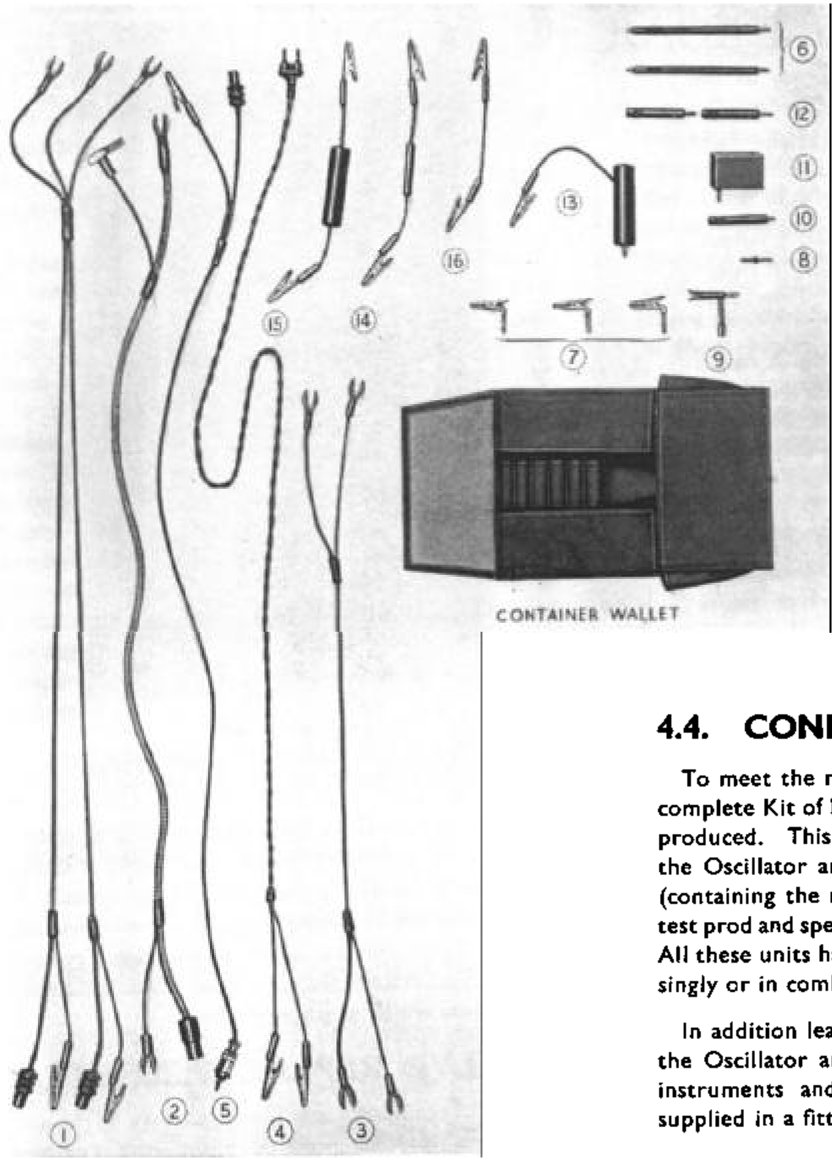


Fig. 6. Cossor 426 Radio Service Kit, comprising:—

1. Twin screened Oscillograph Input Leads.
2. Low Capacity Lead.
3. Screened Interconnecting Lead.
4. Deflector Coil Lead.
5. Oscillator Output Lead.
6. Test Prods.
7. Crocodile Clip Plug Adaptors.
8. Plug Adaptor.
9. Grid Cap Adaptor.
10. Low Capacity Coupling Unit.
11. R.F. Coupling Unit.
12. Resistance Coupling Unit (White dot).
13. R.F. Filter Coupling Unit.
14. Resistance Loading Unit.
15. By-Passing Unit.
16. Shorting Link.

4.4. CONNECTING LEADS.

To meet the needs of Radio Service and other work a complete Kit of Instrument Leads (List No. 426) has been produced. This includes not only the screened leads for the Oscillator and Oscillograph, but also coupling units (containing the resistors or condensers) together with a test prod and special crocodile clips and top-cap connector. All these units have fixings which enable them to be used singly or in combination. (Fig. 6.) See Section 9.

In addition leads are also provided for interconnecting the Oscillator and Oscillograph and for use with other instruments and applications, the complete kit being supplied in a fitted leatherette wallet.

5. MAINTENANCE.

5.1. ADJUSTMENTS.

The instrument is adjusted at the factory to ensure that the mean carrier frequency under frequency modulation conditions corresponds to that obtained with amplitude modulation and coincident in position with the centre of the Time Base traverse. A Time Base sweep amplitude of 10 cms. corresponds to a horizontal frequency scale of the appropriate setting of the Band-Width control and the design has been arranged to give a linear variation over this range. If the Amplitude control of the Oscillograph is adjusted to reduce the sweep to less than 10 cms. width, the effect is simply to reduce the voltage swing used for frequency modulation and the band spread is reduced in the same proportion.

Certain adjustments are provided on the instrument which are set during manufacture. These are illustrated in Fig. 8 and comprise T1, T2 and T3 trimmer condensers and P pre-set potentiometer. Their location makes it impossible for their setting to be altered accidentally. Care must, however, be taken when withdrawing the chassis from the case to avoid the settings being affected by coming into contact with the sides of the cover, because this might necessitate re-calibration of the instrument. The function of the various adjustments is as follows :—

T1. Is a trimmer condenser to set the fixed frequency oscillator to 380 kcs. when frequency modulated so that the mean Oscillator output frequency given on the calibrated dial corresponds to the middle of the tube screen (C8 of Fig. 2).

T2. Is the trimmer condenser used to set the fixed frequency oscillator to 380 kcs. under conditions of amplitude modulation (C9 of Fig. 2).

T3. Is the 380 kcs. oscillator filter circuit trimmer. This serves for corrections of variation in height of the response curve along the Time Base traverse (C17 of Fig. 2).

This pre-set potentiometer controls the X sweep voltage applied to the reactance valve for frequency modulation. It enables the setting of the Swept Band-Width control to be adjusted to correspond with the calibration (P2 of Fig. 2).

For Frequency Modulation up to ± 25 kcs. is required the equivalent of about 225 volts D.C. re urrent change of voltage applied to the X terminal of the instrument. Such a voltage is the average of the maximum values obtainable from the Time Base of the Cossor Model 339 Double Beam Oscillograph. When other oscillographs are used it is possible to adjust the oscillator to provide the same operating conditions for a different voltage change by adjusting the pre-set resistance (P2 of Fig. 8), which is initially set to suit the Model 339 Oscillograph.

It is possible to adjust the range of Frequency Modulation, and in particular to its maximum value of 50 kcs., either to suit a given oscillograph or to check with a given Model 339 Cossor Oscillograph, by measuring the displacement of a signal on altering, by the required amount, the setting of the Frequency Control dial. This is best done when the range switch is set to position 5 (lowest frequency). With the correct setting a dial displacement of 50 kcs. should cause the signal to move the whole width of the Time Base when this latter is set at 10 cms width.

It may often be found that a given Oscillograph Time Base will not enable the sweep to embrace the full 10 cms. of the screen scale, in which case the full ± 25 kcs. is unobtainable. The instrument can, however, be adjusted to provide the equivalent scale on the tube by adjusting for a smaller sweep width and reduced frequency sweep to the same scale. Thus instead of 10 cms. for a total of 50 kcs. the adjustment can be made at 5 cms. for 25 kcs., and on increasing the sweep control to the maximum obtainable, the same scale will apply to the maximum width of trace obtainable.

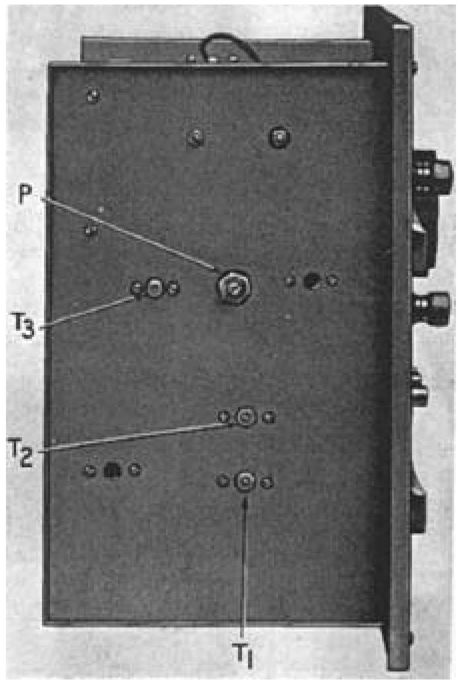
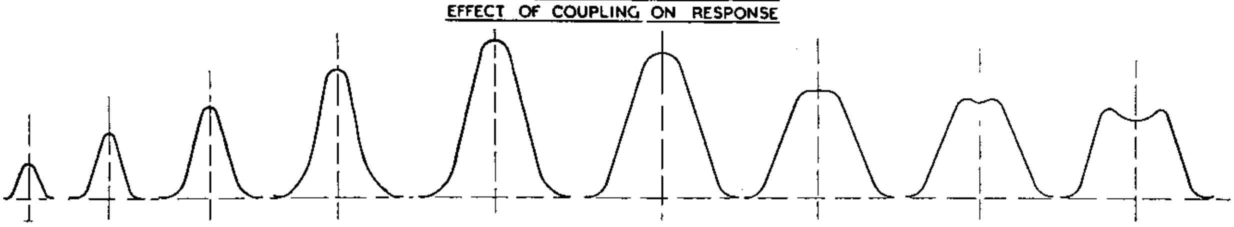


Fig. 8. Side view of chassis withdrawn from case to show location of the pre-set controls.

5.2. VALVE REPLACEMENTS.

The design of the instrument is such that the 4THA and MS/Pen. valves may be replaced without causing any noticeable error in the calibration. In exceptional cases a slight variation may be found in the case of the MS/Pen. reactance valve, which may entail the necessity of adjusting slightly trimmers T1 and T2.

EFFECT OF COUPLING ON RESPONSE



INCREASING COUPLING INCREASES AMPLITUDE & RETAINS SINGLE-PEAKED CHARACTERISTIC UP TO "CRITICAL COUPLING" $\left(K^2 = \frac{1}{Q1\,Q2}\right)$

FURTHER INCREASED COUPLING BEYOND CRITICAL VALUE DECREASES AMPLITUDE & PRODUCES DOUBLE-PEAKED RESPONSE.

Fig. 9.

6. ALIGNMENT OF RADIO RECEIVERS.

In this section will be described the use of a Ganging Oscillator for alignment of a radio receiver. It covers initially the procedure on a standard superheterodyne; subsections are added to cover most other cases.

In order to assist the user in recognising the characteristics of the various types of response curves likely to obtain in practice, a series of illustrations have been included. The effect of coupling in a band-pass coil on responses is shown in Fig. 9 by a series of outlines. In Figs. 10 and 11 are illustrated the type of responses obtainable with different couplings with coils of a high and low "Q." In Fig. 12 is shown the comparison of the effect of high and low "Q" coils on a single and two-cell band pass assembly. Finally, in Fig. 13 is given the fundamental data concerning band-pass circuits. This latter serves to demonstrate the presence in such circuits of two tuning frequencies, and not one frequency only, as would appear to be implied and often generally assumed when aligning at a specified frequency I.F. and other band-pass circuits.

It is the last-mentioned effect that makes it laborious to align correctly a Band-Pass receiver with an Output-Meter using an ordinary Oscillator, as this latter generates only a single frequency. The present frequency modulated Ganging Oscillator, on the other hand, produces frequencies covering the whole range to which the coil responds. With the aid of the Double Beam Cathode Ray Tube of the Oscillograph the trace of both the primary and secondary can be examined visually, thereby enabling the adjustment of the circuit to the symmetrical outline for which it was designed. The true response curve can thus be obtained with the individual coils set at their respective and correct tuning frequencies.

The factors which bring about the symmetrical response are that both coils of a two-cell band-pass are purposely made identical, both are usually placed across high impedance circuits, and finally, as the frequency band spread of each coil is small in relation to the mean tuning frequency, the response curve of both coils must therefore be sensibly identical and symmetrical about their centre line.

As a further illustration of these facts Fig. 14 is included to compare the outline of a correctly adjusted I.F. bands pass circuit with an Oscillograph and Ganging Oscillator for symmetrical outline against one adjusted with an Oscillator and Output-Meter for maximum response. The illustration includes representative dotted outline of the individual tuned circuits of the band-pass, indicating approximately, on theoretical considerations, the manner

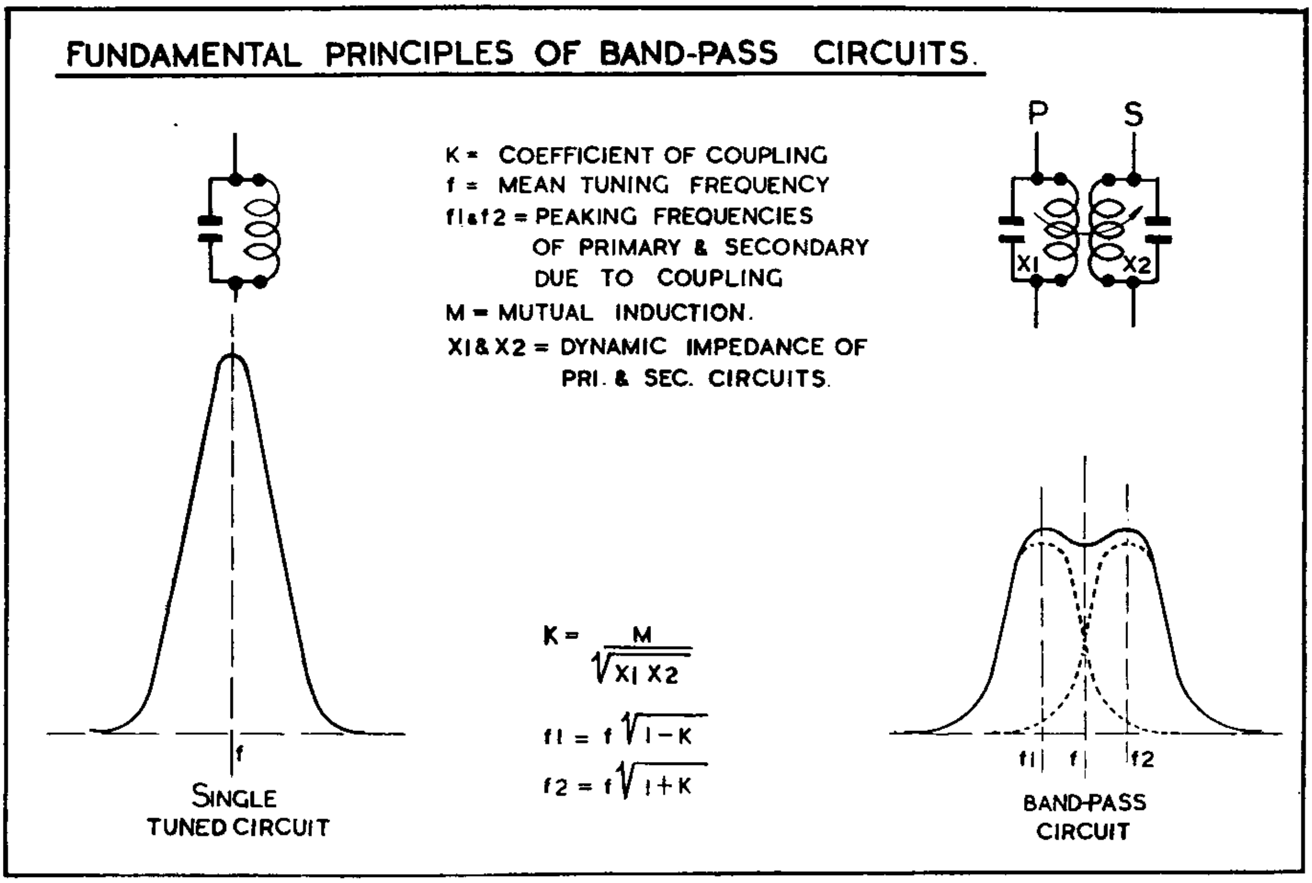


Fig. 13. See Section 6, pp. 11 and 12.

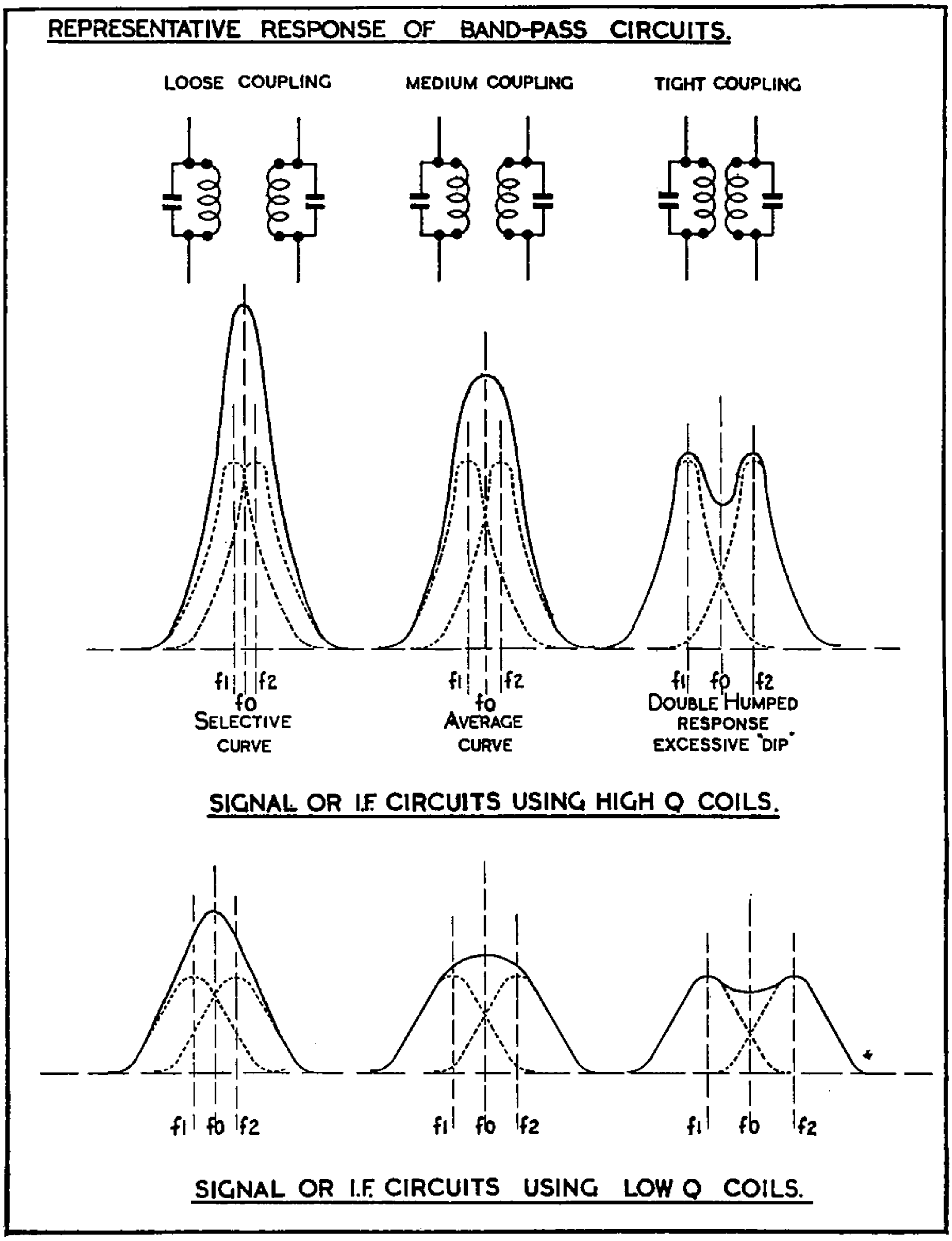


Fig. 10. (High " Q " coils) and Fig. 11 (Low " Q " coils). See pp. 11 and 12.

in which they react and finally set themselves by the two different methods of alignment. The full line represents the final outline of the adjusted circuit as derived by vectorial addition of the component curves. Figs. 18 illustrate actual curves after alignment by an Output-Meter as viewed subsequently on the Oscillograph.

On the subject of the response curve obtained by the present method, it must be remembered that the equipment, and in particular the Oscillograph amplifier, is designed to give a linear response. Therefore the curve obtained is on a linear scale. This implies that the response at half overall amplitude of the curve only corresponds to a 6 db drop. This means that the symmetrical outline required is obtained on alignment

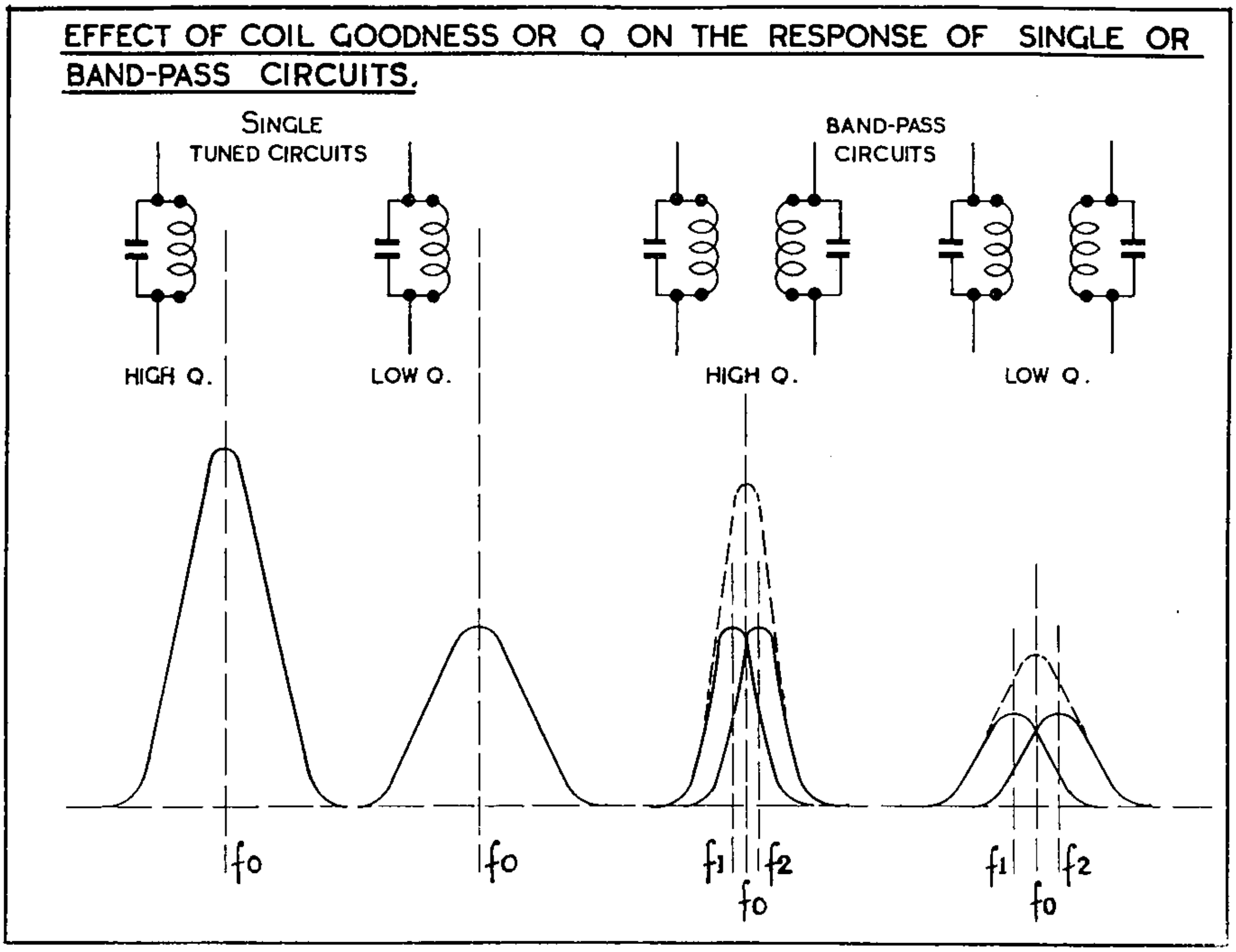


Fig. 12. See Section 6, pp. 11 and 12.

by adjustment on what in effect is not much more than the tip of the response curve. This fact is made clear in Fig. 16a and shows up very markedly when aligning receivers with two I.F. stages.

When true selectivity data are required a logarithmic response is necessary. The outline will then appear as in Fig. 16b. To obtain such a response it is necessary that between the output of the detector of the receiver and the input of the Oscillograph be inserted a device converting the linear voltage obtained into a voltage varying logarithmically. This is not a justifiable elaboration on Radio Service instruments because it involves additional apparatus, but more so because selectivity tests are not called for in Radio Service work. The selectivity conditions of a given receiver are fixed by the manufacturer in the design. For those Engineers who would like to add this refinement to their equipment it can be stated that suitable devices and circuits for logarithmic conversion of voltage have often been described in the technical press. (See Bibliography 6 and 8, Section 7). It is well to note that Section 6.4.2. on "H.F.Response" method, though placed in its correct sequence and is discussed because recommended by some instrument makers, should be omitted on first reading.

6.1. CONNECTIONS AND PRELIMINARY ADJUSTMENTS.

The Ganging Oscillator has been designed for use with the Cossor Model 339 Double Beam Oscillograph, and these operating instructions assume the use of this latter instrument. The connections and adjustments in the procedure described have been grouped so that those relating to the Oscillograph, the Radio Set on test and the Oscillator are dealt with separately. This has involved a certain amount of repetition, which should be found helpful. The diagram of Fig. 17 gives the dispositions for alignment, illustrating pictorially the two instruments, the relative position of the terminals and controls, and connections to a schematic circuit diagram of a representative modern superhet. It is assumed in the connections that the standard Cossor Service Kit of Leads or their equivalent is used.

Although given in full, the procedure is essentially simple and rapid, and will be found quite easy to apply once it has been acquired after a little practice. It has been described in great detail with the object of taking into consideration most contingencies so that the following notes can be referred to in the case of difficulty. It will enable the Service Engineer to tackle the most complicated sets with the same ease and certainty as the simplest receiver.

Various refinements on the final adjustments on receiver alignment have been purposely elaborated for the reason that these often contribute in making a considerable difference in the results obtained. Not only is the receiver thereby enabled to produce its best sensitivity and selectivity, but also its best audio quality. More important still is that it will do so with the absolute minimum of noise allowed by the interference level at the location of the receiver.

6.2. OSCILLOGRAPH. (Fig. 15).

6.2.1. CONNECTIONS.

It is assumed in the following that the user is familiar with the operation of the Model 339 Double Beam Oscillograph. Full information is provided in the Operating Instruction Booklet for this instrument, which should be consulted in case of doubt.

(1) Join the Syn. terminal to Cal. with the link provided, and not to either the Y1 or Y2 terminal, as is usual for synchronising.

(2) Connect the X1 terminal of the Oscillograph to the X terminal of the Oscillator by a screened lead. The screening of this lead is joined to the E terminals of both instruments.

(3) Connect a double screened lead to the A1 and A2 terminals on the Oscillograph, and its screening to the E terminal.

(4) Fit to the free end of both the A1 and A2 leads a 1 MΩ resistance terminated by a crocodile clip. Fit a crocodile clip only to the free earth leads attached to the screening of each lead.

(5) Apply the crocodile clips of the Oscillograph input lead as follows :—

(*a*) That corresponding to A2 to the D2 detector diode anode valve pin of the set.

(*b*) That corresponding to A1 to the D1 A.V.C. diode anode valve pin.

(*c*) Those corresponding to the E terminal and screening to the chassis of the set or other convenient circuit earth point.

(*d*) It is not necessary to connect an independent true earth point to the equipment. As a matter of fact it is preferable not to do so, in the case of A.C./D.C. sets. To avoid risk of accidents with A.C./D.C. sets, however, it is best to use an isolating transformer with a 1 : 1 ratio and a suitable wattage ; 120 watts will cover most requirements. In this case, as with A.C. sets, a true earth can be used.

6.2.2. ADJUSTMENTS.

(1) Connect the Oscillograph to the mains and switch on. Set the Focus and Brilliance controls as required and adjust the X, Y1 and Y2 Shift controls to place the two traces central on the screen about ¼ in. apart.

Fig. 15. Cossor Model 339 Double Beam Oscillograph.

(2) Throw over the terminal link provided from across the Syn. and Y1 terminals as normally set, to the Syn. and Cal. terminals, required for this test for the purpose of synchronising the Time Base to a sub-multiple of the mains frequency, as this is more convenient.

It is, of course, possible to align the receiver equally satisfactorily by synchronising at other frequencies which are not sub-multiples of the mains frequency. This method is often advantageous in showing up the presence of hum voltages on the H.F. and detector circuits by the presence of a drifting and thus unsynchronised ripple on the trace.

(3) Set the Condenser control on the third stud and keep the Trigger control as far anti-clockwise as is consistent with regular operation of the Time Base.

(4) Place the Amplifier switch in the third position (Y1 Y2) and join, temporarily, Cal.-Syn. and Y2 to obtain a 50 c.p.s. mains waveform. Alternatively, by placing a finger close to the A1 terminal a 50 c.p.s. induced mains pick-up will show on the tube and will serve the same purpose. Then adjust the Velocity control until two whole waves appear on the screen and are practically stationary.

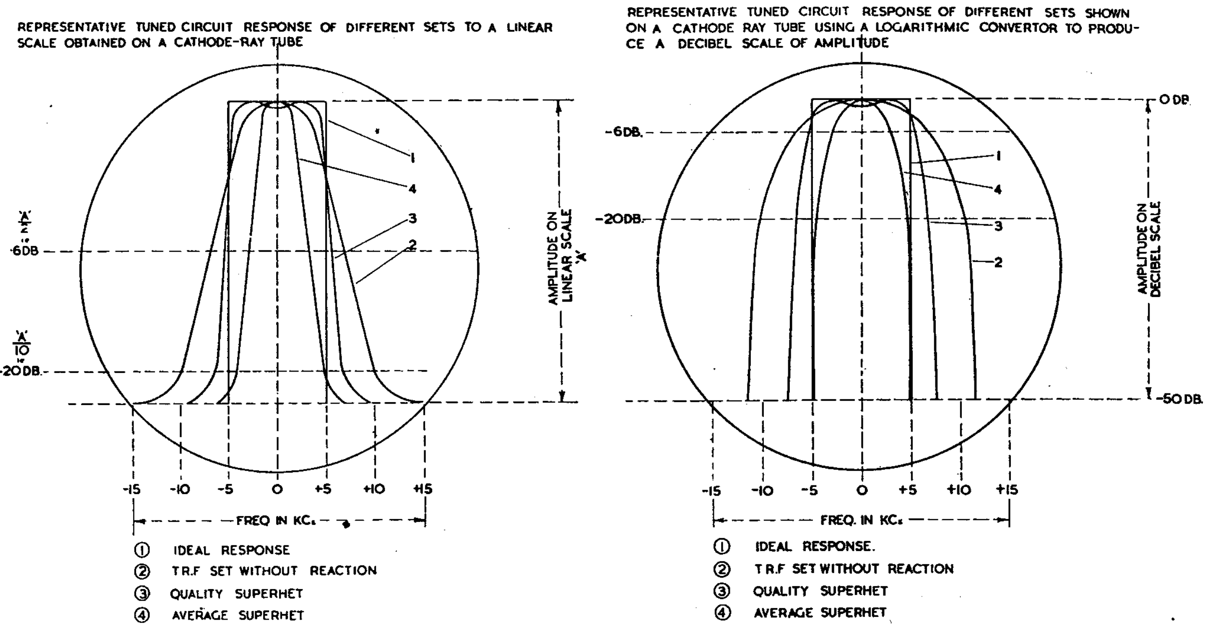


Fig. 16a and 16b. See Section 6, pp. 11 and 12.

(5) Set the X Amplitude control so that the sweep width occupies 10 cms., i.e., the full width of the transparent scale provided. With the Band-Width control normally set at 25 or $\pm 12\frac{1}{2}$ kcs., 10 cms. will correspond to 25 kcs. Thus the 10 kc. transmission band spread will occupy 4 cms. or four large divisions of the Oscillograph scale. The centre line of the scale will thus correspond to the mean frequency and will serve as axis of symmetry for alignment. Readjust the velocity control if the Time Base frequency has been altered by this operation.

(6) Turn the Syn. control clockwise to lock the Time Base at this frequency, which is 25 c.p.s.

(7) Remove the temporary link from the Y2 terminal (or remove finger from near the A1 terminal if this method has been used). The Time Base will then be sweeping at the frequency of 25 c.p.s. required for frequency modulation of the Oscillator.

(8) Set both Amplifier gain controls to somewhat less than maximum to benefit by the improvement in low frequency response and phase characteristic of the amplifier that result at such settings. The maximum gain is seldom necessary. When aligning with a frequency modulation rate of 25 (or at $12\frac{1}{2}$ c.p.s.) to avoid "ringing" on high "Q" circuits, phase shift effects in the amplifier may occur, especially at the lower frequency, which upsets the symmetry of the lower end of the curve, causing the trace to dip below the base-line on the downward section. The effect may be avoided by operating the amplifier as much as possible below maximum gain. The effect is not serious and only tends to render less accurate the estimation of a symmetrical outline of the curve as a whole. For this reason it may often not be possible to use $12\frac{1}{2}$ c.p.s., also because, whilst flicker is perceptible at 25 c.p.s., it is objectionable at $12\frac{1}{2}$ c.p.s., and especially over long periods. It can, however, be used with advantage for A.F.C. discriminator circuit adjustment.

6.3. RADIO SET.

It is assumed that a standard mains superheterodyne receiver is used, as per the block schematic diagram of Fig. 17, although the procedure as given covers all cases.

6.3.1. CONNECTIONS.

(1) To the OSCILLATOR through its output lead :—

(*a*) For I.F. alignment.—From the grid of the frequency changer through a 0·01 mfd. condenser.

(*b*) For R.F. alignment.—From the aerial terminal through a Dummy Aerial.

Both these are fully described later.

(2) To the DOUBLE BEAM OSCILLOGRAPH A1 and A2 terminals through its two screened input leads—each terminated by a 1 MΩ resistance and a crocodile clip—from the A.V.C. and Signal Detector Diode valve pins.

(3) Ensure that the Earth terminal or chassis of the RADIO SET is joined to the Earth terminals of both instruments by means of the crocodile clips fitted to the screening of the instrument leads.

(4) Once having effected the receiver adjustments considered in the following section 6.3.2., connect the receiver to the mains and switch on. Turn the Volume control of the set to almost maximum so that the resultant sound or note on tuning when the Oscillator is connected is just audible.

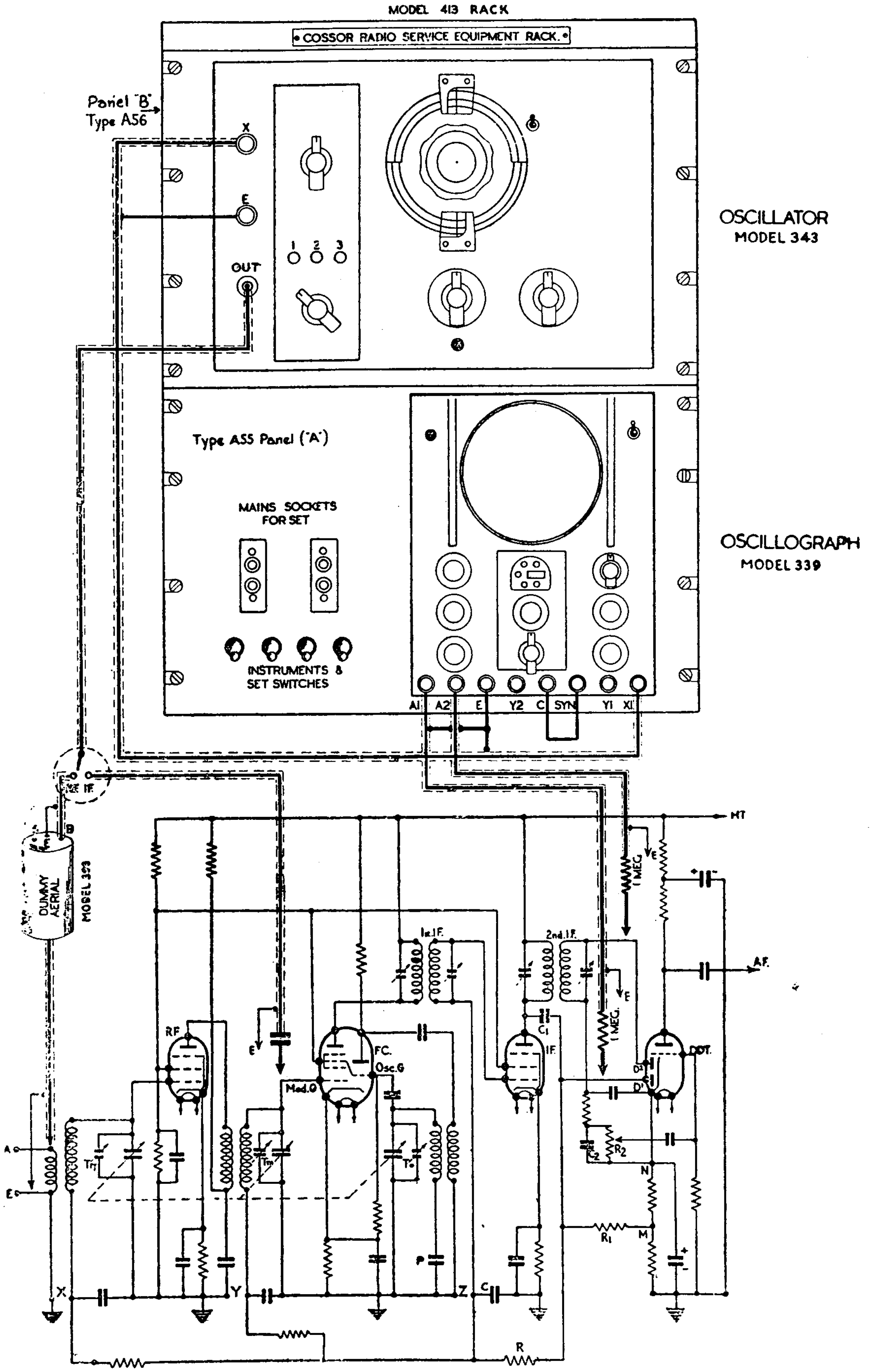


Fig. 17. Diagram of connections of Oscillator and Oscillograph for alignment of a typical Superhet shown in schematic form.

6.3.2. ADJUSTMENTS.

In the following paragraphs are discussed in detail the receiver adjustments which are an essential preliminary to the alignment procedure.

6.3.2.1. REMOVE AUTOMATIC VOLUME CONTROL (A.V.C.).

For correct alignment the A.V.C. has to be made inoperative. This is fundamental and is independent of the method of alignment. This point must be stressed because in the majority of cases Radio Service Engineers neglect to carry out this precaution before starting alignment. Quite apart from the difficulty of obtaining satisfactory alignment with the A.V.C. in circuit, its disconnection can provide considerable assistance in fault tracing.

An attempt is often made to justify the retention of the A.V.C. whilst carrying out alignment by suggesting that the adjustments be made with a signal the amplitude of which is insufficient to cause the A.V.C. to operate. This argument is partly valid for the detector circuit alone when the A.V.C. system has a heavy delay voltage, but it does not enable a response curve to be obtained at the primary of last I.F., essential for correct alignment, as on this depends the whole procedure described herewith. An endeavour to obtain a primary signal by increasing the oscillator voltage would inevitably entail an overload on the H.F. or I.F. stages. In the case of sets using a small A.V.C. delay voltage, alignment below the delay level is rarely satisfactory because the amplitude of the traces obtained under these conditions usually is not sufficient to enable true symmetry of the curves to be judged.

The effects responsible for incorrect alignment when the A.V.C. is not disconnected are the following :—

(i) The time constants of the A.V.C. filters are usually sufficiently long partially to respond to the low periodicity frequency modulation pulses applied to the set and the A.V.C. voltage can therefore modify and, in general, alter the difference in amplitude of the two peaks of the responses of the primary and secondary band-pass coils. Thus a symmetrical curve may apparently be obtained with the A.V.C. operating, even though the tuned circuits are sufficiently out of alignment to yield an asymmetrical response when the A.V.C. is disconnected.

(ii) The A.V.C. will reduce the signal obtained from the detector diodes. Even with the use of a very large signal input, an output large enough for accurate alignment may not be obtainable. In any case such a high input level is likely to produce amplitude distortion and other effects, notably frequency drift with high values of A.V.C. bias voltage especially on short waves.

(iii) The more perfect the A.V.C. the more difficult it is to distinguish between the wanted and unwanted channels from the Oscillator when on the short wave bands (particularly range 1). This will also cause spurious frequencies in the Oscillator output to become more noticeable at the receiver output due to the fact that the gain of the set automatically proportions itself to the strength of the input signal.

(iv) Both H.F. (and I.F.) stages, and particularly Short Wave stages, change their frequency adjustment with applied A.V.C. voltage due to the change of valve input conductance. This effect is often noticeable operationally with the receiver in service as a form of fading, which can also cause "flutter."

There are many types of A.V.C. circuits and different methods will apply. In whichever way the disconnection is carried out, the guiding consideration is that the A.V.C. diode load (at high frequency), and thus the impedance across the primary of the last I.F. transformer, remains the same during alignment as when the A.V.C. is reconnected. This also entails that the D.C. load on the diode remains the same. This latter precaution, though not strictly necessary because not affecting the tuning capacity, is nevertheless advisable because affecting gain, and therefore it will avoid the risk of the receiver, which is stable on alignment, ceasing to be so when A.V.C. is reconnected, or vice versa. The more usual methods are given herewith :—

(*a*) There is one method of removing the A.V.C. action which meets all the above-mentioned requirements and which can be applied to every receiver irrespective of the type of A.V.C. used and without the need of disconnecting any lead. The method is to earth individually all the points in the A.V.C. line which are connected to the low potential end of the grid circuit of the valves to which the A.V.C. is applied, whether the coil or a grid leak is used. Incidentally, this is the best method as it does not interfere with circuits affecting the tuned stages of the receiver. It entails the use of various shorting links terminated by crocodile clips at each end. This method must always be used when the A.V.C. feed resistances are in parallel, that is, when all the points in Fig. 17 are connected as in X and Y. Fig. 17 illustrates the case when the A.V.C. is applied to the low potential end of the coils. In other cases these points are earthed and the A.V.C. is applied directly to the grid of the valves through a grid leak. A blocking condenser is then inserted between grid and coil, an arrangement often preferred for short waves. The low potential ends of the grid leaks are earthed in this case to remove A.V.C.

(*b*) Depending on the type of A.V.C. circuit used, it is often possible to simplify the procedure mentioned above so that one single shorting link will suffice. This occurs when the A.V.C. feed resistances are in series

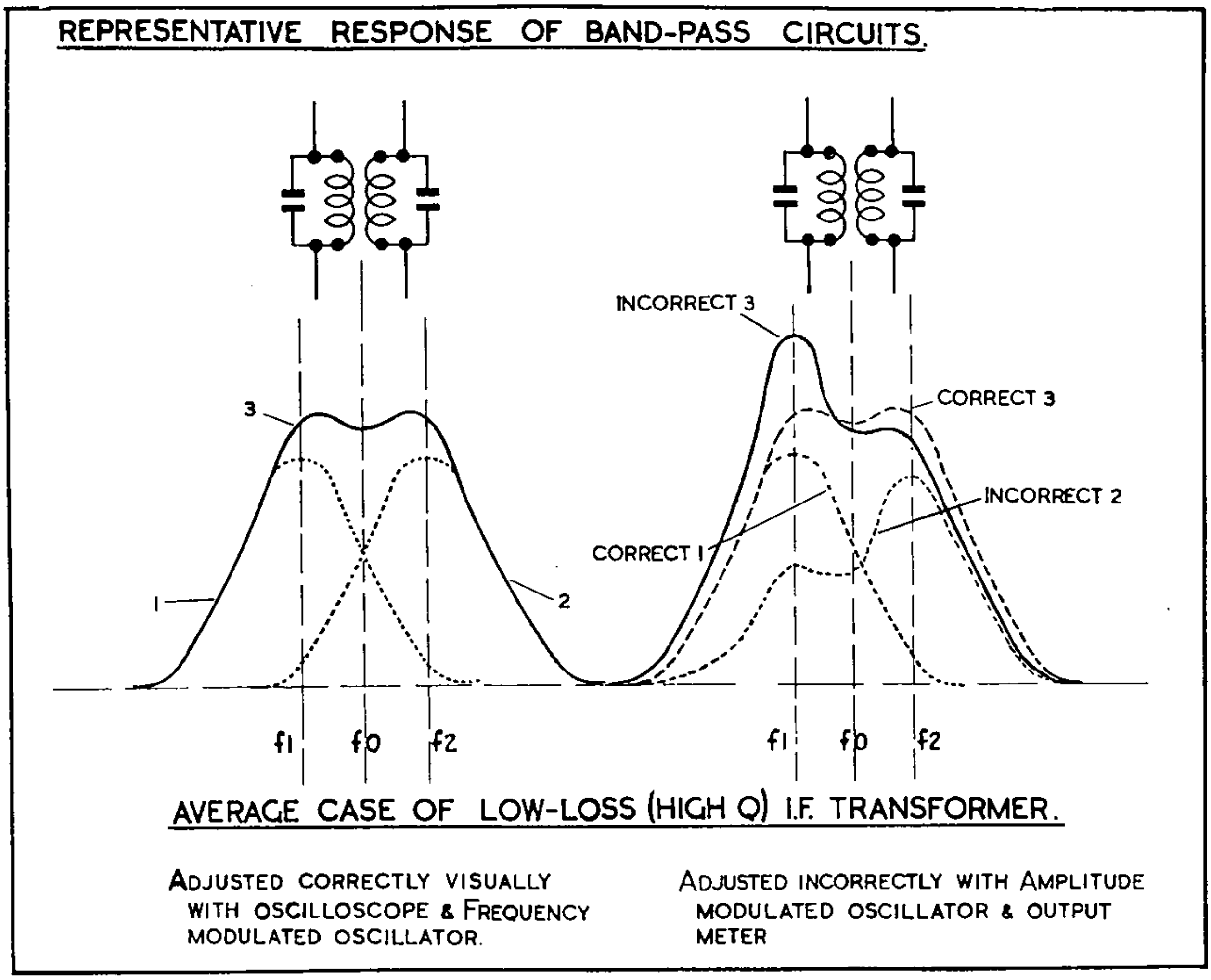


Fig. 14. See Section 6, pp. 11 and 12.

or, as is the more general practice in modern receivers, one resistance, such as R in Fig. 17, is common to all the A.V.C. feed circuits. It is then sufficient to earth the point Z alone to short effectively the A.V.C. to all the valves. Because of the shorting effect at H.F. of the by-pass condenser at Z the impedance of the other A.V.C. resistances does not noticeably affect the A.C. or D.C. loading of the A.V.C. diode. This is therefore comprised totally by the resistance R. The same procedure is applied when a filter network resistance and condenser are connected at the A.V.C. diode lead. In this case the resistance functions very much as R in Fig. 17, and by earthing the low potential end of this resistance the A.V.C. is again removed without affecting the A.V.C. diode load.

(c) In those cases where the A.V.C. is of the amplified type obtained by means of a separate valve, either the A.V.C. line is earthed directly or the A.V.C. D.C. amplifier valve removed. No disconnection is required. If a separate A.V.C. detector is used it should be left in circuit. When the detector valve itself also provides the amplified A.V.C., the A.V.C. line should be made inoperative by one of the methods given above, according to the circuit used.

6.3.2.2. REMOVAL OF A.V.C. DELAY.

The effect of the delay voltage is to cause an abrupt cut-off of the sides of the primary response curve. With large delay voltages only the tip of the curve may appear, from which it is difficult to effect a symmetrical adjustment. Whilst it is possible to align a set without removing the A.V.C. delay, it is preferable to do so for the reasons stated.

To remove the delay voltage on the A.V.C. diode, disconnect the low potential (lower) end of the A.V.C. diode resistance R from the point providing the delay voltage and return it directly to the cathode of the valve.

Various cases may occur :—

(*a*) When a double diode triode (DDT) type valve is used, which is the more general case, shown in Fig. 17, the resistance R is earthed or taken to a point along the cathode resistance. The delay voltage arises from the voltage drop across the valve's cathode biassing resistance or a fraction thereof. The resistance R should be disconnected from earth or point M, as the case may be, and returned to the cathode at N.

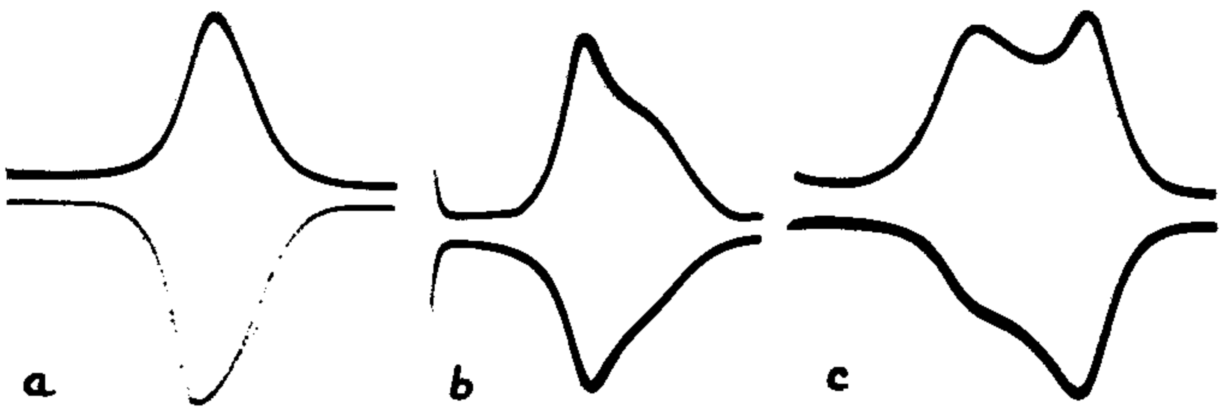


Fig. 18a, b, c. Asymmetrical I.F. response curve of Fig. 14 obtained with "Output Meter" method of alignment (Section 6). The figures illustrate circuits of different degrees of coupling.

(*b*) In cases when the same circuit of Fig. 17 is used but the A.V.C. delay voltage is obtained from another point, usually from the voltage drop on resistances connected across the smoothing chokes or L.S. field coil on the negative return of the H.T. supply circuit, the lead from R1 should be disconnected and again returned to the cathode of the valve. Should the cathode be earthed, proceed as mentioned in the next paragraph, (*c*).

(*c*) When a simple double diode valve is used as detector and A.V.C. rectifier, the cathode is usually earthed and the A.V.C. delay is obtained as in (*b*). In this case the lead from R1 should be disconnected and earthed. Because of the small delay voltage usual it is generally safe not to disconnect the lead and simply to earth this point, provided firstly, that the same point or lead does not give the standing bias to the pre-detector valves, and secondly, that if the output stage is biassed in the same way, the delay voltage thus removed represents a small fraction of the value required by that valve. Otherwise in both cases the disconnection of the lead providing the A.V.C. delay is inevitable, as in the former case the pre-detector valves will be operating with grid current and in the latter case there is the risk of damaging the output valve.

In cases when a double diode valve is provided with a cathode resistance, either by connecting its cathode to the bias resistance, or a point thereon, of the L.F. amplifier valve, or when the biassing is done via a potentiometer across the H.T. supply, the return lead from R1, which is then earthed, should be disconnected and taken to the cathode.

6.3.2.3. REMOVAL OF THE QUIET AUTOMATIC VOLUME CONTROL (Q.A.V.C.).

Detector Q.A.V.C. or "squelch" of the type operating on the detector circuit cuts off sharply the sides of the response curve of the detector diode in much the same way as the delay voltage on the A.V.C. diode, only the effect is much more severe. Either no curve is obtained or only the tip of the curve is present, and then only when excessive oscillator signal is applied.

(*a*) Render the Q.A.V.C. inoperative by switching off, if a switch is provided, or by removing the Q.A.V.C. valve when an independent valve is used for the purpose. Providing that in this latter case the circuit is such that the impedance of the valve does not form part of the total impedance across any of the H.F. or I.F. circuits.

(*b*) If the Q.A.V.C. is obtained through a detector valve or any valve in the I.F. amplification chain, the Q.A.V.C. voltage line can be disconnected and earthed, or simply earthed. In many cases, however, this is not necessary because it will be inactive when the A.V.C. line is made inoperative. It will, however, be necessary to interrupt the H.T. supply to the valve which provides the current producing the standing bias for Q.A.V.C. purposes. Usually the Q.A.V.C. switch provided serves this purpose.

(*c*) When the Q.A.V.C. operates on the post-detector end of the receiver, that is, on the L.F. valve or loudspeaker, it can be retained.

6.3.2.4. REMOVE AUTOMATIC FREQUENCY CONTROL (A.F.C.).

The A.F.C. affects the Oscillator via the control valve. It will therefore not interfere with the I.F. alignment. On the other hand it will affect the alignment of the H.F. section of the receiver and for this reason the A.F.C. voltage should be short-circuited. Often a switch is provided for the purpose. The control valve should not be removed for its impedance forms part of that of the local oscillator and therefore affects the alignment.

An important precaution is to mistune the discriminator diode circuits, and preferably in addition damp both these circuits with a 2,000 ohm resistance so as to avoid the transferred resistance effect at resonance of these circuits interfering with the symmetrical adjustment of the response curves of the primary and secondary of the last I.F. coil, to either of which the discriminator may be connected.

6.3.2.5. REMOVAL OF AUTOMATIC SELECTIVITY CONTROL (A.S.C.).

Such control is rarely used in radio receivers except in some of the more expensive type. If present, the A.S.C. must be removed in the same manner as done with A.V.C., A.V.C. delay and Q.A.V.C. The circuits for A.S.C. are usually somewhat complicated. They often include rectifiers to produce both positive and/or negative control voltages, which are applied either to special control valves coupled to the pre-detector amplifying stages or to the I.F. amplifier valves themselves. The condition for alignment is therefore that which obtains when the receiver is in a quiescent condition, that is, when all the control voltages are normal. To provide this it is necessary, therefore, to earth the various A.S.C. lines in the same manner as advocated for A.V.C. and A.F.C. circuits, that is, at the low potential end of the A.S.C. feed resistances. Often a switch is included for this purpose to short out the A.S.C. control voltages. Both the A.S.C. detectors and the special control valves should be retained in circuit as their impedance will affect the I.F. circuit loading.

6.3.2.6. STOPPING LOCAL OSCILLATOR FOR I.F. ALIGNMENT.

Render the oscillator section of the frequency changer valve inoperative. This precaution may sometimes be forgotten and it is well to know the resulting effects so that the omission may be detected and remedied. The most noticeable effects are a distorted trace, reduced amplitude of response due to absorption effects in the oscillator circuit and, occasionally, the presence of oscillation or oscillation " blisters " on the trace. These latter are more often due to a carrier wave passing through the R.F. section and beating with the oscillator to produce a signal at intermediate frequency (see Fig. 18d).

The grid terminal of the valve or the condenser stator should be earthed to the chassis in a R.F. sense. According to the circumstances, one of the following ways will be used :—

(*a*) When grid circuit is tuned :—

Short-circuit the stator of the oscillator section of the ganged condenser by a small lead fitted with crocodile clips.

(*b*) When anode circuit is tuned :—

Because H.T. may be present on the stator of the oscillator section of the ganged condenser, the short-circuiting of the oscillator section to earth should be carried out with a relatively large non-inductive condenser ($\frac{1}{2}$ mfd.).

(*c*) When an independent oscillator valve is used withdraw this valve, provided it does not affect the D.C. voltages applied to any other valve.

6.4. OSCILLATOR.

For alignment purposes it is important to use the smallest possible output signal from the Oscillator in order to avoid the risk of overloading one or more of the valve stages of the receiver either to the extent of being run into grid current or otherwise swept beyond the linear section of the amplitude characteristic, and thus producing distortions likely to affect the accuracy of alignment. In cases where the former effect is severe it is unmistakable, for it will show up as a flattening of the top of the response curve. In general these effects are not so readily perceived. An easy method of testing is to increase the output from the Oscillator by small equal steps, using the divisions marked on the output potentiometer, or fractions thereof, and noting whether the corresponding increases in the amplitude of the response curve are linear. When this linearity ceases to obtain, amplitude distortion is present in either the R.F. or I.F. amplifier. The same effect occurs when one or more stages of the Oscillograph amplifier are overloaded, a condition which likewise interferes with the accuracy

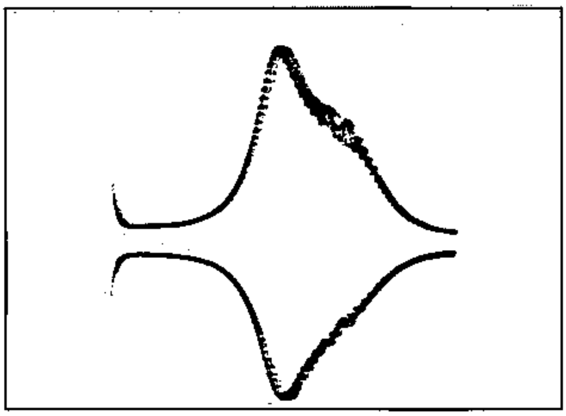


Fig. 18d. An I.F. response curve with superimposed oscillations such as obtain when set oscillator is still operative (6.3.2.6).

of alignment. It is an easy matter to distinguish between the two effects by reducing the gain control of the Oscillograph amplifier, if necessary to minimum. If the trace retains the same configuration the overloading occurs in the receiver on test and the oscillator signal should be reduced. If not it is in the Oscillograph amplifier.

6.4.1. "RECTIFIED RESPONSE" METHOD.

This method relies on applying to the Oscillograph amplifier the signal obtained after rectification by the detector of the receiver. The outline obtained is the radio frequency envelope of the applied constant amplitude frequency modulated signal, the resultant amplitude of which varies with the frequency response of the circuit, and is thus the response curve required, as illustrated in Figs. 20 (a) and (b).

6.4.1.1. ALIGNING I.F. STAGES.

The Oscillator is connected to the mains and thus switched on.

(A) CONNECTIONS.

(1) Fit the screened lead provided to the Oscillator screened output terminal. Connect the free end via a 0·01 mfd. condenser as follows :—

(*a*) For sets with a single I.F. stage :—

To the grid terminal of the frequency changer.

(*b*) For sets using two or more I.F. stages :—

(i) To the grid of the penultimate I.F. valve.

(ii) After adjusting this section up to the detector as described hereunder, remove connection and take it to the grid of the preceding valve, usually the frequency changer, as at (*a*), to complete the adjustment.

(2) When aligning the I.F. section, render the oscillator section of the frequency changer inoperative, as previously described.

(3) Do not forget to restore the frequency changer circuit to normal when the I.F. adjustment is completed and before proceeding to the R.F. section.

(B) PRELIMINARY ADJUSTMENTS.

(1) Set the output switch to position 3 and the output potentiometer to maximum, viz., division 10.

(2) Set the range control to the required position (R4 for I.F.'s around 465 kcs., or R5 for I.F.'s around 110 kcs.), and set the calibrated dial to the wanted I.F. frequency by using the hairline cursor opposite the corresponding range number (R4 or R5).

(3) Set the modulation switch to "AMP." position. The Volume control of the receiver may be increased if required during these preliminaries. If no audible note is obtained from the loudspeaker, turn the Oscillator tuning control until a signal is heard, using maximum output if necessary. If the set is known to be operative from the usual preliminary voltage and fault tracing tests, this will avoid altering unnecessarily the trimmers should other causes be responsible for the absence of signal, such as faults, disconnections, omissions in procedure, etc. Once a signal is received the direction of trimmer adjustment to correct the I.F. frequency should be noted The Oscillator is then set at the required I.F. frequency and rough adjustments are then made to the I.F. trimmers on the set until a note is heard. Continue the adjustment until the 400 c.p.s. sine wave appears on each beam of the Cathode Ray Tube screen (Fig. 19).

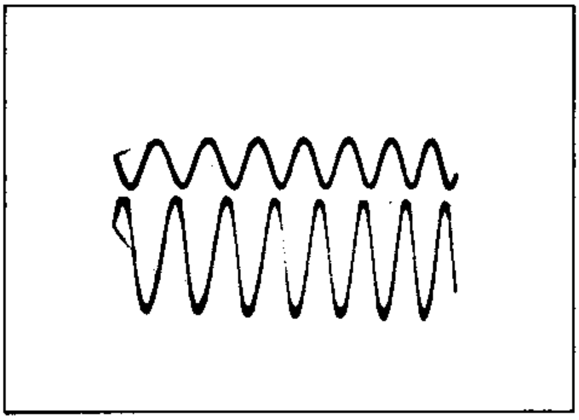


Fig. 19. Illustrates the response obtained on Double Beam Tube with amplitude modulated Signal. Used in preliminary adjustment as per 6.4.1.(B) (3).

It may often happen, especially with sets with two I.F. stages, or when there are more than the conventional two tuned circuits per stage, that in the case of sets considerably out of gang the haphazard adjustment of the trimmers will not produce sufficiently readily a combination to give either an audible note or a trace on the tube from which reference level subsequent adjustments can be rapidly obtained. It may then be more expeditious to apply the oscillator signal to the grid of the last I.F. valve to enable the A.V.C. and Detector circuits to be approximately tuned and then proceeding backwards in this manner to the next stage, if necessary applying the oscillator output from valve to valve, progressively reducing the output at each step as the trimming increases the trace size. The adjustments are continued until either a reasonably sized trace, or preferably a trace of about maximum amplitude, is obtained on the tube screen when the Oscillator is finally connected to the frequency changer modulator grid. If oscillations due to instability appear during these operations, leave the circuits adjusted to positions which are free from these effects, as these will be taken care of in the following procedure. These preliminary adjustments are then completed. In this process the Oscillator output will have been repeatedly reduced as required to contain the trace within the tube screen without overloading the set or

Oscillograph amplifiers. Also, after the appearance of the first trace in the Cathode Ray Tube the Volume control of the set will have been turned down as the loudspeaker is no longer required for the test.

(4) Turn the modulation switch on the Oscillator to the "FREQ." position and a response curve should appear on each beam. Due to the beam being spatially 180° out of phase the two traces point in opposite directions and thus do not interfere with each other. They can thus be inspected separately, even when superimposed.

(5) The Band-Width switch is set at 25 kcs. for all normal alignment. It may be set at other values for closer inspection of waveforms and special tests if required, but this is rarely necessary.

6.4.1.2. ALIGNING R.F. STAGES.

(A) CONNECTIONS.

(1) A suitable plug (included in the Model 426 Cossor Radio Service Kit) is connected to the Oscillator screened output lead, which is then inserted either in the "B" (Broadcast—Long and Medium Wave) or "S" (Short Wave) socket of the Model 393 Dummy Aerial, according to which wave-band is being adjusted.

(2) A similar plug is also connected to the screening of the same lead and is inserted into the "E" (Earth) socket of the Dummy Aerial.

(3) The output lead from the Dummy Aerial (red plug) is taken to the aerial terminal of the set, using a crocodile clip if necessary.

(4) The screening of the Dummy Aerial output lead (black plug) is connected to the Earth terminal or chassis of the set, again using a crocodile clip if necessary.

(5) The lead or condenser used to short-circuit the oscillator section of the frequency changer of the set during I.F. alignment is withdrawn so that the set may operate normally.

(6) The A.V.C., Q.A.V.C., A.S.C. and A.F.C. should still remain inoperative and the delay voltage removed, as previously provided.

(B) PRELIMINARY ADJUSTMENTS.

(1) The Wave Range switch is set to the position covering the signal frequency required and is changed when necessary, proceeding from the higher frequency for trimming to the lower frequency end of the set's tuning range for padding. The calibrated dial of the Oscillator is set to the frequency required, the frequency being read from the hairline marker against that range number (R1, R2, R3, etc.) which corresponds to the Range Selector switch setting in use.

(2) The Ganging Oscillator output switch is set to either position 1 or 2, depending upon the sensitivity of the set tested.

(3) The output potentiometer is turned to the lowest possible setting which provides a picture size deemed adequate.

6.4.2. "H.F. RESPONSE" METHOD.

Whilst the "Rectified Response" method, for which the connections and adjustments have been given above, is the most common and in practice the most satisfactory for aligning receivers, it is also possible to carry out the test by examination of the (unrectified) H.F. response of the receiver. This method calls for greater operational precautions and demands more exacting performance of the Oscillograph amplifier equipment if it is to be used rationally on both the H.F. and I.F. circuits. It is partly for this reason that it is not recommended, but chiefly because the rectified response is the one that indicates the true conditions at the detector circuit which concerns the low frequency response obtained from the loudspeaker, on which the performance of the set finally depends.

Nevertheless, because the "H.F. Response" method may occasionally be useful in signal tracing tests, and above all, in aligning H.F., aerial and intervalve band-pass circuits, the connections and adjustments are given herewith. The procedure remains the same as that given subsequently for the alignment of I.F. and H.F. circuits. The conditions applying in the case of band-pass circuits are discussed in Section 6.6.3.

When a frequency modulated radio frequency signal from the oscillator is applied to the receiver and the unrectified response is picked up from the detector diode or any of the intervening H.F. or I.F. stages, and when this signal is amplified by the Oscillograph wide-band aperiodic amplifier at the 2HFY1 position, the trace obtained will appear as a diffusely illuminated surface the envelope of which is the required response curve (Fig. 20). The H.F. response will show a double envelope, one above and the other below the mean or datum line. It will be noted that the double envelope curves are identical in shape, one being the "reflection" of the other. Therefore only one need be examined during adjustment. It is about both the horizontal axis and the mean tuning frequency that both envelopes of the H.F. trace must be adjusted to provide a symmetrical outline.

A major operational disadvantage of the H.F. method lies in the fact that because the two available amplifier valves of the Oscillograph are used to amplify the H.F. signal on the 2HFY1 setting, the remaining beam of the tube is inoperative. Unless a similar amplifier is provided externally the primary and secondary responses cannot be examined simultaneously as required. Even if one of these responses, that of the detector, for example, were to be examined by the "rectified" method, the signal would be too small for direct application to the Y2 plate and a single stage external amplifier would still be required. Only on favourable conditions of signal strength and I.F. frequency (such as 110 kcs.) can the single stage amplifier of the Oscillograph be used for the primary and secondary response, as in the "rectified" method. A further disadvantage of the H.F. response is that because of the high writing speed of the spot in tracing the H.F. pattern, the tube must be operated at maximum brilliance, and even at this condition the outline of the envelope is not as well defined as with the usual " Rectified Response " method.

One advantage of the method is that it is then possible to adjust individually the I.F. or H.F. band-pass circuits, making use at each stage of the " transferred impedance " effect, used in the overall test of the normal method as described in Section 6.5 (12). The signal is picked up immediately after such circuits, generally at the anode of the following valve.

To obtain the H.F. response special low capacity leads must be used, terminated by a small 1 to 5 mfd. condenser at the free end, in conjunction with the usual crocodile clip. At the Oscillograph end it is advisable to insert a 0.0001 mfd. condenser to block out mains voltage picked up by the lead. This condenser should be small, a ceramic or silvered mica type, and if necessary screened to avoid mains pick-up at this point. It is preferable to avoid the screening if possible, as it increases the input capacity of the instrument. These precautions will avoid the necessity of a low capacity screened lead, which is expensive and difficult to make, and a plain, thin insulated wire will serve the purpose ; such a lead is included in the Model 426 Cossor Radio Service Kit. Care must be taken in use to keep this lead distant from the chassis and away from the field of the valve's heater wiring or wires or components carrying H.F. or L.F. voltages.

the next sections, with the exception that when the primary and secondary responses of the last I.F. coil have to be examined, as is necessary for their final adjustment, as indicated in paragraphs 10 to 12, Section 6.5.1., this will have to be done separately by moving the H.F. lead from the A.V.C. diode to the detector and vice versa.

In order to obtain the R.F. signal, to avoid the objection mentioned above, it is often wrongly recommended to remove the detector valve so as to remove rectification from these circuits. This should on no account be done for it is almost impossible to align a circuit satisfactorily in this way. The reason is that when the detector valve is removed the circuit capacities are changed considerably and unless capacities are added during the alignment procedure which are identical to those, usually unknown, due to the valve, incorrect adjustment will result. In using this method it is endeavoured to avoid these consequences by suitably altering the Oscillograph input lead termination, but this is never satisfactory. Already this method of alignment affects the circuit capacities more than by the normal method. The coupling capacity of the H.F. lead in series with the other lead and input capacities of the instruments are in effect placed across the last tuned circuit, and as the capacity is very small, chiefly in relation to the total tuning capacity, it is not likely to affect unduly the usual I.F. circuits. The effect must, however, be kept present when this procedure is used directly for the adjustment of H.F. band-pass circuits where capacities of the order involved are sufficient to mistune the circuits concerned. In such cases it is better to obtain the signal from the anode of the following valves. It will be seen, therefore, from the above considerations that it is more satisfactory to align a receiver by the " rectified " method and in the following sections this method is assumed unless otherwise stated.

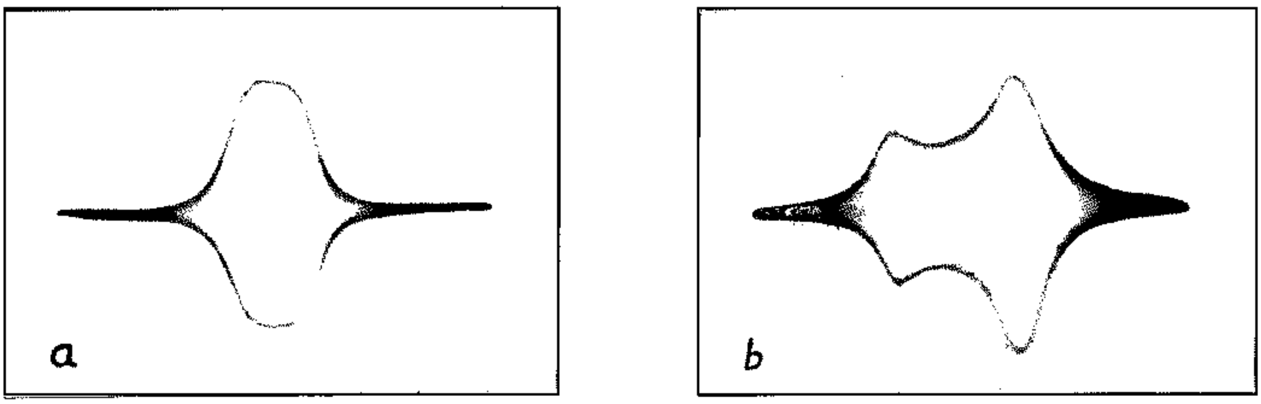


Fig. 20. Illustrating H.F. responses (6.4.2.) :—
(a) Average I.F.
(b) Band pass circuit incorrectly adjusted (6.6.3.2).

By one method of connection the preliminary adjustments for the H.F. method to the last I.F. transformer remain the same as those previously described for the " rectified " method. In this manner use is made of the residual H.F. present at these points and for this reason it is not really satisfactory. The signal will be smaller and the rectified envelope will not appear because it is blocked by the lead series condenser. The procedure for alignment of both the I.F. and H.F. will be identical to that given in

6.5. ALIGNMENT PROCEDURE.

6.5.1. ALIGNMENT OF I.F. SECTION.

(1) The vertical line in the centre of the transparent scale when the middle of the horizontal trace is set thereto, corresponds to the mean tuning frequency about which the alignment is effected to produce a symmetrical response of maximum amplitude.

(2) Accordingly a preliminary trimming of the I.F. circuit is carried out to set the response curves obtained in the middle of the sweep. The circuit to provide this most rapidly is the primary of the last I.F. transformer. To ensure that it is correctly positioned an increased oscillator signal may be temporarily applied to the grid of the last I.F. valve.

(3) The two traces on the tube will be as follows :—

(*a*) The lower inverted trace corresponds to the detector diode signal ; obtained from the D2 anode valve pin.

(*b*) The uppermost trace corresponds to the A.V.C. diode output ; obtained from the D1 anode valve pin.

(4) Trim rapidly all the circuits to obtain approximately maximum setting and adjust the Oscillator so that a reasonable sized double trace is obtained on the screen.

(5) Then proceed to damp the secondary circuit of the last I.F. transformer by connecting across it a 2,000 to 5,000 ohm resistance, terminated by flexible leads and crocodile clips. This may be done conveniently by connecting directly across the detector diode anode pin D2 and the high potential end of the diode load resistance (usually connected to the cathode). The effect of this circuit can be further eliminated by mistuning the trimmers. The lower trace will be reduced in amplitude and become practically a horizontal line. This line can be shifted to the bottom of the Cathode Ray Tube screen allowing the remaining trace to be shifted somewhat below the centre of the tube and increased in size by augmenting the Oscillator output. This makes full use of the screen diameter of the tube with gain in accuracy, resulting from the greater resolution obtained. The remaining trace on the Cathode Ray Tube screen will be that corresponding to the D1 or A.V.C. diode output giving the response of the primary of the last I.F. coil on which the whole I.F. alignment is centred.

(6) Trim the primary of the last I.F. coil (A.V.C. diode, circuit) to maximum amplitude. It will be found that because of the heavy damping on the secondary, the primary circuit behaves virtually as a single tuned circuit and reacts to trimming by peaking to a maximum. This must occur at the point corresponding to the middle of the horizontal sweep.

(7) Then adjust the primary and secondary sections of the first I.F. coil for maximum amplitude consistent with optimum symmetry of the response curve. It will be found that these circuits peak at slightly different frequencies, which lie one on each side of the mean frequency, and their correct adjustment will produce the required symmetry. Care must be taken in such cases to avoid the temptation of trimming to maximum amplitude alone, as this will produce an asymmetrical curve with the peak on one side of the mean frequency (Fig. 18a, b, c). Band-pass circuits should be trimmed so that both side peaks of the curve are at the same level (see Section 6), disregarding whatever apparent loss in amplitude the adjustment may entail (Fig. 14). It is here that the advantage of the visual method is most felt, for such adjustments cannot be done by any other method.

(8) To secure rapidly the results indicated in the previous paragraph, operate the trimmers so that the trace swings either side of the correct tuning position, as this facilitates the accurate setting of the circuit concerned. If necessary, in order to obtain a perfectly symmetrical trace, repeat rapidly this sequence of operations.

(9) If a set has two I.F. stages, first apply the Oscillator output to the grid of the second I.F. valve through a 0·01 mfd. condenser and the alignment procedure of paragraphs 4 and 5 is carried out, after which the signal is applied at reduced strength to the grid of the previous or first I.F. valve. The intervening I.F. transformer is then adjusted in the manner described in paragraphs 7 and 8. The signal is further reduced and then applied to the grid of the previous valve, the frequency changer, and the intervening I.F. transformer adjusted in the same manner as the last. Both these last transformers will exhibit the band-pass effects described in (7) and should accordingly be adjusted to give a symmetrical trace at maximum amplitude.

(10) The trimming of all the I.F. tuned circuits has thus been completed, with the exception of the detector circuits. The Oscillator signal is then reduced so that the single trace occupies a little less than half the screen diameter. It is then shifted to the top half of the tube screen. The horizontal line, constituting the lower trace (so far unused) is then returned to the mid-position on the tube screen and the damping resistance previously applied to the secondary of the last I.F. (detector coil) is withdrawn.

(11) Trim the mistuned detector circuit. In this process the secondary and lower trace will again appear on the tube screen. The adjustment is continued until this circuit is tuned to the same frequency as the primary and uppermost trace. This point, being a critical one, will be shown clearly, not only by corresponding to the maximum amplitude of the trace, but also, and more significantly, by the resulting dip in, or reduction in size of, the upper or I.F. primary trace (A.V.C. diode) so far used for alignment. These two conditions should be coincident (see Figs 25a, b, c).

(N.B.—In these illustrations the secondary curve is uppermost.)

(12) Should the resultant curves show relative dissymmetry, and in particular the frequency dip in the primary be somewhat displaced from the peak of the secondary, this denotes slight misalignment. The previous procedure should then be repeated rapidly as a check and the necessary readjustments made. Usually the cause is due to a wrong setting of the band-pass circuits ahead of the last I.F. It is therefore generally undesirable to correct any dissymmetry obtained by this last adjustment (11) by altering the trimmer settings of the last I.F. coils to give the required results. This would involve deliberate mistuning and therefore loss of selectivity and upset the audio balance.

By the visual method of alignment the trimming of the detector circuit in relation to the primary is always accurate and well defined, in contradistinction to what appears to be the case when aligning with the Output-Meter.

The method of alignment described ensures that both the detector and A.V.C. diode operate at the same mean frequency and therefore in unison at the same carrier frequency, as likewise the tuning indicator, if one is included in the receiver and operates from these circuits. The reduction in amplitude or dip in the primary can only occur when the mean tuning frequency is identical in both circuits, and is due to the resistance transferred from the secondary into the primary circuit brought about by the mutual inductance at resonance, a well known phenomenon in coupled circuits.

(14) It may be advantageous, although slightly more involved, to adjust the detector circuit at the very end of the alignment procedure, that is, after having trimmed the pre-selector or R.F. section of the set given below.

The reason is that before the adjustment of the detector circuit the resulting response curve of the I.F. as viewed from the primary of the last coil is reasonably peaked. It is thus of assistance in setting the single tuned circuits of the Oscillator and Radio Frequency sections, which are themselves peaked. On the other hand, when the detector circuit has been given its final adjustment it may often happen that because of the loose coupling between the primary and secondary of the last I.F. coil, either both the primary and secondary responses show a central dip, or this characteristic is limited to the primary alone, the secondary being flat topped. On such response curves it is often difficult to determine accurately the true mean carrier position when adjusting peaked responses of single tuned pre-selector circuits.

(15) Alternatively, and for the same reason as given in the previous paragraph, it may be found more advantageous instead to adjust the primary and secondary responses of the last I.F. coil, as described in paragraphs (11) and (12), as the very first step in the I.F. alignment by applying a large signal to the grid of the last I.F. valve. This can, in fact, be done advantageously at the very beginning of the alignment procedure. This ensures the correct adjustment of these circuits because of the greater resolution of the trace obtainable under these conditions.

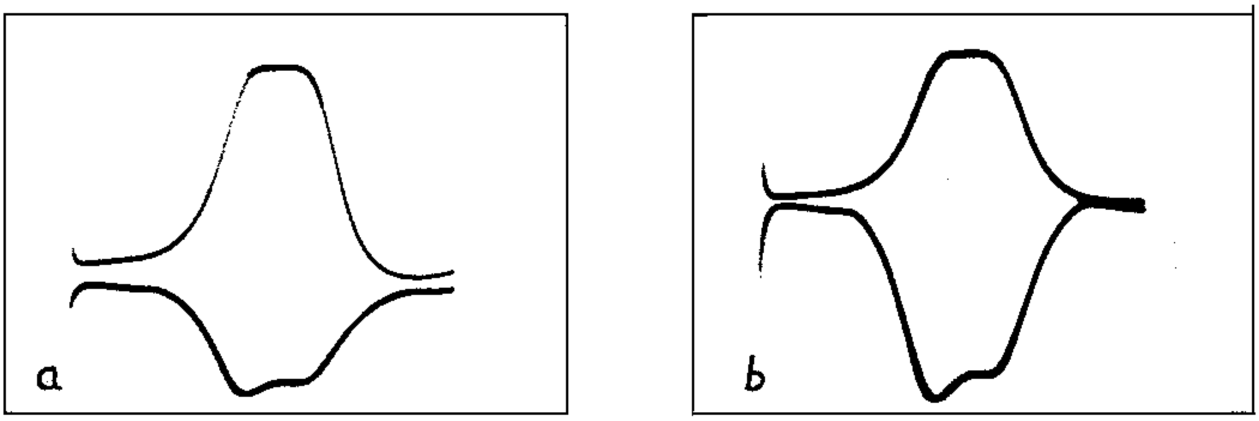


Fig. 21a, b. Illustrates the tolerable residual asymmetry on I.F. primary response which may result when alignment is completed.

(13) It may be found that even when both the mean frequencies of the primary and secondary are coincident, the two curves are not truly symmetrical. In such cases a final adjustment should be made to obtain maximum symmetry of the secondary response, even if as a result it involves a slight sacrifice in symmetry of the primary (see Fig. 21). The reason for this is that it is the former which determines the A.F. performance of the set, and secondly, because conditions may arise both by design or other causes by which absolute symmetry cannot be secured in the pre-detector I.F. stages. In serious cases one or other of the coils may require replacing.

It removes any uncertainty which may arise in the case of receivers with complicated I.F. circuits, and more generally with sets having two I.F. stages, where in this latter case the same size trace represents a response curve of considerably greater amplitude. The combined effect in such cases of the resultant lower resolution and the linear scale of the trace in practice restricts the scope of the adjustment to only the tip of the response curve itself.

After having adjusted the last I.F. coil the secondary is then damped, as stated in paragraph (5), and will again cease to have any further effect on the alignment. The primary response curve then returns to the peaked shape typical of the single tuned circuit, as above stated, for alignment of the I.F. band-pass and H.F. pre-selector circuits ahead, which are adjusted as already indicated.

(16) It is also well to note that the I.F. trimming for a given set may be either of the variable capacity or adjustable iron cored type, but these do not involve a difference of procedure except that the latter will be found to provide a more gradual adjustment, and are more stable.

6.5.2. ALIGNMENT OF R.F. SECTION.

(1) Proceed with the following after having carried out the connections as previously described (Section 6.5.1.2.) :—

(*a*) (1) Apply the Oscillator signal to the aerial terminal of the set through the Dummy Aerial.

(2) If the set is designed to work in conjunction with an anti-interference type of aerial the transformer joining the set to the aerial down lead, if available, is best retained connected to the set's aerial and Earth terminals, and the Oscillator output can then be applied to the primary of this transformer instead of the aerial down lead. The Dummy Aerial need not then be used.

(*b*) Set the Oscillator and Radio Set to the required wave-band range.

(*c*) Free the frequency changer oscillator by withdrawing the shorting link or condenser, or by replacing the separate oscillator valve, as the case may be.

(*d*) Retain the Oscillograph connections unchanged.

(*e*) Leave the A.V.C., Q.A.V.C. and other valve control circuits inoperative.

6.5.3. H.F. AND OSCILLATOR TRIMMERS.

(1) Rotate the ganged tuning condenser of the radio set to about 10° above its minimum capacity setting. Where the setmaker's specified trimming frequencies for the various wave-bands are known the condenser should, of course, be adjusted to the calibration points on the tuning dial which correspond to these frequencies. In the majority of cases the setmaker's test figures will be found to lie around the frequencies outlined in the R.M.A. Specification, and these are : Long Wave 300 kcs., Medium Wave 1,400 kcs. Various frequencies are specified for Short Waves according to the wave-band covered. The general use of these frequencies for all sets will in no way modify or impair the results obtained and they may therefore be adopted unconditionally. Should these figures differ from those specified by the set manufacturer their use will only produce a change in the two or three positions at which the oscillator tracking is in unison with the modulator (Fig. 22), which will involve no operational disadvantage whatsoever.

(2) Set the Ganging Oscillator to the frequency corresponding to the high frequency (low wave length) tuning position of the set, resetting the Oscillator frequency for each wave-band and, of course, seeing that they correspond to the dial setting of the radio receiver.

(3) Adjust the receiver oscillator trimmer (To in Fig. 17) until the two response curves are obtained in the centre of the screen.

(4) Adjust the trimmers of all the signal frequency single tuned circuits until maximum amplitude is obtained for both curves. This will usually include the aerial and/or R.F. stages and the frequency changer modulator grid circuit. The trimmers may be small capacities or adjustable iron cores, usually the former.

6.5.4. OSCILLATOR PADDER.

(1) Now adjust the tuning condenser of the receiver to the dial setting which corresponds to the padding frequency recommended by the setmaker. In the absence of setmaker's figures the frequencies recommended by the R.M.A. may be adopted. These are : Long Wave 160 kcs., Medium Wave 600 kcs. Various frequencies are specified for Short Waves according to the wave-band covered. These frequencies will generally correspond to a tuning condenser setting some 10° short of full plate mesh.

(2) Alter the frequency settings of the Ganging Oscillator to the conditions required for each wave-band, making simultaneous adjustment to the set tuning dial where necessary. It may be necessary to increase the Oscillator output by clockwise rotation of the output potentiometer and/or by setting the output switch to position 2 or 3, because of the drop in coil magnification both in the Oscillator and receiver usually experienced at the lower frequency end of the tuning ranges, unless the receiver circuits have been compensated for this effect.

(3) Many sets are fitted with ganged condensers the oscillator section of which is specially shaped to track continuously over the tuning range at the specified I.F. frequency. The alignment is carried out exactly in the manner described above. It will be found that trimmer adjustments will be provided for each range. The only difference will be that at least for one range (usually the Short Wave range) no padder adjustment is necessary. In such receivers it will also be found that the accuracy of ganging depends much more on the accuracy of the I.F. frequency than in the case of sets where the variable condenser sections are identical and this point should be checked.

(A) Adjust padder condenser P for each range until the two response curves are again obtained in the central position on the screen corresponding to the mean tuning frequency (Fig. 17 and Fig. 22).

It is possible that the calibration of the tuning dial on the receiver may be slightly inaccurate. Such slight inaccuracies are of much less importance than correct tracking and in order to ensure that the signal frequency

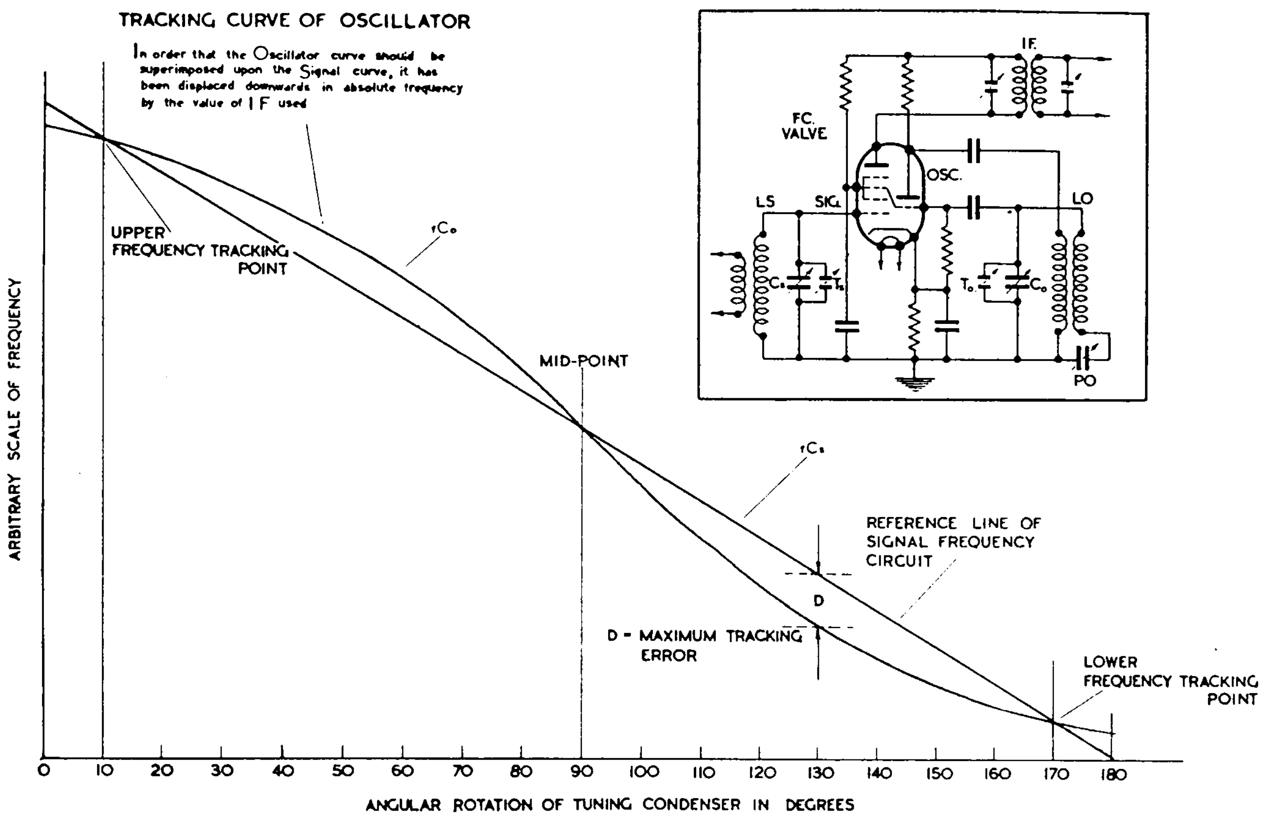


Fig. 22. Padded oscillator tracking curve, illustrating the variation of error over the tuning range.

circuits are, in fact, tuned accurately to the frequency at which padding is being attempted it is wise to rock the tuning condenser slightly about the nominal tuning point whilst adjusting the padder condenser. If the adjustment of the padding condenser and slight rocking of the tuning condenser are carried out simultaneously until a symmetrical outline of maximum amplitude is obtained, accurate tracking will be ensured. After completing the tracking adjustments it may be found that the dial setting on the receiver differs appreciably from the padding frequency.

Such errors are usually due to one of two factors :—

(*a*) The pointer may at some time have been moved relative to the condenser, causing the high frequency trimming to be carried out with the wrong proportions of " standing " and " variable " capacity.

(*b*) The ratio between the circuit constants in the signal frequency and oscillator circuits may have changed due, for example, to inductance drift in the oscillator coil.

Rectification of calibrational errors caused by the second of these factors should, strictly speaking, be achieved by replacing the defective component, but errors of the first type are capable of manipulative rectification. It so happens that within limits the method used for correcting faults of the first type may also be applied to faults of the second type, though in cases of considerable component inaccuracy, a new part should, of course, be fitted. A slight error affecting one end of the scale can often be rendered tolerable by so moving the pointer as to split the inaccuracy into a negative error at one end of the scale, and a positive error at the other, but if the discrepancy between the actual signal frequency and the calibration is too great to allow of such treatment, the following technique should be adopted.

Take first the case where an actual change in signal frequency of, say, 800 kcs., corresponds to a change in dial setting of only 790 kcs. This implies that too large a change in L/C ratio occurs for a given movement of the tuning condenser, and this may be compensated for by increasing the " standing " capacities in the circuit.

To adjust the receiver, the variable condenser should first be set to a frequency slightly higher than the nominal trimming frequency for the particular wave-band under consideration. The Ganging Oscillator is, however, set to the nominal frequency, and the receiver trimmers adjusted until resonance is reached, in the normal way. The Oscillator should now be altered to the padding frequency, and the " rocking " technique, already described, adopted whilst adjusting the padding condenser.

Having made these readjustments it will be found that the angular rotation of the condenser necessary to provide a given frequency coverage is increased. Adjustment on these lines may be carried out until the correct relationship between the frequency band and the angular rotation of the condenser is obtained. Once this has been achieved all that remains is to move the pointer so that the dial setting corresponds to the true signal frequency at some point towards the middle of the scale.

Where it is desired to reduce the angular movement of the condenser for a given frequency coverage the trimming technique is reversed. That is to say, the receiver condenser is set to a slightly lower frequency than the nominal trimming point, and the trimmer capacities reduced until resonance occurs. The subsequent adjustments then follow the routine already described. The padding adjustment should be carried out in a similar manner for each wave-band.

(B) The tuning condenser of the Radio Set should then be returned to the higher frequency setting (lower wave length) so that slight readjustment may be made to the oscillator trimmer to compensate for any dissymmetry and other effect resulting from the padder adjustments made. This procedure may be repeated if required, and once finished, the set is correctly aligned.

(C) With sets fitted with a ganged condenser the oscillator of which is specially shaped to track continuously, it will be found that the padder adjustment is unnecessary for at least one of the ranges (usually the Short Wave range). Sometimes padders may be provided for the other ranges, but more usually fixed condensers are used. In all such cases it is generally still advisable to inspect the response curve at the lower frequency end of the tuning scale to see that the tracking does remain satisfactory. It will be found that this is dependent also on the accuracy of the I.F.

6.5.5. MECHANICAL TRACKING CORRECTION.

When the tuning condensers are suspected of being responsible for errors of tracking due to slight mechanical maladjustment or accident, it is feasible when carrying out the test outlined in the previous paragraph to check this point and adjust the condenser vanes accordingly. Most sets are fitted with condensers provided with split vanes designed for this purpose. When rotating the oscillator and receiver condensers simultaneously and checking the changes in configuration of the response curve at definite intervals, say, of the order of 10° to 15° rotation, the rotor split vanes of each section can be made to approach or separate from the stator by means of a thin insulated prod simply by pressure, relying on the resilience of the vane itself to return to its original position. By this process the equivalent of a slight trimming adjustment on either side of the static setting of the condenser is obtained, and the resulting changed configuration of the trace can be examined. If an increase in amplitude is obtained in one of the directions this means that the corresponding amount of capacity must be added or subtracted and the split vanes last enmeshed in the stator should be adjusted to provide the required adjustment. The adjustment should be continued in the same direction until a maximum response is obtained, that is, until further changes in the same direction cause a reduction in amplitude. This adjustment is carried out for each of the H.F. circuits. Simultaneously the oscillator circuit will be inspected in the same way, but it will be noticed that in this case a change of frequency will be involved. The outline of the trace itself will tell whether the H.F. or the oscillator sections of the condenser vanes require adjustment. Generally speaking, when the outline is symmetrical and a change in the H.F. sections produces a change in amplitude, it is the H.F. sections that require adjustment. When the outline is asymmetrical it is advisable to adjust first the oscillator to produce maximum amplitude and symmetrical outline and then adjust the H.F. sections. Care must be taken in adjusting the Oscillator section not to upset the tracking adjustment. A slight dissymmetry will be present, as explained in paragraph 3 of the next section, due to the unavoidable tracking errors shown in Fig 22. The procedure is continued throughout the tuning range. It is sufficient to effect this on one range only, preferably the medium wave.

6.5.6. FINAL ADJUSTMENTS.

(1) It may be useful to test the set on an actual radio transmission around the high frequency tuning points on each range. Should there be a slight difference between the position on the calibrated scale of the receiver and that of the known transmitter, either the setting of the dial of the receiver is altered accordingly or else the Oscillator trimmer setting is readjusted and the other H.F. circuits retrimmed to the next setting. The reason why this may on occasion be neccessary is because of the inevitable dial reading error also because the allowed tolerances on the frequency accuracy of the Oscillator, though within the R.M.A. Specification, are sufficient to cause differences which become more noticeable at the higher frequencies, when they become comparable to the spacing of radio transmission themselves, more so on the Short Wave bands. It will be appreciated that absolute accuracy is not even obtainable in the laboratory. Therefore the facilities for checking the final adjustments of the re-alignment of actual transmission can be made use of on those rare occasions when it is required.

(2) It is well to note that whilst the Dummy Aerial represents a reasonably satisfactory arrangment for matching the receiver's input circuit to the impedance of an average aerial, it does not necessarily replace the actual aerial. The accurate alignment of the aerial circuit that can be obtained by its use is better than when adjusted without the Dummy Aerial, and is satisfactory for all practical purposes, more so because in general the aerial circuit is designed to meet these contingencies. It is for this reason that the procedure is standardized by all

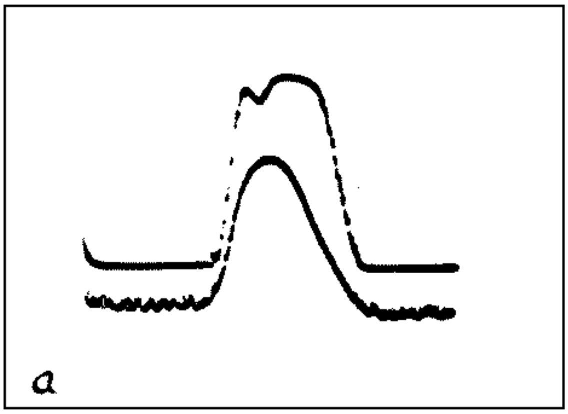


Fig. 23a. Illustrates overload of I.F. stages of a High Sensitivity receiver.

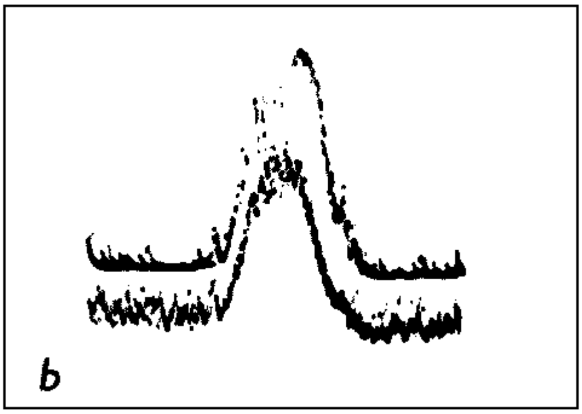


Fig. 23b. The same response with overload conditions removed, as explained in 6.6.1.

manufacturers for aligning their sets. However, depending on the type of aerial used, and also on the type of input circuit to the receiver, it may be found that when testing the set after alignment with the aerial with which it is intended to operate, a further adjustment at the higher tuning frequencies on each wave-band of the aerial circuit trimmer may produce a more accurate adjustment. It is feasible to carry out such adjustment when the opportunity presents itself, as when installing the set. This has only to be effected at the aerial circuit or first tuned circuit of the receiver. This necessity can be overcome if the set is aligned with its aerial down lead step-up transformer. In certain receivers an independent aerial tuning condenser is added to enable the user to trim the input circuit to the aerial actually in use. In such cases the setting obtained with a Dummy Aerial is satisfactory and should be retained.

(3) A final check-up should, however, be made at the middle of the various wave-bands. The frequencies specified by the R.M.A. for this purpose are : Long Wave 200 kcs., Medium Wave 1,000 kcs. (various on Short Wave). By inspecting the response curve obtained at this frequency after completing the alignment, any dis-symmetry or change of configuration of the response curve may be detected. It is important to note that on no account should any adjustment be made to the circuits in this position, as it will upset both tracking and alignment. Its purpose is to check the mean tuning position of the receiver to see whether the response curve retains a satisfactory outline or whether it is distorted. In most cases this point will correspond closely with the third and mid-point tracking position of the Oscillator, and for this reason the curve should be satisfactory. A representative graphical illustration of the tracking conditions obtained by the Oscillator trimmer and padding adjustment is shown in Fig. 22. The true mid tracking point can be located by turning the Oscillator and receiver dial simultaneously across the central tuning range. In the process it will be found that asymmetric changes on the curve will occur on one side of the curve and gradually move across to the other side. These are due to the tracking error gradually changing, as shown in Fig. 22.

The mid tracking point is that at which the curve regains a symmetrical outline during the change-over. This test may be extended over the entire tuning range, and will show whether the alignment holds and the oscillator section is tracking correctly. For this test both the frequency of the Ganging Oscillator and tuning control of the set are varied simultaneously, thus retaining the response curve central on the tube screen. Should a symmetrical response still be retained at and around the mid-frequency, the operation of alignment has been completed satisfactorily, and all the tuning and padding components may be assumed to be in order.

6.6. SPECIAL CASES OF H.F. CIRCUITS.

In this section will be discussed cases not considered in the general procedure, such as those connected with special types of circuits or receivers and covering the high frequency section of the set.

6.6.1. HIGH SENSITIVITY RECEIVERS.

When aligning receivers having sensitivities of the order of a few microvolts per metre, certain difficulties may be experienced. These sets usually have two or more I.F. stages and it may be found that the gain is such that it is necessary to readjust to the minimum output setting of the Oscillator to avoid overloading when aligning the I.F. stages. In proceeding thence with the H.F. alignment a condition is inevitably reached when the H.F. trimmers are brought in line when overloading occurs, as illustrated in Fig. 23a, by distortion and flattening of the curves. In such cases the following expedient can be adopted. Disconnect the Oscillator lead from the aerial terminal of the set but place it sufficiently near this terminal so that the small capacitative coupling resulting thereby is sufficient to provide a trace on the tube which is free from overload. Under these conditions the inherent noise of the receiver will show up to a considerable extent, not only because the receiver is then operating at maximum gain, but because the level of the input signal is of the same order as the noise. The effect obtained is illustrated in Fig. 23b. This procedure enables a correct alignment.

This is only possible provided the output of the Oscillator can be kept small, and what is more important, that the leakage of the Oscillator is very low.

On the subject of Oscillator leakage, a further cause of complication may arise with high sensitivity receivers when the harmonics of the Oscillator output applied as an H.F. signal to the aerial may be close to the I.F. frequency and therefore interfere with the correct alignment setting. A change of tuning frequency may often avoid this effect.

6.6.2. TUNED RADIO FREQUENCY RECEIVERS.

The resonant circuits of tuned radio frequency (T.R.F.) or so-called " straight " sets can be ganged in the same way as described for the R.F. section of superhet receivers. The Oscillator trimmer and padder adjustments mentioned do not, of course, apply, except the case mentioned in 6.5.4.C, and should band-pass aerial or intervalve circuits be used it will be necessary to align them stage by stage, as described in the next section.

6.6.3. PRE-SELECTOR BAND-PASS STAGES (Fig. 24).

Should the set possess any aerial or intervalve band-pass stage in the signal frequency section the following procedure is adopted :—

6.6.3.1. NORMAL METHOD.

(*a*) Align, as previously described, all circuits from the valve following the pre-selector and up to the detector.

(*b*) Then apply the Oscillator signal either to the grid of the valve immediately prior to the band-pass circuit in the case of an H.F. intervalve band-pass circuit, or to the aerial terminal in the case of an aerial band-pass circuit.

(*c*) Adjust the two circuits of the band-pass R.F. coupling in the manner recommended in paragraphs 7 and 8 of Section 6.5.1 for aligning the first stage of the I.F. section of a radio set, i.e., adjust the circuits for maximum amplitude consistent with a perfectly symmetrical outline on both traces.

(*d*) The above step can be taken in conjunction with the padder and trimmer adjustments if the secondary section of the band-pass circuit tunes the grid of the frequency changer, the oscillator section being, of course, trimmed first. If the circuit is prior to the frequency changer modulator grid, the Oscillator padder and trimmer adjustments should be made in conjunction with the tuning of the frequency changer grid circuit, and the preceding band-pass circuit adjusted independently afterwards.

(*e*) Apply the Oscillator output to the aerial terminal and complete the alignment of the set as previously described.

6.6.3.2. H.F. METHOD.

Whilst the rectified response method so far used has been assumed, if the necessary precautions are taken it is also possible to use the R.F. unrectified response method of alignment when adjusting aerial or H.F. intervalve band-pass circuits. This is done by taking the band-pass output via a low capacity lead to the Oscillograph A1 amplifier input terminal with the Amplifier switch set in the " 2HFY1 " position. Reference should be made to Section 6.4.2 for the procedure to be adopted in this case.

Whilst with the low capacity lead the signal can be picked up from the secondary coil of the band-pass circuit itself without sensibly upsetting its tuning, it is preferable to obtain the output from the band-pass coupling from the anode of the valve immediately following. By this means a larger signal can be obtained, not only because of the amplification of the valve stage, but because the small series capacity by which the lead is normally terminated can at least be increased if not dispensed with entirely.

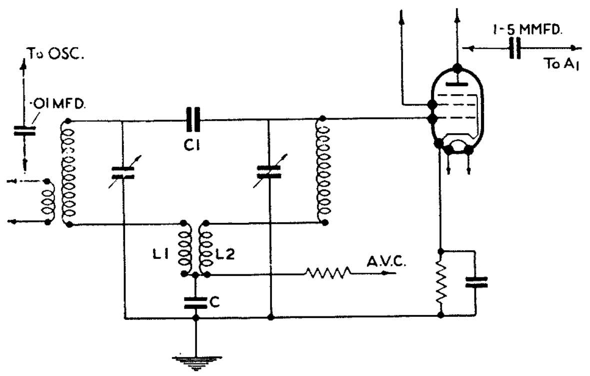


Fig. 24. Mixed-coupled (L1, L2, C1 and C) Band Pass, Aerial or inter-valve circuit. See Section 6.6.3 (1 and 2).

Should this anode circuit consist of a single resonance circuit, it should then be tuned to give the maximum image height at the centre of the screen with the Oscillograph input lead connected. The loading due to the Oscillograph will tend to flatten the tuning, which will be helpful for adjusting for a symmetrical outline of a response curve. Should the capacity due to the Oscillograph so severely mistune the circuit as to make a retune to resonance impossible, a series capacity must be used on the input lead. Its value will, however, be much larger than the 1 to 5 mmfds. normally fitted, and in fact it can be of the order of a capacity change of the condenser tuning the coil. In general a value of about 10 to 30 mmfds. will meet the case.

If, on the other hand, the anode circuit takes the form of a pair of coupled tuned circuits, which in this case is usually the 1st I.F. coil, not only should the anode trimmer be tuned, as stated, but this adjustment should be succeeded by a drastic mistuning of the subsequent circuit to which the anode circuit is coupled, that is, the secondary of the I.F. coil. The extent of this mistuning should be such as to take the resonant frequency of the second circuit outside the swept frequency range of the Oscillator, so that the trace obtained is entirely due to the band-pass circuit being aligned. The ideal requirement here is an aperiodic amplifier or one having a flat response over the frequency modulation range.

The band-pass circuit is then adjusted as in (c) and (d) on the H.F. response obtained. Once completed, the Oscillograph input is applied to the detector and A.V.C. diodes, as in the normal alignment procedure of Section 6.5.1, paragraphs (7) and (8), use being made of the transferred impedance phenomenon to obtain the correct adjustment, and is completed in manner to leave a symmetrical outline to both circuits. The mistuned circuits from the anode of the valve immediately following the bandpass are adjusted again to complete the alignment

6.6.3.3. TYPES OF CIRCUITS.

It will be found that pre-sel ctor band-pass circuits, whether aerial or inter-valve type, may be of different design. These differences do not entail a difference in procedure to that outlined in the previous paragraph except that if additional tuning elements are provided the makers' operating instructions will usually indicate the manner in which these have to be carried out. For a given frequency setting the ultimate result will be the same in that a symmetrical trace should be obtained. The differences between the various circuits or methods of coupling used will show up when carrying out the final adjustment tests outlined in Section 6.5.5 when examining the response curve over the whole tuning range. According to the type the separation of the two tuning frequencies of the band-pass assembly will vary, and as a result the resulting conditions of selectivity will vary over the range. It is not possible with the use of one type of coupling to produce uniform results over a ratio of frequency of the order of 2 to 3 : 1, as met in practice. Two types of coupling are usually required, one which is effective at the high frequency end and the other at the low frequency ends of the range. Usually a combination of capacity and mutual inductance is preferred. Nevertheless on most receivers one single method of coupling is often adopted and the distinguishing features of the various types should be recognised so that the results obtained can be correctly assessed. With capacity coupling, whether top or bottom type, the effect is to sharpen the tuning at the high frequency end of the range. With inductive coupling, whether of the direct or mutual inductive type, the effect is to sharpen the tuning at the low frequency end of the range. With mixed coupling the tendency is to provide an apparent constant selectivity over the whole range.

6.6.4. SUPERHET RECEIVERS WITH TWO I.F. STAGES.

Receivers with two or more intermediate frequency amplifiers of the usual band-pass coupled type can often be difficult to align. The adjustment of such circuits is much more involved than two or more single circuit H.F. stages of tuned radio frequency (T.R.F.) or "straight" type or receiver. The reason for this is that in the latter case incipient instability (Fig. 18e) definitely denotes excessive gain for the given conditions in a receiver. It can be corrected either by lowering the gain of the H.F. valves, such as by reducing the screen voltage or increasing the grid bias, or improving conditions of the receiver to increase stability, such as by additional decoupling and better H.F. screening. In the case of a superhet such incipient instability with band-pass stages may also be due to incorrect alignment of the I.F. circuits, resulting from

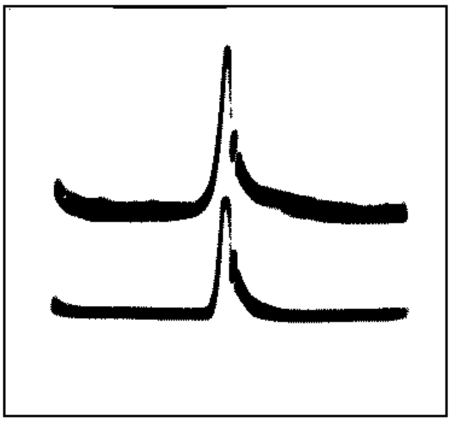


Fig. 18e. Illustrates fairly representative case of incipient instability during alignment which, because unstable, is difficult to photograph. Note disappearance of response curve. See Section 6.6.4.

the effects described in Section 6 and illustrated in Fig. 14. These effects are aggravated by being repeated at each stage. As the resultant increase in normal gain is the product of the increased gain obtained by misalignment with each coil, the risk of instability is obvious and in cases of receivers in which the normal gain already approaches the maximum permissible, instability is inevitable.

When the circuits have been correctly aligned, as per instructions in Section 6, not only will the circuits be set at their most selective conditions, but it will be found that the receiver regains its stability. In such cases, and more particularly when the gain appears to be close to the maximum permissible (this, incidentally, is not a desirable condition and is best avoided), it may be feasible to align the circuits individually by the H.F. method except for the last I.F. stage, and then revert to the normal "Rectified Response" method with a final trimming of the various circuits. One method which is often used is to damp all the H.F. circuits by resistances of the order of 50,000 to 100,000 ohms connecting across each tuned circuit so as to reduce the gain sufficiently to enable alignment without instability. Unfortunately, the final trimming for a symmetrical response, when the damping resistances have been removed, may be extensive and difficult to effect without instability.

A better method is to reduce the screen voltages of the I.F. valves so that the gain is reduced, if possible, to such an extent that a condition of instability is not reached under any condition of adjustment. The band-pass circuits can then be adjusted for a symmetrical outline. The screen voltages and the gain are then returned to normal, and as this may in turn show up further slight dissymmetry, a final trimming can be made as required to complete the alignment.

Other points which may arise in connection with the alignment of two I.F. stages are covered in the General Procedure, and in particular in paragraph 3 of Section 6.4.1.1. (B) and paragraphs 9, 13 and 14 of Section 6.5.1.

6.6.5. SHORT WAVE SETS.

The general procedure covers the general case of Short Wave sets and Short Wave sections of standard receivers, but there are cases in which special conditions exist on Short Waves which entail certain precautions :—

(*a*) FREQUENCY SHIFT (PULL IN).

This is due to the residual coupling between modulator (signal) grid and oscillator grid of the frequency changer valve. It can be due to coupling within the valve itself, but also to the fact that at the intermediate frequencies normally used the impedance of the modulator section is still high to the oscillator frequency. The effect, which is often present on Medium Waves, is more noticeable on Short Waves and varies with different types of frequency converters used, such as pentode ; hexode, triode pentode, triode hexode, etc., all of which vary in this respect. The effect is often very marked in old type receivers, but modern sets using the later versions of converters designed for Short Wave work are usually more satisfactory. The effect shows up on alignment by a shift of the tuning frequency when the modulator section of the receiver is trimmed, whereas this effect should only occur when the oscillator section is adjusted. In these circumstances it is preferable usually to align first all the other H.F. circuits to the chosen oscillator setting, and in so doing only adjusting approximately the modulator section, which should be completed in the last operation of all. It is usually satisfactory to tune it to provide maximum response provided the frequency shift is small. This frequency shift can also occur with a change of supply voltage or variation of supply voltage due to the modulation voltage swing on the output section of the receiver, particularly in cases of poor regulation of the power supply. This effect may often cause "flutter," which may necessitate further decoupling or other methods of cure, probably by replacing the valves, such as the rectifier or the frequency changer itself. The normal method of stabilizing the H.T. supply is not possible in Service work.

(*b*) INDUCTANCE TRIMMING.

On certain Short Wave sets the oscillator padding condenser is fixed and the alignment of both the Oscillator and H.F. sections of the receiver at the low frequency end of the scale is obtained by adjusting the inductance of the coils. Such adjustments are more often carried out by means of an iron core, the setting of which can be altered to change the inductance as required.

In such cases the adjustment must be carried out not only to the Oscillator but also to all its corresponding H.F. coils, care being taken to set the Oscillator adjustment to such a position as to enable a definite setting to be obtained on all the H.F. circuits. This will show up on the Cathode Ray Tube as the response curve of maximum amplitude in each case. These adjustments must be carried out with the tuning condenser fully meshed.

6.6.6. VARIABLE SELECTIVITY.

In many, and in general the more ambitious types of receivers, some system of variable selectivity is used. Only in a few sets is an Automatic Selectivity Control system added. In general these latter circuits require additional valves and function very much in the same manner as automatic frequency controlled circuits, involving various detectors. These are adjusted according to the same rules as previously given. The set manufacturer's instructions will be followed with regard to the tuning of these circuits, which may be connected either to the control valves or the H.F. valves direct according to the type of circuit.

The more general case of variable selectivity met in practice, however, is of the manually operated type, either as a variable control (resistance/condenser or mutual inductance, or a combination of any of these) or as a switch, either a rotary multiple position switch, or more usually a two-position switch giving a narrow and wide-band response. When a single circuit parameter is varied for variable selectivity purposes it is general to find that the action causes a displacement of the mean tuning frequency of the related circuit. No adjustment should be made to the tuned circuits to correct for this because the effect is inherent to the system. The more complex circuits are generally designed to avoid this frequency shift and their effectiveness in this respect varies. The inspection of the response curve on narrow and wide-band settings or intermediate values whenever possible will indicate to what extent the circuit is satisfactory. In Fig. 25 (*a*), (*b*) and (*c*) are shown a series of traces obtained on a variable selectivity control of a Cossor receiver, where it will be noted that the change in mean frequency is small, but what is more important, the curve retains a symmetrical outline at all settings.

It is precisely this latter point which must be inspected on such circuits. The procedure is to align in the usual manner with the Selectivity control set in the narrow band position. Once the alignment has been completed the curve should be inspected in the wide-band position. Some minor adjustments may be made in the latter, not to correct for frequency shift but to obtain the symmetrical outline, provided they do not materially affect the adjustment of the narrow band setting.

With regard to the type of circuits used, it is general to apply the variable selectivity to I.F. stages using band-pass coils as the adjustment of these offers the simplest means of providing variable selectivity. As mentioned above the main difficuty is concerned with retaining a symmetrical outline with change of coupling. When the circuit resistance of the two sections of the coil are not equal the selectivity remains symmetrical, but as the coupling is increased the amplitude of the two peaks decreases. With mutual inductive coupling increased above critical value a single peak is replaced by two disposed symmetrically on either side of the mean frequency. With further increases in coupling the two peaks will displace equal distances from the mean frequency, which does not change. This is an important point, the effect being unique to this type of coupling. The sequence of outlines is illustrated in Fig. 9. With all other types of coupling when increased beyond critical value, one peak remains approximately at the original position and the other moves away, thus causing a virtual change in mean frequency.

6.6.8. COMPLEX CIRCUITS.

Special circuits have been used in the past, and many are still being used for certain purposes in some radio sets. Complicated tuned circuits are included in many ambitious multi-valve radio sets, such as Communication and Diversity receivers. These special circuits are either series or parallel circuits serving as filters, or mixed series-parallel circuits acting as both filters and special I.F. couplings. In other cases standard filter networks are used. When circuits are used, as filters they can be either low pass, high pass or band-pass networks. All these types may be either tuneable or untuned and may be arranged to operate as rejector or acceptor circuits, and as the case may be, designed to present either a low impedance or a high impedance to the wanted or unwanted frequency.

The method of adjustment of such circuits is usually self-evident in the light of the general instructions already

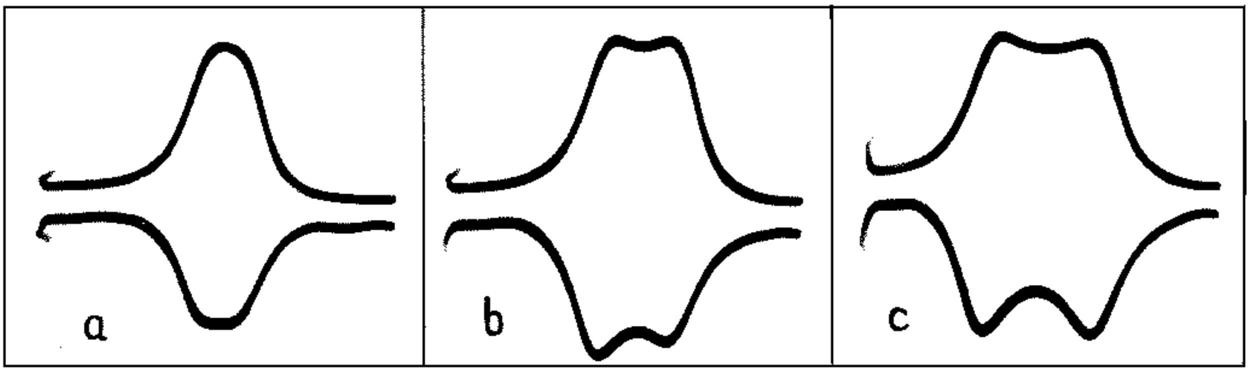


Fig. 25a, b, c. Illustrates a set of three correctly adjusted responses obtained at various positions of the Variable Selectivity control on a Cossor Model 584 receiver, as per 6.6.6.

6.6.7. REACTION CIRCUITS.

In the case of receivers fitted with a Reaction control it will be found that the setting of this control necessarily affects the tuning of the resonant circuit to which it is coupled. Accordingly the alignment of receivers incorporating such a control should be carried out with this control set at that position in which it is most commonly used in practice. In the case of low sensitivity receivers, however, it may be advisable to carry out the alignment with the Reaction control set to the point immediately below that setting at which oscillation commences. In this way the maximum possible sensitivity will be assured, whilst the frequency drift consequent upon a change in the Reaction setting will be greatest when the minimum amount of reaction is being used, that is, in its least sensitive conditions when receiving a local station, when it is less seen. It is advisable to test for the smoothness of reaction by noting the incidence of oscillation on the trace at the critical reaction settings (Fig. 18e).

given on band-pass and single tuned circuits, and the most useful data as to the correct adjustment is obtained from the Service Instruction Sheet of the manufacturer of the receiver. The most simple and also the more common cases used in receivers are given herewith as they illustrate the procedure to be adopted in other cases.

6.6.8.1. SERIES REJECTOR TYPE.

These are designed to exclude or attenuate a local station or other strong signal or harmonics thereof to prevent interference with weaker signals. It is generally situated in the aerial circuit of the receiver, but it is often used in combination with the receiver I.F. circuits as an intervalve coupling to reject adjacent channel signals, or in receivers with low I.F. frequency, such as 100 to 150 kcs., as a second channel rejector. It consists of a parallel circuit tuned to the required frequency and inserted in series with the signal path (see Fig. 26). The procedure is to inject from the Oscillator a signal of the

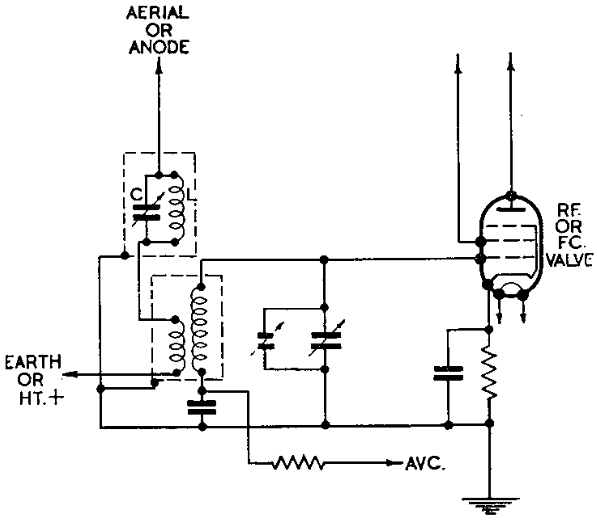


Fig. 26. Aerial or inter-valve Filter Circuit of the " Series Rejector " type. Section 6.6.8.1.

frequency which it is desired to reject. This signal may be either frequency modulated or amplitude modulated, and is introduced into the aerial circuit of the set through a Dummy Aerial at a fairly high level. With the Oscillograph A1 lead connected to the detector diode and the Amplifier switch in the 2Y1 position, using as much gain as is necessary to obtain a signal without excessive hum pick-up, adjust the tuning of the circuit to obtain a minimum trace or wave on the tube.

6.6.8.2. SHUNT ACCEPTOR TYPE (Fig. 27).

These are designed to exclude usually from the aerial and input circuits of the set any signal at either intermediate frequency or some harmonic of this frequency so that coupling and feed-back effects in the I.F. amplifier chain and detector circuits may be avoided. It comprises a series circuit tuned to the required frequency with the purpose of short-circuiting the unwanted signal but still representing a high impedance to the wanted signals. It is generally used as an I.F. filter and occasionally as part of the intervalve I.F. coupling to attenuate adjacent channel signals. When used as an I.F. filter, according to the I.F. involved the pre-selector circuits include certain regions over their tuning range which are particularly susceptible to the unwanted frequency. Thus for I.F. frequencies in the 100 to 140 kc. range the Long Wave band around the point where the tuning condenser is fully closed is the most affected, whilst for I.F.'s between 400 and 470 kcs. the Medium Wave band with the tuning condenser in the same position or the Long Wave band with the tuning condenser fully opened out are positions around which the set is most likely to be affected.

In order to adjust aerial I.F. filter circuits, the radio receiver should be tuned to the " susceptibility " band corresponding to the intermediate frequency employed, and the maximum Oscillator output at intermediate frequency should be injected into the aerial terminal of the set. The same procedure as described for aerial wave traps is then followed, the filter trimmer being adjusted to produce the minimum amplitude of signal on the Cathode Ray Tube.

When the circuit is used as a Second Channel Rejector, more usually in sets having a low intermediate frequency between 100 to 140 kcs., the same procedure is adopted. The set is switched on to the medium waves at a position corresponding to, say, 1,000 kcs. A signal should then be injected into the aerial terminal of the receiver having a frequency of 1,000 kcs. plus twice the intermediate frequency. The rejector circuit should then be tuned until a minimum output amplitude is shown on the Cathode Ray Tube.

6.7. SPECIAL DETECTOR CIRCUITS.

Although diode detectors are almost universal in modern receivers, certain other types of detector have been used in the past and are still used in various specialized types of modern receiver. The following notes cover the points which must be borne in mind in such cases.

6.7.1. PHASE INVERSION.

Before discussing the detector circuits it is important to bear in mind the polarity of detection and the phase inversion that occurs at each stage of amplification between detection and the Y deflector plate of the Oscillograph. Naturally due account must be taken of whatever combination of the Oscillograph amplifiers is being employed. A signal applied to the Y1 terminal of the Oscillograph gives an upward vertical displacement for a positive input voltage and the reverse occurs with

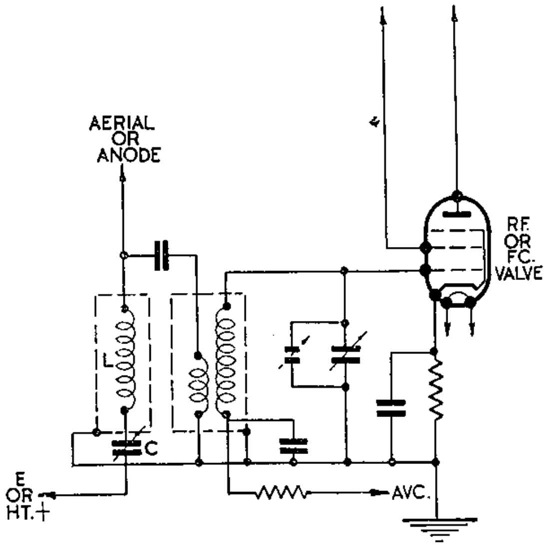


Fig. 27. Aerial or inter-valve Filter Circuit of the " Shunt Acceptor " type. " C " is trimmed for minimum signal at detector. Section 6.6.8.2.

the Y2 terminal. When a single stage Amplifier is used in the Oscillograph (YIY2 position) and the signal is applied to the AI terminal the displacement for the same positive voltage recurrent at the repetition frequency is downwards, due to phase inversion in the Amplifier. With two stages of amplification (2YI and 2HFYI positions) the conditions again reverse and a positive output produces upward movement.

Diode detectors are usually connected to give a negative rectified voltage at the diode end of the load resistance, likewise at the grid with grid detectors, but when the signal is obtained at the anode of grid detectors, phase inversion makes it positive.

In special cases diodes are sometimes operated to give a positive voltage, as in certain amplified A.V.C. and A.S.C. circuits, when it may therefore happen that the only trace obtainable from these circuits is from the cathode. In particular the two discriminator diodes of A.F.C. circuits also operate in opposite polarity, and as one cathode is earthed the signal obtained on the A.F.C. line across the other cathode and earth represents the summation of these two voltages.

With Infinite Impedance detectors the rectified signal across the cathode load is positive. In Anode Bend detector circuits the signal obtained from the anode is negative. Illustrations of the result of phase inversion are given in Fig. 23 (*a*) and (*b*), which in this case is due to the inversion of the A.V.C. diode intended for operation of an A.V.C. D.C. coupled amplifier.

6.7.2. HIGH IMPEDANCE DETECTOR STAGES (Fig. 28).

In the case of an Infinite Impedance Detector, or Negative Feed Back Anode Bend Detector, as it is often called (as also with normal or Power type Anode Bend Detectors) the same general I.F. alignment procedure should be followed, but several additional points should be borne in mind. Incidentally, the signal for the Oscillograph is obtained from the cathode of the valve (Fig. 28) and not from the anode, as in true Anode Bend Detectors. On account of the very light loading placed across the secondary of the last I.F. transformer by detectors of these types the selectivity of the last I.F. coupling is invariably greater than in receivers employing diode detection. For this reason, even though the normal procedure is carried out, greater care is necessary in carrying out the final adjustments if a response is to be obtained which is symmetrically disposed about mid-frequency. It may be advantageous alternatively to adjust the last I.F. coil independently, as described in paragraph 15 of Section 6.5.3.1, and without the need of damping the circuits, by adjusting the primary response first and then the secondary, both for a symmetrical outline. The transferred resistance effects, causing a dip in the primary and described in paragraphs (11) and (12) of Section 6.5.3.1, are still present to aid the correct alignment of the two circuits.

Whilst on the subject of this type of Negative Feed-

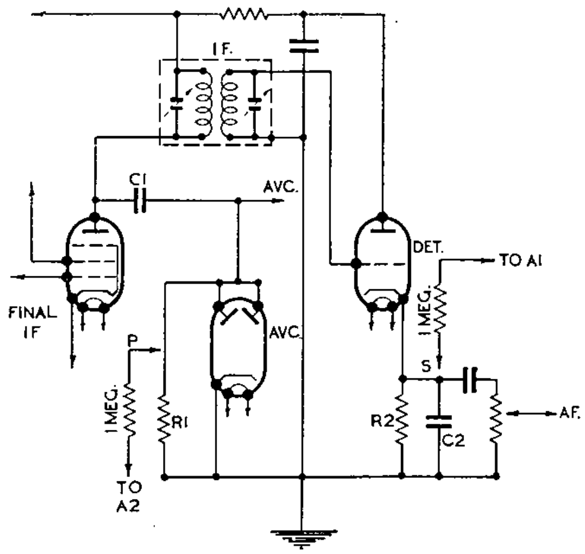


Fig. 28. Infinite-impedance or negative feed-back Anode Bend detector, Section 6.7.2.
(1) Rectified secondary (Det) response at "S."
(2) Rectified primary (A.V.C.) response at "P."

Back Anode Bend Detector it is not out of place to mention the case of sets with negative feed-back L.F. amplifiers, where the feed-back voltage is taken from the output stage or the loudspeaker to the detector circuit itself. The alignment procedure is not affected in such cases and the negative feed-back coupling components in the detector circuit (usually in the cathode) should be retained. Such detectors are more generally of the double dode triode type.

6.7.2.1. REFLEX DETECTOR.

A further type of detector which can be considered in this same class is the reflex detector. This is essentially an anode bend detector with negative feed-back. The amount of feed-back varies ; the greater the amount, the less distortion. This type of detector also has a high input impedance. The alignment procedure is the same and the signals can be obtained from the two diodes or from the anode of the valve and one diode. This type of circuit is not usually arranged to produce A.V.C. except of the amplified type. The point to notice is the restricted input signal that this type of detector will accept without overloading. Both leads to the Oscillograph should be terminated by a 1 MΩ resistance in the usual way.

6.7.3. GRID AND ANODE BEND DETECTORS (TRIODE OR PENTODE).

Grid or Anode Bend Detectors, both of the simple and power type, were used in receivers some years ago and are therefore likely to be encountered in Radio Service work.

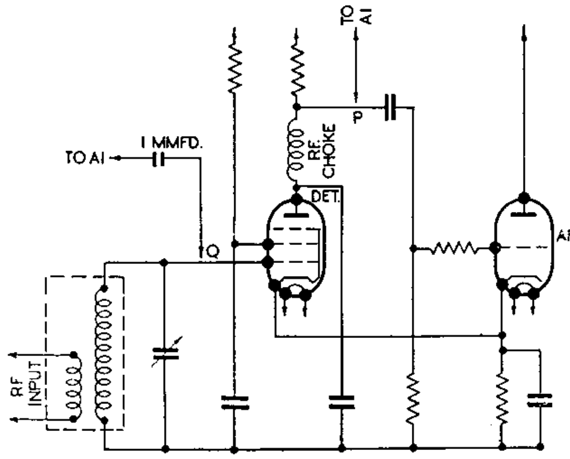


Fig. 29. Typical Anode Bend detector, resistance-capacity coupled to A.F. stage. Section 6.7.3.2.
(1) Rectified amplified response may be obtained at " P."
(2) Alternative connection for R.F. response shown at " Q."

The Grid Detector is similar to a Diode Detector and the signal for the Oscillograph can be collected from the grid (Fig. 30). The Anode Bend Detector is similar to the Infinite Impedance Detector but the signal in the former case is taken from the anode (Fig. 29). Notwithstanding the fundamental dissimilarity of the two classes, it is more convenient in this section to consider them simultaneously, because such detectors were formerly used on relatively insensitive receivers, for which reason it is more convenient to obtain the signal from the anode circuit in both cases, whether a triode, tetrode or pentode valve is used. As a result the alignment arrangements are dependent solely on the type of L.F. coupling used in the receiver. Only two cases need thus be considered, one with a resistance/capacity coupling and the other with transformer or choke coupling, including in this latter the variation of parallel-fed connections.

6.7.3.1. RESISTANCE COUPLING (Figs. 29 and 30).

When a Grid Leak or Anode Bend Detector is used with a triode, tetrode or pentode, the best procedure is to take the Oscillograph input from the anode of the valve, as mentioned above, and thus make use of the amplification of the detector stage. This must always be done with Anode Bend Detectors (Fig. 29), but it is not essential with Grid Detectors as the rectified signal can also be obtained from the grid, as shown in Fig. 30. In this case the alignment procedure is the same as with Diode Detectors. By taking the signal from the anode the amplifier stage of the Oscillograph can occasionally be dispensed with, although as such detectors are more often used in insensitive receivers this may not always be possible. If the detector is resistance coupled to the low frequency stage, no special precautions are needed, although it is preferable to disconnect the low frequency section from the detector's anode circuit point so that the capacity coupling components do not interfere with the phase of the low frequency response of the trace obtained. This shows up as a dip of the descending portion of the curve below the base-line, as mentioned in Section 6.2.2(8).

6.7.3.2. TRANSFORMER OR CHOKE COUPLING (Fig. 31).

When the Oscillograph amplifier is taken from the anode of the valve it is essential that this anode load be resistive. The transformer must therefore be replaced by a resistance because a reactive load distorts the shape of the curve. The resistance value used should be equivalent to the load of the transformer and impose as nearly as possible the same operating conditions. The same arguments apply in the case of choke coupling.

The filter shown in Fig. 31 serves to block the radio frequency that may be present at this point when a choke filter is not provided, as in Fig. 29, in the set. It can be used in the case of low sensitivity receivers to avoid the loss of signal when the standard 1 megohm termination of the Oscillograph lead is retained, although it can usually be replaced as effectively by a 50,000 ohm resistance with insignificant loss of gain. The low impedance of these filters is justified because, as is the present case, the point to which the lead is applied does not affect any of the tuned circuits. These considerations apply also for Figs. 29, 30 and 32.

6.7.3.3. PARALLEL FED TRANSFORMER OR CHOKE COUPLING (Fig. 32).

In the case of parallel fed transformers or chokes it is only necessary to disconnect the L.F. section of the set at the transformer primary (see Fig. 32) as recommended for resistance/capacity coupling.

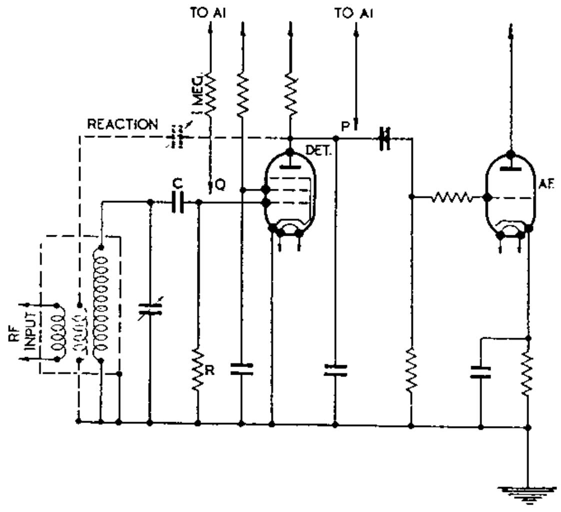


Fig. 30. Grid Detector with resistance-capacity coupled A.F. stage. (Pentode or Triode). Sections 6.6.7.1., 6.7.3.1.
(1) Rectified amplified response may be obtained at " P " direct, or
(2) Rectified response at " Q " through 1 MΩ.

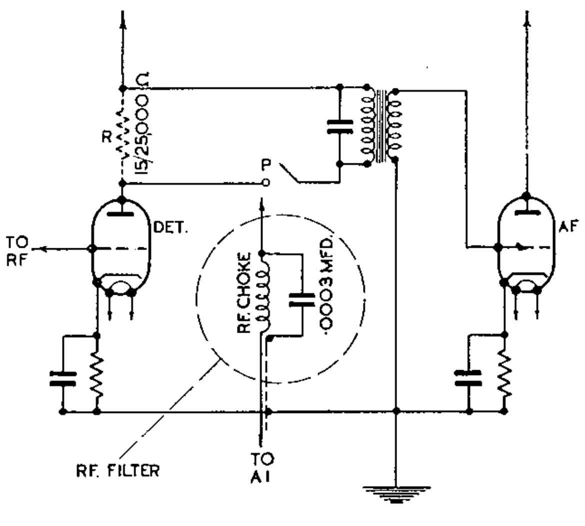


Fig. 31. Anode Bend (or Grid) Detector, Transformer (or A.F. choke) coupled. Section 6.7.3.2.

(1) Disconnect transformer or A.F. choke at " P " and replace by resistance " R."
(2) Connect oscillograph screened input lead terminated by R.F. filter shown to "P." The rectified and amplified response is obtained at " P."

6.7.4. AUTOMATIC FREQUENCY CONTROLLED (A.F.C.) CIRCUITS.

A.F.C. circuits are used to a wide extent in radio receivers to-day, chiefly because of the increasing popularity of push button tuning. The adjustment of all A.F.C. circuits is fundamentally the same, whether they be of the " side-tuned circuit " type or of the " centre-tapped phase-splitting I.F. transformer " type. This similarity of method also applies not only when all the coils feeding the detector, A.V.C. and discriminator diodes are coupled within the same coil can, but also when some of the coils concerned are in separate cans and are coupled either capacitatively or inductively.

It is in an application such as this that the advantages of the Double Beam Oscillograph become outstanding, because of the simplicity with which the circuit may be adjusted. When using an Oscillator and Output-Meter, and even with a Single Beam Oscillograph (unless the complicated method of superimposed records obtained by tracing or electronic switching is used), it is extremely difficult to obtain accurate adjustment of the resonant peaks of the discriminator circuits relative to the detector response, particularly in circuits of the side-tuned type. This is due to the extreme accuracy demanded of the Oscillator calibration and its manipulation in view of the few kilocycles (1 to 4 kcs.) separation required between the side-tuned circuit peak and the intermediate frequency.

In this respect the centre tapped phase-splitting transformer circuit is better because of its automatic adjustment at resonance. Even in this case the correct symmetry of the A.F.C. response with respect to the detector response cannot be determined accurately without the Double Beam Tube because it often happens that the responses of the two discriminator sections do not always provide equal and opposite voltages or the same slope. Neither is it easy without a Double Beam equipment to ensure the same frequency separation between the maximum response of each discriminator diode and that of the intermediate frequency.

There are two outstanding advantages of the Double Beam tube for this application. Firstly, the "S " response of the A.F.C. voltage and the signal detector response can be inspected simultaneously by connecting the A.F.C. line directly, viz., without the usual 1 M Ω termination, to the A2 terminal on the Oscillograph, the detector diode being connected to A1 in the normal way through a 1 M Ω resistance (Figs. 33, 34). Secondly, on account of the greater resolution of the order of 5 kcs. per 10 cms. provided by the swept frequency scale on the Oscillograph screen it is possible to adjust both the frequency separation between each discriminator diode circuit and the mean intermediate frequency with much greater accuracy than is ever possible with a normal oscillator.

For such work it may be found an advantage to reduce the band-spread from the maximum of ± 5—10 kcs. to obtain still greater resolution by reducing the range with the Band-Width control on the Oscillator.

Incidentally, the time constants of the A.F.C. filter are usually such that a larger deflection can be obtained from the A.F.C. signal by operating the Oscillograph time base at $12\frac{1}{2}$ c.p.s. At this frequency (at which the calibration voltage from 50 c.p.s. mains shows as four complete cycles) appreciable flicker may be experienced, but the trace is no less easy to examine.

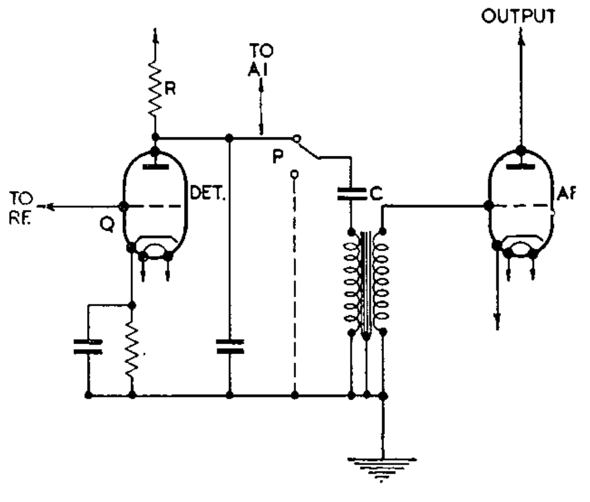


Fig. 32. Triode detector coupled to an A.F. stage by a parallel-fed transformer or choke. Section 6.7.3.3.

(1) Disconnect transformer primary at " P " and short-circuit this point to Earth. The rectified and amplified response may be observed at " P."
(2) R.F. response may be taken by connection to " Q " without disconnecting the transformer.

The symmetrical positioning of the two discriminator diodes relative to the mean frequency is always possible with the sidetuned circuit type (Fig. 33), and can also be effected with the phase-splitting, transformer type (Fig. 34) on condition that suitable adjustments are provided in the circuit for this purpose.

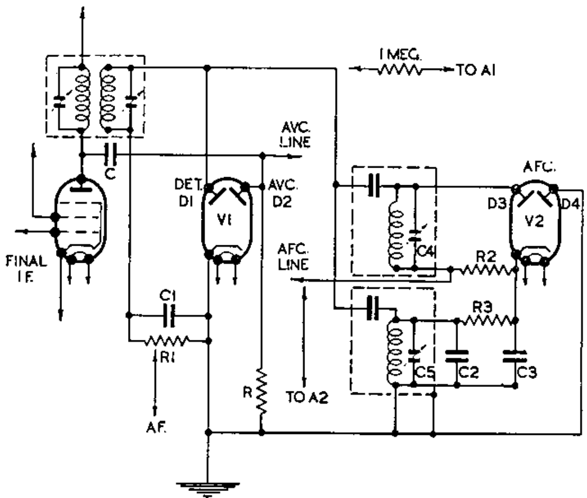


Fig. 33. Typical A.F.C. discriminator circuit of the side-tuned type (6.7.4.A.) illustrating connections for adjustment. The usual 1 MΩ lead termination is not required for A.F.C. line pick-up.

It is important that the Oscillator output be maintained constant at the I.F. frequency involved when A.F.C. circuits are being adjusted. From Fig. 35 the conditions required for correct adjustment of A.F.C. circuits relative to the detector response are clearly shown. The signals are obtained at the detector diode and the A.F.C. line, as shown in Figs. 33 and 34. The points which can be determined readily with a Double Beam tube are the following :—

(*a*) That the " S " curve of the A.F.C. voltage crosses the datum line or horizontal axis at the position corresponding to the mean tuning frequency of the detector circuit.

(*b*) That the I.F. response curve and the discriminator peaks A1 and B1 are symmetrically placed relative to the vertical axis CC1.

(*c*) That the frequency difference between each peak and the I.F. frequency is that specified by the set makers, which is measured by the distance AC=CB, usually of the order of from 1 to 4 kcs.

(*d*) That the peaks A1 and B1 are similar in amplitude and general form.

(*e*) That the slope of the midsection of the " S " curve is within the required limits. This latter is a very important point.

In Figs 36a and b are shown satisfactory oscillograms obtained in practice on the lines of the outline illustrated in Fig. 35, as per the test conditions of Figs. 33 and 34, whilst Fig. 36c illustrates the case of incorrect conditions or faulty components. In Fig. 36d is shown the component voltages of the " S " curve obtained from each of the two discriminator diode load resistances when the earth point is removed from one (R3) and taken to the juncture of the two loads R3 and R4 of Fig. 34 (incidentally, disconnecting the lead to C). In the case of Fig. 33 this means removing earth connection at lower end of C5 and earthing instead the cathode of V2. These responses are not required in practice and are only shown to illustrate the theoretical conditions obtaining.

Before adjusting the A.F.C. circuits it is necessary to align the I.F. amplifiers, as previously described (Section 6.5.1), the A.F.C. circuits being rendered inoperative by the method outlined in Section 6.3.2.4, whilst the I.F. alignment is being carried out. It is possible that, once having aligned the signal circuits, the discriminator circuit adjustments will affect, and to some extent modify the settings of either or both the primary and secondary of the last I.F. transformer to which these circuits are connected. The discriminator secondary does not add amplification but reduces it slightly because it is in adsorbtive resonance. This effect is due to the transferred impedance between these circuits at resonance, and is identical to the phenomenon discussed in Section 6.5.1 (11) which is used as the basis of adjustment of the detector circuits during alignment. Normally the effect should involve only a reduction in amplitude of the I.F. and increase the amplitude of the discriminator response when transferred resistances only are involved, but as reactive effects are often also present a slight change in frequency setting of these circuits may be produced. In such cases the trimmer of the last I.F. transformer coils, usually the secondary, is adjusted to correct for this effect and produce the required symmetrical curve in all the signal circuits, as illustrated in Figs. 36a, b.

(A) THE SIDE-TUNED TYPE OF FIG. 33.

The positioning of the discriminator peaks A1 and B1 is obtained by adjusting the C4 and C5 discriminator coil

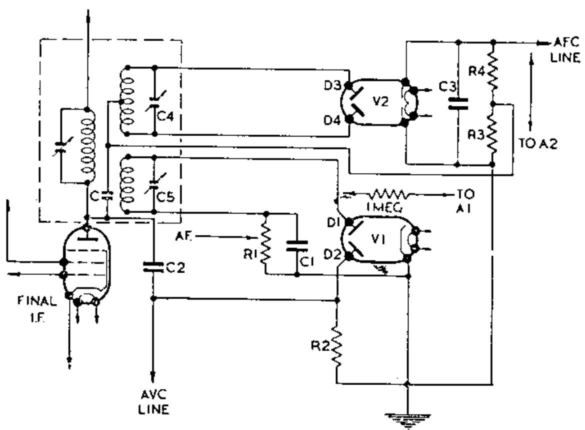


Fig. 34. Typical A.F.C. discriminator circuit of the type employing a centre-tapped phase-splitting I.F. transformer secondary, indicating connections for adjustment. Section 6.7.4. A.

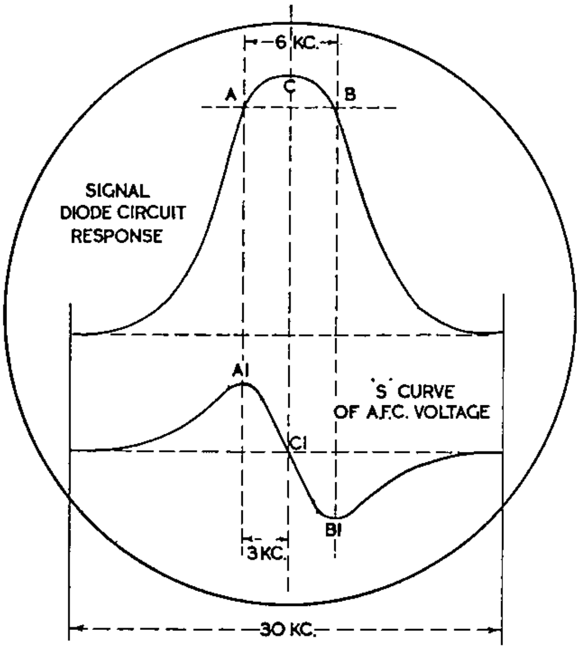


Fig. 35. Diagrammatic representation of the Double Beam method for quantitative determination of the performance of A.F.C. discriminator circuits. Section 6.7.4.

near to perfection by various expedients, these amount in most cases to bodging, or if carried out rationally, to design changes, and thus fall outside the province of the Service Engineer. Failing the possession of manufacturer's tolerance figures, the Service Engineer should therefore decide upon acceptable tolerances from his own practical experience and replace any defective components should he be unable to achieve the desired results with the adjustments normally provided.

(B) THE PHASE-SPLITTING TRANSFORMER TYPE (Fig. 34).

The adjustment as far as symmetry is concerned is obtained automatically by trimming the discriminator circuit condenser C4 in Fig. 34. If the coil and circuit constants have been correctly chosen this single adjustment should automatically provide correct peak separation of the discriminators relative to the intermediate frequency, and should also ensure that the positive and negative peaks are both of equal amplitude. Should this not be the case, circuits of this type are more difficult to correct than the side-tuned type as, in general, no provisions are made in the set for this purpose. The resultant asymmetric effects invariably render the A.F.C. unsatisfactory, and are generally due to unequal coupling

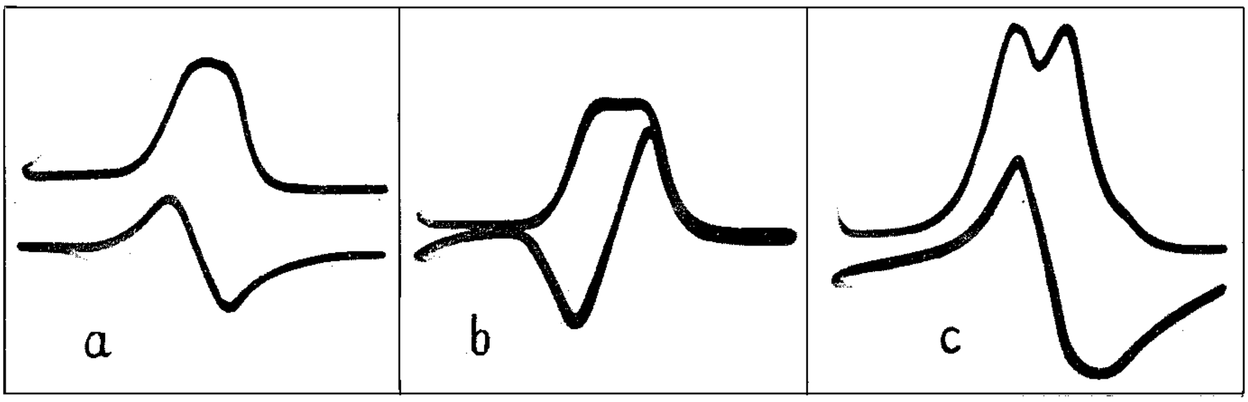


Fig. 36a, b, c. Illustrate good (a and b) and bad (c) case of A.F.C. adjustment, as per Fig. 35.

trimmers. Should the two discriminator peaks be of dissimilar amplitude these can be adjusted by altering the value of the coupling condensers to the I.F. chain. If an inductively coupled link is used, this also may be modified by changing the coil position. Alternatively, the coils may need changing or the fault may be remedied to some extent by adding a suitable impedance in shunt across one or other or both circuits to match the impedances and obtain a symmetrical trace, provided that the resultant damping on this circuit is not sufficient to affect the slope and thus to interfere with the sharpness of the A.F.C. action. In practice it is rarely possible to correct an imperfect A.F.C. response, set manufacturers do not normally provide any adjustments beyond trimming condensers for the appropiate I.F. circuits. Thus, whilst a knowledgeable engineer can obtain results reasonably

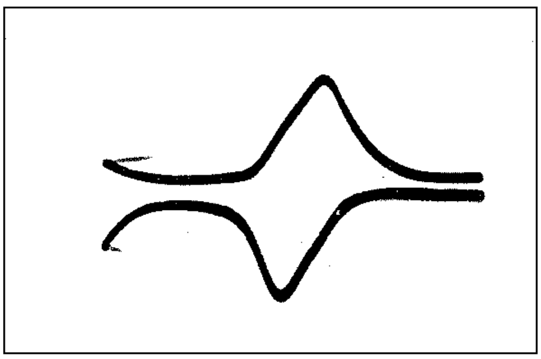


Fig. 36d. Illustrates the individual responses of the diodes obtained by the method given at end of Section 6.7.4.

between the primary and the two halves of the secondary, or to differences in the impedance of the two discriminator diode circuits.

Other possible contributory factors are, of course, an incorrect centre tap on the phase-splitting transformer or dissimilarity between the two discriminator diodes themselves. With the exception of the peak separation, correction for all these factors can be made by modifying the impedance of the circuits concerned provided that the alterations called for are not so drastic as to affect materially the amplitude of the A.F.C. voltage developed on the slope of the " S " curve.

7. BIBLIOGRAPHY

1. "The Wobbulator." O. H. Davie.
   Electronic Engineering. August, 1941.
2. "Oscillators for Circuit Alignment." O. S. Puckle.
   Wireless World. 6th August, 1937.
3. "Oscillographic Response Curve Examination." R. F. Proctor and M. O.'cHorgan.
   Wireless Engineer. July/August, 1935.
4. "Frequency Modulated Generators." A. W. Barber.
   Radio Engineering. November, 1936.
5. "Receiver Production Tests." S. Bagno and J. Sadowsky.
   Radio Engineering. November 1934.
6. "A Logarithmic Cathode Ray Resonance Curve Indicator." S. Bagno and M. Posner.
   Radio Engineering. January, 1936.
7. "Tube Capacity put to Work." J. M. Hollywood and M. P. Wilder.
   Electronics. October, 1935.
8. "A Vacuum Tube Voltmeter with Logarithmic Response." F. V. Hunt.
   Review of Scientific Instruments. December, 1933.
9. "Visual Test Set." Gunther Ulbricht.
   Proc. I.R.E. January, 1934.
10. "A Wobbly Oscillator." J. H. Reyner.
    Wireless World. 11th August, 1938.
11. "Visual Test Devices." Schuck.
    Proc. I.R.E. October, 1932.
12. "The Panoramic Radio Spectroscope." H. G. Miller.
    Q.S.T. March, 1942.
13. "Panoramic Reception." M. Wallace.
    Electronics. July, 1938.
14. "A Wide Band High Frequency Sweep Generator." E. J. H. Bussard and T. T. Michel.
    Electronics. May, 1942.

8. SPECIFICATION.

The figures given are approximate and representative of the average Instrument ; variations must be expected.

POWER RATING.

Mains Voltage	110, 200, 220, 240 volts A.C.
Frequency	40—100 c.p.s.
Power Consumption	30 watts.
4 Valves	43IU, MS/Pen., 4THA, MS/Pen.

DIMENSIONS.

Height	$12\frac{3}{4}''$	32 cms.
Depth	8″	20 ,,
Breadth	$15\frac{1}{4}''$	39 ,,
Weight	25 lbs.	11·5 Kgs.

MODULATION.

Switch Position.

Freq.	(1) Unmodulated signal with X and E terminals joined. (2) Frequency modulated up to 50 kcs. (± 25 kcs.) with the equivalent of about 225 volts D.C. from the Oscillograph Time Base applied to the X terminal.
Amp.	400 c.p.s. 30%.

FREQUENCY RANGES.

Range Switch Position.	*Frequency Ranges. Approx.*	*H.F. Voltage Outputs Approx.*
1	20 to 8 Mcs.	10 to 20 mV.
2	8 to 3 ,,	30 to 40 mV.
3	2·46 to 0·98 ,,	40 to 60 mV.
4	0.98 to 0·36 ,,	40 to 50 mV.
5	0·34 to 0·07 ,,	5 to 10 mV.
Fixed Oscillator frequency	380 kcs.	
Amplitude modulation	400 c.p.s. at 30%.	
Frequency modulation	Rate of 25 c.p.s. max. ±25 kcs. width, of which $\pm 12\frac{1}{2}$ kcs. free from amplitude modulation.	

ATTENUATOR.

Type ... ... Ladder network fed by slide wire.

Switch Position.	*Output Resistance.*	*Output Ratio.*
1	69 ohms.	1
2	20 ,,	1/10
3	20 ,,	1/100
Variable potentiometer	100 ohms, graduated in 1/10ths.	

AVAILABLE AS EXTRAS.

426 Kit of Leads.
413AB Service Rack and Oscillograph and Oscillator Panels.

The Company reserves the right to alter specification if necessary.

9. REPLACEMENTS PARTS LIST.

Part No.	Description.	Price Each
M.S.Pen.	H.F. Pentode Oscillograph Valves.	10 6
4.T.H.A.	Mixer Valve.	11 6
43.I.U.	Rectifier Valve....	9 0
ZA5259	Sub-Chassis Assembly.	Prices on Application.
ZA5262	Resistance Panel Assembly.	
ZA5261	Resistance Panel Assembly.	
TA10031	Mains Transformer.	
MC11410	Choke.	
MC13097	Filter Coil.	
MC203187	C.T. Heater Resistance, 25Ω	
TA10032	Oscillator Transformer.	
M12738	Trimmer Condenser, 100 mmfd. (max.).	
M15859/16	Potentiometer, 100Ω P3.	
M15870/30	Potentiometer, 1 Meg.Ω P1.	
M15875/6	Preset Potentiometer, ½ Meg.Ω P2.	
M15353/2	3-Pole Switch.	
G1173–72	Screened Output Socket.	
G1173–171	Screened Output Plug.	
Z2548	3-Push-Button Switch.	
393	Dummy Aerial.	
M12540/3	Slow Motion Drive.	
Z1543	Dial (Large).	
Z2555	Condenser (Electrolytic), 8+8 mfd.	
M240968	Dial (Small).	
Z2550	Escutcheon.	
M240973	Cursor.	
M13626	Terminal.	
Z2013	Pointer Knob.	
M16999	Knob.	
S9215	6.5 v., 0.3 amp. Bulb.	
ZA5256	Oscillator Coil.	
ZA5257	Phase Splitting Inductance.	
Z2549	Inspection Plate.	
Z2567	Miniature Signal Lamp.	
M199110	Rubber Feet.	

AUXILIARY INSTRUMENTS AND ACCESSORIES.

RADIO SERVICE INSTRUMENTS.

Model 339	Double Beam Oscillograph	Prices on Application.
Model 427	Camera	

ACCESSORIES.

Model 426	Radio Service Kit	Prices on Application.
Model 413	Radio Service Rack	
A55	Oscillograph Rack Panel and Shelf	
A56	Oscillator and Bridge Rack Panel	
A39	Oscillograph Viewing Hood	
CB55G	Operating Instruction Booklet for Model 339 Oscillograph ...	5 0
CB56C	Operating Instruction Booklet for Model 343 Ganging Oscillator	4 6

Prices are subject to alteration without notice and orders can only be accepted at prices ruling at date of invoice. The prices shown do not include Taxes which may be applicable.

The items can be supplied only on condition that they are available in stock.

The Company reserves the right to vary the specification.