COMMONWEALTH OF AUSTRALIA

# AUSTRALIAN BROADCASTING CONTROL BOARD
## TECHNICAL SERVICES DIVISION



REPORT No. 12

TITLE: OVERLOADING, SELECTIVITY, AND SPURIOUS RESPONSES IN MEDIUM FREQUENCY BROADCAST RECEIVERS.

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Date: 2nd May, 1957.

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OVERLOADING, SELECTIVITY, AND SPURIOUS RESPONSES IN MEDIUM FREQUENCY BROADCAST RECEIVERS.

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# OVERLOADING, SELECTIVITY, AND SPURIOUS RESPONSES IN MEDIUM FREQUENCY BROADCAST RECEIVERS.

## 1. Introduction.

This investigation was undertaken in order to provide some information on the adequacy of blanketing standards of field strength used by the Board.

The Board's present Standards of Good Engineering Practice specify a population in the 250 mV/m. contour not exceeding $< 1\%$ of that within 50 miles of the transmitter excluding the population of any town or city not intended to be served by the station and in the primary service area of another station.

The F.C.C. have recently altered their standards for medium wave broadcasting to the effect that the blanket area will be based on a field intensity of one volt per metre in lieu of the old criterion of 0.25 volts per metre. It should be noted, however, that the laboratory tests represent only a part of the general problem since many of the worst types of interference in practice are the result of external cross modulation in spurious rectifiers in the house wiring and construction, and means for simulating theseeffects in laboratory tests are not very complete at the present time.

## 2. Methods of Measurement.

Three distinct types of measurement were made on each of the commercial tested receivers as follows:-

### (a) Overload with large inputs.

As the input voltage of the wanted signal is raised, a point is reached at which the output is intolerably distorted. Of the four receivers tested, two became inoperative with wanted input signals greater than 0.2 volts, while the remaining two would take wanted input signals in excess of one volt.

### (b) Two signal generator cross modulation tests.

These are true selectivity tests. Selectivity tests are not normally made in this way because of the extra equipment required. The signal generators are connected in parallel at the dummy antenna output terminals, the impedances of each dummy antenna having double impedances, and consequently doubled output voltages are required from each signal generator. Only one of the signal generators available was capable of one volt input to the receiver, so that the tests were slightly restricted. These restrictions can be removed by approximate exterpolation from the measurements made. The criterion of tolerable interference was that suggested by the Institution of Radio Engineers (U.S.A.) of -30 db. cross modulation factor. This results when an unwanted signal modulated 30% at 400 c/s. is of sufficient amplitude to cause a spurious 400 c/s. modulation of 1% depth to an unmodulated wanted carrier. These were made on each receiver for three values of input voltage of the wanted signal at each of three frequencies (600, 1,000 and 1,400 kc/s.). The frequency of the unwanted signal was made higher and lower than the wanted signal in 10 kc/s. increments and its amplitude adjusted for the degree of interference quoted above. The results are tabulated in the first part of Appendices 1, 2, 3 and 4 for each of the four receivers tested, and corresponding curves are given in the attached drawing No. GC-3 sheets, 1 to 10. Appendix 5 gives figures for an average receiver based on median figures of the four receivers and corresponding curves are given on sheets 11 and 12 of the above drawing. They show that the true selectivity is, as expected, markedly better at the low carrier frequencies. Also, as expected, it does not vary greatly with the strength of the wanted signal, except for very large signals. The large variation of the figures for 10 kc/s. carrier separations results from the fact that in this case the predominant interference was a 10 kc/s. heterodyne beat rather than a 400 c/s. modulation.

An attempt was made to correlate these figures for the average receiver with the F.C.C.'s proposed figures (1946) for the relative field intensities of wanted and unwanted carriers spaced by 10 and by 20 kc/s. The F.C.C. ratios are respectively 1:2 and 1:30. The measurements show ratios for the 10 kc/s. spacing of about 1.7:1 at 600 kc/s. and 5:1 at 1,400 kc/s. and in both cases, the ratios are greater than that stipulated by the F.C.C. This does not necessarily mean that the F.C.C. figures would result in objectionable interference with Australian receivers, since the ear is less sensitive to energy at 10 kc/s. than it is to 400 c/s. energy and in addition the loudspeaker is less efficient. For 20 kc/s. spacing between carriers at 600 kc/s. the measurements give ratios of 1:60 and 1:40 for 0.5 and 5 millivolts wanted input signals. The corresponding figures for 1400 kc/s. are 1:30 and 1:20, the latter being slightly poorer than the F.C.C. figure of 1:30.

(c) Heterodyne whistle tests.

It was desired to investigate the effect of increasing receiver input voltages on the severity of heterodyne whistles. The same set-up was used as for section 2 above and the same wanted frequencies and input signals were used. Neither signal was modulated and the procedure was to vary the unwanted signal frequency until a whistle was produced and then adjust its amplitude until the heterodyne beat signal (adjusted to approximately 400 c/s.) was 40 db. below 100% modulation of the wanted carrier, or in other words a spurious modulation of 1% was produced. The results for the four test receivers were tabulated in the second half of Appendices 1, 2, 3 and 4 and median figures for the four receivers are tabulated in Appendix 5.

It is seen from Appendix 5 that "I.F. beats" are in general the worst sources of whistles with large wanted carrier input signals. This has long been recognised in Australian broadcasting and frequency allocations are specifically made to avoid this condition. With small wanted signal amplitude, "image" or second channel interference is seen to be the worst cause of interference, a fact which is well known in Australian broadcasting. A station on twice the intermediate frequency is also a serious cause of interference and this is avoided as far as possible. Of the other interferences some are only bad when the receiver is tuned at a particular region of the frequency spectrum. For instance when tuned at the low frequency end of the band the whistle caused by twice the wanted frequency and the unwanted frequency (2W-U) is particularly bad with large amplitudes of the wanted signal. Also

2U-O causes a bad interference when tuned near the middle of the band, and three times the intermediate frequency is bad at the high frequency end of the band.

The tabulation of Appendix 5 can be used by interpolation or exterpolation to predict the frequencies and approximate intensities of the more serious whistle interferences for any other value of the wanted signal frequency and intensity in the medium wave band. It should be noted that the tabulation of whistles for the condition of 0.5 millivolts wanted input signal in Appendices 1 to 4 is not complete, since these were rather numerous with one or two of the receivers. They are complete, however, for the two other input levels. It is believed that those omitted for the low input level are relatively unimportant, involving for the most part high order harmonics of the various signals, and in most cases these were caused by actual harmonics of the signal generators used.

## 3. Comparison with C.C.I.R. Document.

## C.T. - 45 - E. (Stockholm - 1948)

Document CT-45-E contains replies to a questionnaire sent to European countries, in which their opinions are sought on the worst causes of whistles in receivers, and whether it was practicable to fix a standard intermediate frequency. An average evaluation of the replies has been made and the following table sets out the reported causes of whistles in Europe in approximate order of importance -

| Item No. | Description of Interference | Frequency relations causing interference.<br>I is the intermediate frequency.<br>W is the wanted frequency.<br>U is the unwanted frequency.<br>O is the local oscillator frequency |
|---|---|---|
| 1. | Unwanted signal has intermediate frequency. | $U = I$ |
| 2. | Either the wanted or unwanted signal has twice the intermediate frequency. | $W = 2I$ or $U = 2I$ |
| 3. | Second channel or "image" interference. | $U - O = I$ |
| 4. | Either the wanted or unwanted signal is half the intermediate frequency. | $W = \frac{1}{2}I$ or $U = \frac{1}{2}I$ |
| 5. | "I.F. Beat" - Two carriers differ by the intermediate frequency. | $U_1 \pm U_2 = I$ or $U \pm W = I$ |
| 6. | Second harmonic of unwanted signal differs from the local oscillator frequency by the intermediate frequency. | $2U = O \pm I$ |
| 7. | Wanted or unwanted signal three times the intermediate frequency | $W = 3I$ or $U = 3I$. |

| Item No. | Description of Interference | Frequency relations causing interference. I is the intermediate frequency. W is the wanted frequency. U is the unwanted frequency. O is the local oscillator frequency |
|---|---|---|
| 8. | Local oscillator radiation. | |
| 9. | Intermediate frequency radiation into receivers having the same intermediate frequency. | |
| 10. | Second harmonic of oscillator differs from unwanted signal by the intermediate frequency. | $2O = U \pm I$ |

A comparison of the above table with the table in Appendix 5 is made with the following comments of the various items -

<u>Item 1</u> - This is a potentially serious form of interference, but is avoided by appropriate frequency allocations.

<u>Item 2</u> - Wanted frequencies having twice the intermediate frequency are known to be unworkable with large input signals but measurements were not made. In this case twice the wanted signal frequency beats with the oscillator frequency to give the intermediate frequency. A similar interference results from second I.F. harmonic feedback in a poorly designed receiver. Tests were made of unwanted signals at twice the intermediate frequency, and the interference was worst for wanted frequencies close to the double intermediate frequency.

<u>Item 3</u> - It was found from the measurements that image interference could be very serious particularly with small wanted signals.

<u>Item 4</u> - Tests were not made but this could undoubtedly be a serious cause of trouble from outside services.

<u>Item 5</u> - Tests were made only for the case where one of the carriers was the wanted carrier, and was found to be a serious cause of interference with large amplitudes of wanted signal. The case of two unwanted carriers causing an I.F. beat has in the past been a serious source of trouble in Australian broadcasting.

<u>Item 6</u> - The tests indicated that this is a serious source of trouble for large unwanted signals and small wanted signals particularly at frequencies close to the double intermediate frequency.

<u>Item 7</u> - Tests were made only for the case where the unwanted carrier is three times the intermediate frequency, and the interference is only serious with large wanted signal intensities and for frequencies close to three times the intermediate frequency. The case of the wanted carrier at three times the intermediate frequency is known to be unworkable with large input signals. In this case the trouble is caused by the third harmonic of the wanted signal beating with the second harmonic of the local

oscillator to form the intermediate frequency. A similar interference results from 3rd I.F. harmonic feed-back in a poorly designed receiver.

Item 8 - Local oscillator radiation should not be serious if adequate precautions have been taken about item 5, except possibly to services having frequencies outside the medium wave band.

Item 9 - Receivers of reasonable design should not be subject to this type of interference.

Item 10 - This is relativelyinnocuous in Australia where the long wave band is not used for broadcasting.

4. Conclusions.

Tests have been made chiefly to gauge the effect of large input signals on representative medium wave receivers with the following results -

(a) Some receivers become inoperative with input signals in excess of 0.2 volts while others will accept signals greater than one volt.

(b) Cross modulation or true selectivity tests indicate that the cross modulation factor will increase sharply as the unwanted signal amplitude is increased and with one volt of unwanted input signal a frequency spacing of 300 to 400 kc/s. will be necessary between wanted and unwanted carriers at the high frequency end of the band. Reducing the input to 0.25 volts reduces the required spacing to something slightly less than 100 kc/s. Appendix 5(a) and drawing GC-3 sheets 11 and 12 give the characteristics of a typical Australian receiver, averaged from tests on four receivers.

(c) Tests have been conducted to indicate the severity of heterodyne whistles with increasing amplitude of input signals. Appendix 5(b) gives the characteristics of a typical Australian receiver (averaged from tests on four receivers). This can be used for predicting the performance under other conditions of input and frequency. The results have been compared with a precis of C.C.I.R. Document CT-45-E, which is given on page 3. It is concluded that if care is exercised with frequency allocations, particularly in relation to items 1 to 7, whistle production should not seriously increase by increasing the wanted input signal to one volt, but great care will be necessary to receive small input signals in the presence of large signals.

Summing up, it is indicated that most troubles would disappear with a small enough aerial to curb the large signals, always providing this aerial is large enough for the weaker wanted signals. In especially difficult cases a trap circuit in the aerial could be used to reduce the unwanted signal. External cross modulation effects have not been considered and could reverse or modify these conclusions.

5. Application to Australian Station Allocations

The conclusion is reached that the input to a receiver should not exceed 250 millivolts if signals separated by 100 kc/s. are to be received. The separations of stations in Australian capital cities are of this order, being as follows:-

| | |
|---|---|
| Sydney | 60 - 130 kc/s. |
| Melbourne | 80 - 160 kc/s. |
| Brisbane | 100 - 330 kc/s. |
| Adelaide | 80 - 230 kc/s. |
| Perth | 70 - 250 kc/s. |
| Hobart | 80 - 260 kc/s. |
| Newcastle | 90 - 320 kc/s. |

An aerial of effective height one metre (actual height about 2 metres) would be tolerable in this case if the present standard of 250 mV/m. for blanketing is adhered to. The sensitivity of a typical 5 valve broadcast receiver is of the order of 35 microvolts. Such a set and such an aerial would enable the reception of signals of strength 35 microvolts per metre. This would enable the reception in the absence of noise of a 10 kW. station at night at 1,000 miles for 90% of the time (using curves from F.C.C. Standards of Good Engineering Practice) or a daylight 10 kW. station on 1,000 kc/s. over ground of conductivity $10^{-13}$ e.m.u. at a distance of 230 miles.

It is concluded that the use of a blanketing standard of 250 mV/m. would not impose serious limitations on a typical modern receiver. A higher value is regarded as undesirable at the present time.

## APPENDIX I - TESTS ON RECEIVER "A" 5-VALVE MODEL.

### 1. Cross Modulation Tests.

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. Unwanted signal characteristics. | Column 4. | Column 5. Unwanted signal characteristics. | Column 6. |
|---|---|---|---|---|---|
| | | Frequency kc/s. above "W" | Input for -30 db. cross modulation factor (millivolts) | Frequency kc/s. below "W" | Input for -30 db. cross modulation factor (millivolts) |
| 600 kc/s. | 0.5 | 10 | 0.04 | 10 | 0.42 |
| | | 20 | 5 | 20 | 280 |
| | | 30 | 70 | 30 | 125 |
| | | 40 | 370 | 60 | 800 |
| | | 60 | 670 | 100 | 1,000 |
| | | 100 | 1,000 | | |
| 600 kc/s. | 5 | 10 | 0.48 | 10 | 2.8 |
| | | 20 | 60 | 20 | 200 |
| | | 30 | 300 | 40 | 440 |
| | | 40 | 400 | 80 | 800 |
| | | 80 | 700 | | |
| | | 100 | 900 | | |
| | | 110 | 1,000 | | |
| 600 kc/s. | 135 | 10 | 32 | 10 | 200 |
| | | 20 | 480 | 20 | 725 |
| | | 30 | 800 | 25 | 1,000 |
| | | 35 | 1,000 | | |
| 1000 kc/s. | 0.5 | 10 | 0.38 | 10 | 0.8 |
| | | 20 | 2 | 20 | 27 |
| | | 30 | 30 | 30 | 105 |
| | | 40 | 300 | 50 | 225 |
| | | 60 | 250 (peak) | 60 | 325 |
| | | 100 | 450 | 100 | 475 |
| | | 140 | 575 | 140 | 725 |
| | | 200 | 850 | 200 | 1,000 |
| 1000 kc/s. | 5 | 10 | 0.6 | 10 | 8 |
| | | 20 | 22 | 20 | 250 |
| | | 40 | 190 | 30 | 285 |
| | | 60 | 325 | 40 | 375 |
| | | 80 | 450 | 100 | 750 |
| | | 100 | 600 | 140 | 1,000 |
| | | 140 | 800 | | |
| | | 170 | 1,000 | | |
| 1000 kc/s. | 200 | 10 | 75 | 10 | 475 |
| | | 20 | 250 | 20 | 750 |
| | | 40 | 750 | 30 | 1,000 |
| | | 50 | 1,000 | | |
| 1400 kc/s. | 0.5 | 10 | 0.085 | 10 | 1.0 |
| | | 20 | 1.5 | 20 | 20 |
| | | 40 | 115 | 30 | 80 |
| | | 100 | 200 | 40 | 275 |
| | | 200 | 400 | 60 | 215 |

(cont'd.)

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. Unwanted signal characteristics. Frequency kc/s. above "W" | Column 4. Unwanted signal characteristics. Input for -30 db. cross modulation factor (millivolts) | Column 5. Unwanted signal characteristics. Frequency kc/s. below "W" | Column 6. Unwanted signal characteristics. Input for -30 db. cross modulation factor (millivolts) |
|---|---|---|---|---|---|
| | | 300 | 700 | 100 | 300 |
| | | 400 | 950 | 140 | 400 |
| | | 500 | 1,000 | 200 | 550 |
| | | | | 300 | 850 |
| | | | | 360 | 1,000 |
| 1400 kc/s. | 5 | 10 | 0.85 | 10 | 6 |
| | | 20 | 17.5 | 20 | 235 |
| | | 30 | 60 | 40 | 250 |
| | | 40 | 85 | 100 | 475 |
| | | 60 | 160 | 140 | 725 |
| | | 100 | 285 | 200 | 1,000 |
| | | 200 | 625 | | |
| | | 240 | 1,000 | | |
| 1400 kc/s. | 350 | 10 | 110 | 10 | 460 |
| | | 20 | 120 | 20 | 540 |
| | | 40 | 250 | 40 | 825 |
| | | 60 | 450 | 60 | 1,000 |
| | | 100 | 1,000 | | |

## 2. Heterodyne Whistle Tests.

| Wanted fre-quency "W" kc/s. | Inter-fering signal fre-quency "U" kc/s. | Interfering signal input (millivolts) to cause 1% spurious modulation of the wanted carrier. Wanted carrier input 0.5 mv. | Wanted carrier input 5.0 mv. | Wanted carrier input (mv.) as stated on left side of column | | Frequency relations causing the whistle. "O" and "I" are respectively local oscillator and intermediate fre-quencies. | Remarks |
|---|---|---|---|---|---|---|---|
| 600 | 505 | 100 | 375 | 135 | - | 3U-O = I | |
| " | 529 | - | 600 | " | 875 | 2U-W = I | |
| " | 552 | 140 | 600 | " | - | 2O-3U = I | |
| " | 644 | 400 | 675 | " | - | 2U-O = I/2 | |
| " | 742 | - | - | " | 500 | 2W-U = I | |
| " | 759 | 60 | 260 | " | - | 2U-O = I | |
| " | 830 | 50 | 825 | " | - | O-U = ½I | ½ I.F. beat |
| " | 917 | 425 | 600 | " | - | U-O+W = I | Twice the I.F. |
| " | 1060 | 220 | 175 | " | 145 | U-W = I | I.F. beat. |
| " | 1200 | 375 | 500 | " | 1,000 | O-U+W = I | Twice wanted frequency. |
| " | 1517 | 0.85 | 11.0 | " | 700 | U-O = I | Image. |
| 1000 | 541 | 140 | 125 | 200 | 120 | W-U = I | I.F. beat. |
| " | x640 | 50 | 270 | " | - | 3U-O = I | |
| " | 820 | 375 | 800 | " | - | 2O-3U = I | |
| " | 917.5 | 60 | 125 | " | 230 | U-O+W = I | Twice the I.F. |
| " | 959 | 12 | 42.5 | " | 600 | 2U-O = I | |
| " | 1125 | 300 | 750 | " | - | 3U-2O = I | |
| " | 1229 | 170 | 390 | " | - | O-U = ½I | |
| " | 1457 | 125 | 120 | " | 115 | U-W = I | I.F. beat. |
| " | 1686 | 675 | 1000 | " | - | U-O = ½I | |
| " | 1914 | 0.4 | 4.5 | " | 300 | U-O = I | Image. |
| 1400 | 917 | 180 | 335 | 350 | 600 | U-O+W = I | Twice the I.F. |
| " | 944 | 105 | 125 | " | 100 | W-U = I | I.F. Beat. |
| " | x1158 | 16.5 | 100 | " | - | 2U-O = I | |
| " | 1375 | - | - | " | 325 | U-2O + 2W = I | 3 times the IF. |
| " | 1507 | 400 | 650 | " | - | 4U-3O = I | |
| " | 1628 | 70 | 200 | " | - | O - U = ½I | |
| " | 1705 | 500 | 1000 | " | - | O-U = 1/3I | |
| " | 1857.5 | 55 | 100 | " | 90 | U-W = I | I.F. beat. |
| " | 2088 | 250 | 600 | " | - | U - O = ½I | |
| " | 2318 | 0.175 | 1.7 | " | 130 | U - O = I | Image |

## 3. Overload Point

Wanted signal input > 0.1 volt.

## APPENDIX 2 – TESTS ON RECEIVER "B" 6-VALVE MODEL.

### 1. Cross Modulation Tests.

| Column 1. | Column 2. | Column 3. Unwanted signal characteristics. | Column 4. | Column 5. Unwanted signal characteristics. | Column 6. |
|---|---|---|---|---|---|
| Wanted frequency "W" | Wanted signal input (millivolts) | Frequency kc/s. above "W" | Input for -30 db. cross modulation factor (millivolts) | Frequency kc/s. below "W" | Input for -30 db. cross modulation factor (millivolts) |
| 600 kc/s. | 0.5 | 10 | 0.15 | 10 | 0.13 |
| | | 20 | 30 | 20 | 16.5 |
| | | 40 | 275 | 30 | 120 |
| | | 60 | 450 | 40 | 290 |
| | | 80 | 600 | 60 | 350 |
| | | 100 | 700 | 80 | 500 |
| | | 140 | 1,000 | 100 | 800 |
| 600 kc/s. | 5 | 10 | 2.0 | 10 | 1.25 |
| | | 20 | 135 | 20 | 200 |
| | | 30 | 250 | 40 | 260 |
| | | 40 | 325 | 60 | 435 |
| | | 60 | 460 | 80 | 575 |
| | | 100 | 725 | 100 | 700 |
| | | 130 | 1,000 | | |
| 600 kc/s. | 150 | 10 | 100 | 10 | 75 |
| | | 20 | 375 | 20 | 390 |
| | | 40 | 900 | 40 | 775 |
| | | 50 | 1,000 | 60 | 1,000 |
| 1000 kc/s. | 0.5 | 10 | 0.1 | 10 | 0.06 |
| | | 20 | 13.5 | 20 | 8.0 |
| | | 40 | 140 | 30 | 100 |
| | | 60 | 220 | 40 | 200 |
| | | 100 | 350 | 100 | 325 |
| | | 140 | 500 | 140 | 475 |
| | | 200 | 700 | 200 | 700 |
| | | 300 | 1,000 | 300 | 1,000 |
| 1000 kc/s. | 5 | 10 | 1.0 | 10 | 0.9 |
| | | 20 | 90 | 20 | 150 |
| | | 40 | 185 | 60 | 300 |
| | | 100 | 500 | 100 | 525 |
| | | 140 | 700 | 140 | 650 |
| | | 200 | 900 | 200 | 1,000 |
| 1000 kc/s. | 200 | 10 | 50 | 10 | 60 |
| | | 20 | 190 | 20 | 200 |
| | | 40 | 400 | 30 | 300 |
| | | 100 | 1,000 | 40 | 375 |
| | | | | 60 | 550 |
| | | | | 100 | 1,000 |
| 1400 kc/s. | 0.5 | 10 | 0.1 | 10 | 0.065 |
| | | 20 | 10 | 20 | 7.0 |
| | | 40 | 55 | 40 | 75 |
| | | 60 | 85 | 100 | 150 |

(cont'd.)

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. Unwanted signal characteristics. | Column 4. | Column 5. Unwanted signal characteristics. | Column 6. |
|---|---|---|---|---|---|
| | | Frequency kc/s. above "W" | Input for -30 db. cross modulation factor (millivolts) | Frequency kc/s. below "W" | Input for -30 db. cross modulation factor (millivolts) |
| | | 100 | 125 | 160 | 250 |
| | | 200 | 250 | 300 | 400 |
| | | 400 | 400 | 520 | 1,000 |
| | | 600 | 475 | | |
| | | 800 | 700 | | |
| | | 1,000 | 600 | | |
| | | 1,200 | 800 | | |
| 1400 kc/s. | 5 | 10 | 0.65 | 10 | 0.85 |
| | | 20 | 25 | 20 | 150 |
| | | 40 | 60 | 40 | 160 |
| | | 60 | 100 | 60 | 220 |
| | | 100 | 200 | 100 | 340 |
| | | 160 | 320 | 160 | 525 |
| | | 200 | 440 | 200 | 650 |
| | | | | 300 | 1,000 |
| 1400 kc/s. | 350 | 10 | 30 | 10 | 65 |
| | | 20 | 70 | 20 | 200 |
| | | 40 | 140 | 40 | 300 |
| | | 60 | 250 | 60 | 380 |
| | | 100 | 450 | 100 | 575 |
| | | 200 | 800 | 160 | 1,000 |

## 2. Heterodyne Whistle Tests.

| Wanted frequency "W" kc/s. | Interfering signal frequency "U" kc/s. | Interfering signal input (millivolts) to cause 1% spurious modulation of the wanted carrier. | | | | Frequency relations causing the whistle. "O" and "I" are respectively local oscillator and intermediate frequencies. | Remarks |
|---|---|---|---|---|---|---|---|
| | | Wanted carrier input 0.5 mv. | Wanted carrier input 5.0 mv. | Wanted carrier input (mv.) as stated on left side of column | | | |
| 600 | 503 | 100 | 350 | 150 | - | 3U-O = I | |
| " | 527 | 325 | 425 | " | 850 | 2U-W = I | |
| " | 550 | 150 | 485 | " | - | 2O-3U = I | |
| " | 642 | 350 | - | " | - | 2U-O = I/2 | |
| " | 745 | - | - | " | 275 | 2W-U = I | |
| " | 757 | 60 | 275 | " | - | 2U-O = I | |
| " | 829 | 190 | 750 | " | - | O-U = I/2 | |
| " | 911 | 150 | 200 | " | 450 | U-O + W = I | Twice the I.F. |
| " | 1057 | 125 | 200 | " | 200 | U-W = I | I.F. Beat. |
| " | 1200 | 325 | 525 | " | - | O-U + W = I | Twice wanted frequency. |
| " | 1510 | 1.0 | 10 | " | 450 | U-O = I | Image. |
| 1000 | 544 | 60 | 100 | 200 | 130 | W-U = I | I.F. Beat. |
| " | x637 | 65 | 300 | " | - | 3U-O = I | |
| " | 820 | 185 | - | " | - | 2O-3U = I | Twice the I.F. |
| " | 910 | 20 | 35 | " | 58 | U-O + W = I | |
| " | 956 | 6.5 | 35 | " | 375 | 2U-O = I | |
| " | x1203 | 100 | 700 | " | - | 4U-3O = I | |
| " | x1226 | 50 | 1000 | " | - | O-U = I/2 | |
| " | 1454 | 35 | 80 | " | 140 | U-W = I | I.F. Beat. |
| " | 1543 | - | - | " | 450 | | |
| " | 1605 | 30 | 550 | " | - | U-O = 1/3I | |
| " | 1907 | 0.4 | 4. | " | 275 | U-O = I | Image. |
| 1400 | 910 | 65 | 140 | 350 | 240 | U-O + W = I | Twice the I.F. |
| " | 947 | - | 100 | " | 130 | W-U = I | I.F. Beat |
| " | 1155 | 20 | 70 | " | - | 2U-O = I | |
| " | 1362 | - | - | " | 1000 | U-2O + 2W = I | 3 times the I.F. |
| " | 1382 | - | - | " | 900 | | |
| " | 1505 | - | 400 | " | - | 4U - 3O = I | |
| " | 1626 | 20 | 450 | " | - | O-U = ½I | |
| " | 1701 | 50 | 165 | " | - | O-U = 1/3I | |
| " | 1854 | 16 | 50 | " | 95 | U-W = I | I.F. Beat. |
| " | 2008 | 275 | 725 | " | - | | |
| " | 2083 | 60 | 600 | " | - | U-O = ½I | |
| " | 2310 | 0.2 | 1.7 | " | 125 | U-O = I | Image. |

## 3. Overload Point.

Wanted signal input > 1 volt.

APPENDIX 3 - TESTS ON RECEIVER "C" 5-VALVE MODEL.

1. Cross Modulation Tests.

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. Unwanted signal characteristics. Frequency kc/s. above "W" | Column 4. Input for -30 db. cross modulation factor (millivolts) | Column 5. Unwanted signal characteristics. Frequency kc/s. below "W" | Column 6. Input for -30 db. cross modulation factor (millivolts) |
|---|---|---|---|---|---|
| 600 kc/s. | 0.5 | 10 | 2 | 10 | 0.5 |
| | | 20 | 140 | 20 | 30 |
| | | 40 | 500 | 40 | 425 |
| | | 60 | 1,000 | | |
| 600 kc/s. | 5 | 10 | 20 | 10 | 1.5 |
| | | 20 | 325 | 20 | 150 |
| | | 35 | 540 | 40 | 325 |
| | | 60 | 1,000 | 90 | 550 |
| 600 kc/s. | 150 | 10 | 100 | 10 | 90 |
| | | 20 | 220 | 20 | 160 |
| | | 40 | 425 | 30 | 200 |
| | | 60 | 625 | 100 | 1,000 |
| | | 90 | 1,000 | | |
| 1400 kc/s. | 0.5 | 10 | 1 | 10 | 0.1 |
| | | 20 | 40 | 20 | 20 |
| | | 40 | 300 | 40 | 420 |
| | | 60 | 450 | 110 | 800 |
| | | 100 | 700 | | |
| 1400 kc/s. | 5 | 10 | 10 | 10 | 0.9 |
| | | 20 | 100 | 20 | 100 |
| | | 40 | 184 | 25 | 200 |
| | | 60 | 250 | 35 | 240 |
| | | 100 | 400 | 160 | 700 |
| | | 160 | 600 | | |
| 1400 kc/s. | 200 | 10 | 40 | 10 | 35 |
| | | 20 | 75 | 20 | 100 |
| | | 40 | 150 | 40 | 180 |
| | | 80 | 300 | 60 | 250 |
| | | 160 | 570 | 120 | 480 |

## 2. Heterodyne Whistle Tests.

| Wanted frequency "W" kc/s. | Interfering signal frequency "U" kc/s. | Interfering signal input (millivolts) to cause 1% spurious modulation of the wanted carrier. | | | | Frequency relations causing the whistle. "O" and "I" are respectively local oscillator and intermediate frequencies. | Remarks |
|---|---|---|---|---|---|---|---|
| | | Wanted carrier input 0.5 mv. | Wanted carrier input 5.0 mv. | Wanted carrier input (mv.) as stated on left side of column | | | |
| 600 | 500 | | 700 | 200 | - | 3U-O = I | |
| " | 525 | | 250 | " | 170 | 2U-W = I | |
| " | 540 | | 580 | " | 700 | 3O-5U = I | |
| " | 549 | | 200 | " | - | 2O-3U = I | |
| " | 638 | | 1000 | " | - | 2U-O = I/2 | |
| " | 748 | | - | " | 300 | 2W-U = I | |
| " | 752 | | 300 | " | - | 2U-O = I | |
| " | 825 | | 1000 | " | - | O-U = ½I | |
| " | 904 | | 480 | " | 400 | U-O+W = I | Twice the I.F. |
| " | 1052 | | 300 | " | 300 | U-W = I | I.F. Beat |
| " | 1200 | | | " | 100 | O-U+W = I | Twice wanted frequency. |
| " | 1503 | | 18 | " | 550 | U-O = I | Image. |
| 1400 | 902 | 200 | 250 | 200 | 180 | U-O+W = I | Twice the I.F. |
| " | 950 | 200 | 150 | " | 135 | W-U = I | I.F. Beat |
| " | x1086 | 60 | 200 | " | - | 2O-3U = I | |
| " | 1151 | 60 | 200 | " | - | 2U-O = I | |
| " | 1356 | - | - | " | 75 | U+2W-2O = I | 3 times I.F. |
| " | 1385 | 10 | 40 | " | 250 | 3U-2O = I | |
| " | 1452 | 480 | - | " | 250 | - | |
| " | 1625 | 380 | 60 | " | 850 | O-U = ½I | |
| " | 1850 | 65 | 60 | " | 70 | U-W = I | I.F. Beat |
| " | 1900 | - | - | " | 55 | 3W-U-O = I | |
| " | 2080 | 100 | 360 | " | - | U-O = ½I | |
| " | 2304 | 0.375 | 5 | " | 130 | U-O = I | Image |

## 3. Overload Point.

Wanted signal input of 0.2 volts.

## APPENDIX 4 - TESTS ON RECEIVER "D" 5-VALVE MODEL.

### 1. Cross Modulation Tests.

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. | Column 4. | Column 5. | Column 6. |
|---|---|---|---|---|---|
| | | Unwanted signal characteristics. | | Unwanted signal characteristics. | |
| | | Frequency kc/s. above "W" | Input for -30 db. cross modulation factor (millivolts) | Frequency kc/s. below "W" | Input for -30 db. cross modulation factor (millivolts) |
| 600 kc/s. | 0.5 | 10 | 0.3 | 10 | 0.33 |
| | | 20 | 28.5 | 20 | 18 |
| | | 40 | 475 | 40 | 325 |
| | | 60 | 550 | 100 | 1,000 |
| | | 70 | 1,000 | | |
| 600 kc/s. | 5 | 10 | 4.3 | 10 | 1.5 |
| | | 20 | 190 | 20 | 50 |
| | | 40 | 350 | 30 | 115 |
| | | 60 | 475 | 40 | 180 |
| | | 80 | 625 | 60 | 300 |
| | | 100 | 750 | 80 | 400 |
| | | 150 | 1,000 | 100 | 558 |
| 600 kc/s. | 130 | 10 | 2.0 | 10 | 7.0 |
| | | 20 | 85 | 20 | 250 |
| | | 40 | 600 | 40 | 600 |
| | | 60 | 800 | 75 | 1,000 |
| 1400 kc/s. | 0.5 | 10 | 0.25 | 10 | 0.75 |
| | | 20 | 13 | 20 | 10 |
| | | 40 | 225 | 40 | 90 |
| | | 60 | 250 | 60 | 33.5 |
| | | 100 | 325 | 80 | 16 |
| | | 200 | 500 | 100 | 35 |
| | | 400 | 700 | 130 | 100 |
| | | 500 | 850 | 160 | 170 |
| | | | | 200 | 250 |
| | | | | 300 | 500 |
| | | | | 400 | 800 |
| | | | | 490 | 1,000 |
| 1400 kc/s. | 5 | 10 | 1.0 | 10 | 5.0 |
| | | 20 | 95 | 20 | 100 |
| | | 40 | 250 | 40 | 110 |
| | | 100 | 450 | 60 | 70 |
| | | 200 | 550 | 80 | 25 |
| | | | | 100 | 30 |
| | | | | 120 | 65 |
| | | | | 200 | 240 |
| | | | | 300 | 500 |
| | | | | 400 | 800 |
| | | | | 500 | 1,000 |
| 1400 kc/s. | 375 | 10 | 150 | 10 | 350 |
| | | 20 | 825 | 20 | 450 |
| | | 40 | 1,000 | 40 | 375 |

(cont'd.)

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. Unwanted signal characteristics. Frequency kc/s. above "W" | Column 4. Unwanted signal characteristics. Input for -30 db. cross modulation factor (millivolts) | Column 5. Unwanted signal characteristics. Frequency kc/s. below "W" | Column 6. Unwanted signal characteristics. Input for -30 db. cross modulation factor (millivolts) |
|---|---|---|---|---|---|
| | | | | 60 | 250 |
| | | | | 78 | 110 |
| | | | | 88 | 90 |
| | | | | 100 | 125 |
| | | | | 120 | 270 |
| | | | | 140 | 440 |
| | | | | 200 | 1,000 |

## 2. Heterodyne Whistle Tests.

| Wanted frequency "W" kc/s. | Interfering signal frequency "U" kc/s. | Interfering signal input (millivolts) to cause 1% spurious modulation of the wanted carrier. | | | | Frequency relations causing the whistle. "O" and "I" are respectively local oscillator and intermediate frequencies. | Remarks |
|---|---|---|---|---|---|---|---|
| | | Wanted carrier input 0.5 mv. | Wanted carrier input 5.0 mv. | Wanted carrier input (mv.) as stated on left side of column | | | |
| 600 kc/s. | 505 | | 200 | 130 | - | 3U-O = I | |
| | 529 | | 300 | " | - | 2U-W = I | |
| | 552 | | 180 | " | - | 2O-3U = I | |
| | 731 | | - | " | 70 | 2W-U = I | |
| | 759 | | 150 | " | - | 2U-O = I | |
| | x(917 | | 200 | " | - | U-O+W = I | Twice the I.F. |
| | (937 | | - | " | 190 | U-O+W = I | Twice the I.F. |
| | (1060 | | 200 | " | - | U-W = I | I.F. Beat. |
| | (1069 | | - | " | 200 | U-W = I | I.F. Beat |
| | 1200 | | 450 | " | 125 | O-U+W = I | Twice wanted frequency. |
| | (1515 | | 4 | " | - | U-O = I | Image. |
| | (1534 | | | | 200 | U-O = I | Image. |

x - Note that the intermediate frequency changes 10 kc/s. with an input change from 5 to 130 millivolts.

## 3. Overload Point.

(a) 600 kc/s. 0.25 volts wanted signal input.

(b) 1400 kc/s. (misaligned) wanted signal input >1 volt.

## APPENDIX 5 - AVERAGE OF RECEIVERS TESTED.

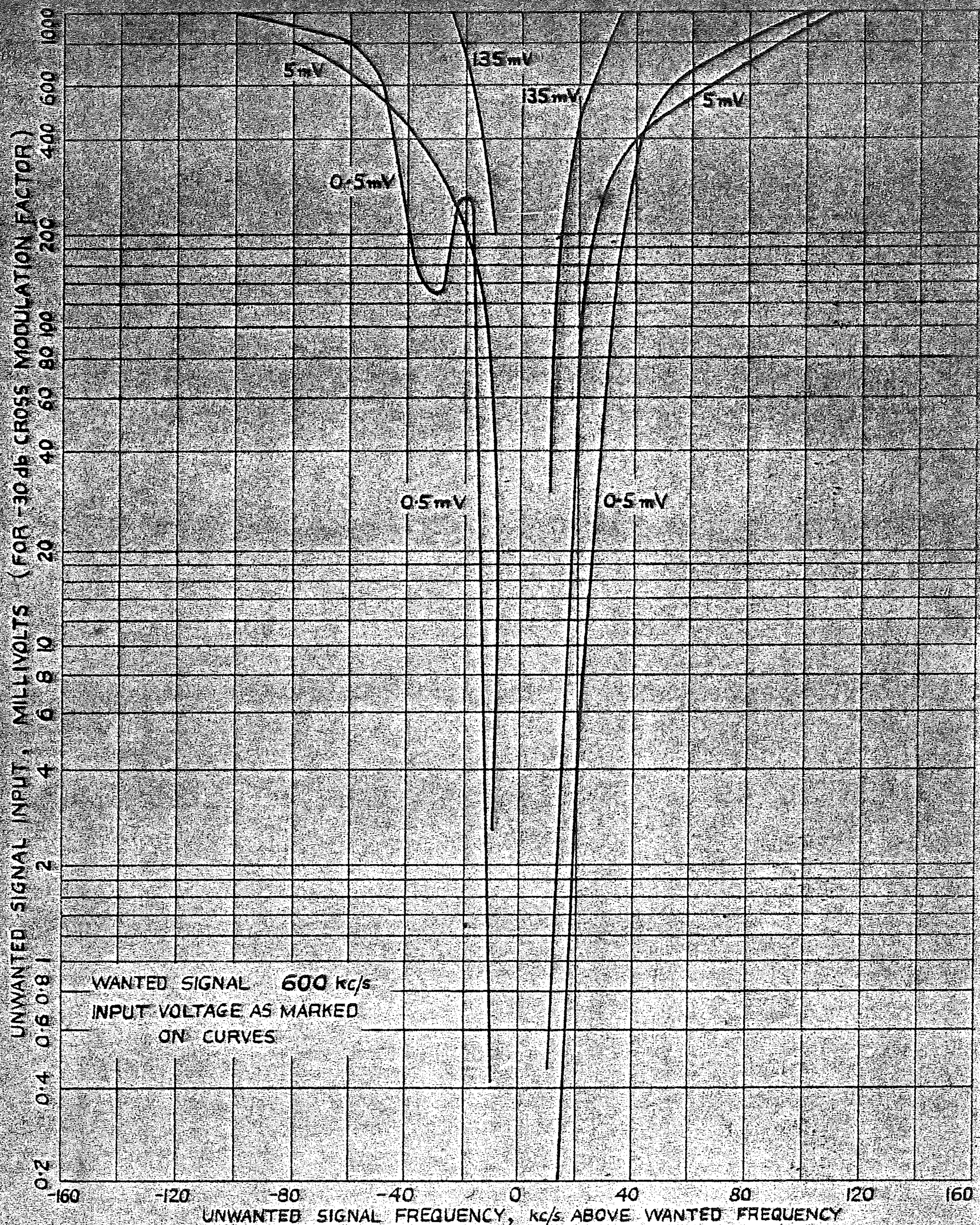
### 1. Cross Modulation Tests.

| Column 1. Wanted frequency "W" | Column 2. Wanted signal input (millivolts) | Column 3. Unwanted signal characteristics. Frequency kc/s. above "W" | Column 4. Unwanted signal characteristics. Input for -30 db. cross modulation factor (millivolts) | Column 5. Unwanted signal characteristics. Frequency kc/s. below "W" | Column 6. Unwanted signal characteristics. Input for -30 db. cross modulation factor (millivolts) |
|---|---|---|---|---|---|
| 600 kc/s. | 0.5 | 10 | 0.3 | 10 | 0.3 |
| | | 20 | 30 | 20 | 30 |
| | | 40 | 400 | 40 | 400 |
| | | 60 | 670 | 60 | 670 |
| | | 100 | 1,000 | 100 | 1,000 |
| 600 kc/s. | 5 | 10 | 1.8 | 10 | 1.8 |
| | | 20 | 195 | 20 | 195 |
| | | 40 | 340 | 40 | 340 |
| | | 60 | 465 | 60 | 465 |
| | | 100 | 740 | 100 | 740 |
| | | 130 | 1,000 | | |
| 600 kc/s. | 140 | 10 | 90 | 10 | 90 |
| | | 20 | 385 | 20 | 385 |
| | | 40 | 690 | 40 | 690 |
| | | 60 | 900 | 60 | 900 |
| 1400 kc/s. | 0.5 | 10 | 0.1 | 10 | 0.1 |
| | | 20 | 15 | 20 | 15 |
| | | 40 | 200 | 40 | 200 |
| | | 100 | 250 | 100 | 250 |
| | | 200 | 400 | 200 | 550 |
| | | 400 | 950 | 400 | >1,000 |
| 1400 kc/s. | 5 | 10 | 0.9 | 10 | 0.9 |
| | | 20 | 100 | 20 | 100 |
| | | 40 | 170 | 40 | 170 |
| | | 100 | 200 | 100 | 350 |
| | | 200 | 625 | 200 | 1,000 |
| 1400 kc/s. | 300 | 10 | 50 | 10 | 50 |
| | | 20 | 110 | 20 | 110 |
| | | 40 | 220 | 40 | 220 |
| | | 100 | 450 | 100 | 500 |
| | | 200 | 800 | 200 | >1,000 |

## 2. Heterodyne Whistle Tests.

Only the main whistles which are common to the four receivers tested are included.

| Wanted fre-quency "W" kc/s. | Inter-fering signal fre-quency "U" kc/s. | Interfering signal input (millivolts) to cause 1% spurious modulation of the wanted carrier. | | | | Frequency re-lations causing the whistle. "O" and "I" are res-pectively local oscillator and intermediate frequencies. | Remarks |
|---|---|---|---|---|---|---|---|
| | | Wanted carrier input 0.5 mv. | Wanted carrier input 5.0 mv. | Wanted carrier input 250 mv. | Wanted carrier input 1000 mv. | | |
| 600 | 503 | 100 | 350 | - | - | 3U-O = I | |
| " | 527.5 | 325 | 350 | 700 | 1000 | 2U-W = I | |
| " | 552 | 150 | 350 | - | - | 2O-3U = I | |
| " | 641 | 400 | 675 | - | - | 2U-O = I/2 | |
| " | 745 | - | - | 200 | 50 | 2W-U = I | |
| " | 755 | 60 | 270 | - | - | 2U-O = I | |
| " | 827.5 | 200 | 825 | - | - | O-U = I/2 | |
| " | 910 | 300 | 400 | 400 | 400 | U-O+W = I | Twice the I.F. |
| " | 1055 | 200 | 200 | 200 | 200 | U-W = I | I.F. Beat |
| " | 1200 | 350 | 500 | 500 | 500 | O-U+W = I | Twice "W" |
| " | 1510 | 1 | 10 | 700 | - | U-O = I | Image |
| 1000 | 545 | 120 | 120 | 120 | 120 | W-U = I | I.F. Beat |
| " | 637 | 57 | 285 | - | - | 3U-O = I | |
| " | 818 | 375 | 800 | - | - | 2O-3U = I | |
| " | 910 | 20 | 35 | 58 | 70 | U-O+W = I | 6 valve receiver |
| " | 910 | 60 | 125 | 230 | 300 | U-O+W = I | 5 valve receiver |
| " | 955 | 9 | 40 | 500 | 1000 | 2U-O = I | |
| " | 1455 | 120 | 120 | 120 | 120 | U-W = I | I.F. Beat. |
| " | 1910 | 0.4 | 4.3 | 360 | - | U-O = I | Image. |
| 1400 | 910 | 200 | 200 | 200 | 200 | U-O+W = I | Twice the I.F. |
| " | 945 | 125 | 125 | 125 | 125 | W-U = I | I.F. Beat |
| " | 1155 | 20 | 100 | - | - | 2U-O = I | |
| " | 1365 | - | - | 450 | 110 | U-2O+2W = I | 3 times I.F. |
| " | 1855 | 65 | 65 | 65 | 65 | U-W = I | I.F. Beat |
| " | 2310 | 0.2 | 1.7 | 100 | 400 | U-O = I | Image |

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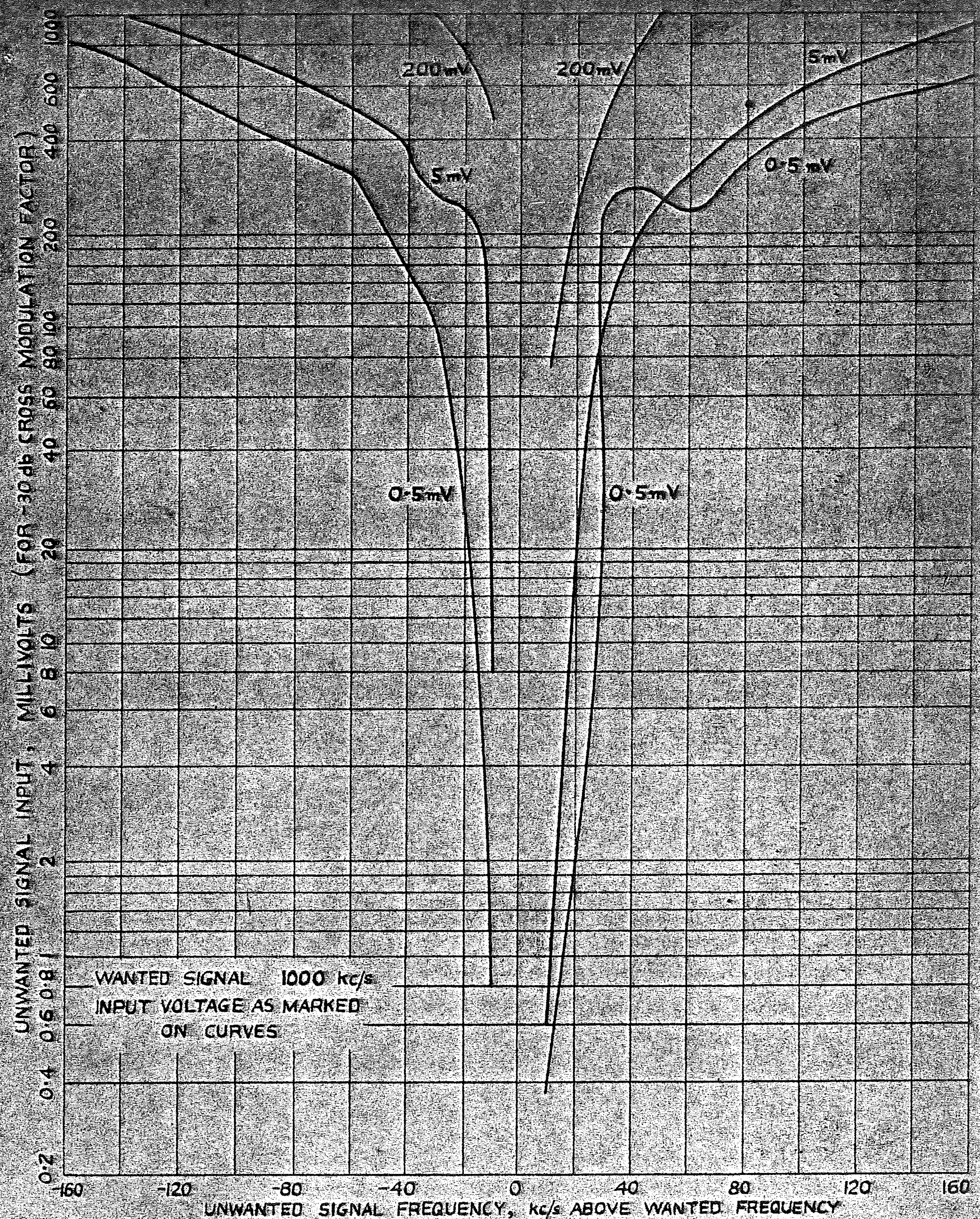
| AUSTRALIAN BROADCASTING CONTROL BOARD<br>**CROSS MODULATION TESTS ON M.F. BROADCAST RECEIVERS**<br>**RECEIVER "A"**<br>PART OF REPORT NO 12. | DRAWN J. N. H.<br>APPROVED W.R.B. 2-5-57<br>**GC-3**<br>SHEET 1 OF 12 SHEETS |




| AUSTRALIAN BROADCASTING CONTROL BOARD<br>CROSS MODULATION TESTS ON<br>M.F. BROADCAST RECEIVERS<br>RECEIVER "A"<br>PART OF REPORT NO 12. | DRAWN J. N. H<br>APPROVED W.R.B. 2-5-51<br>GC-3<br>SHEET 2 OF 12 SHEETS |
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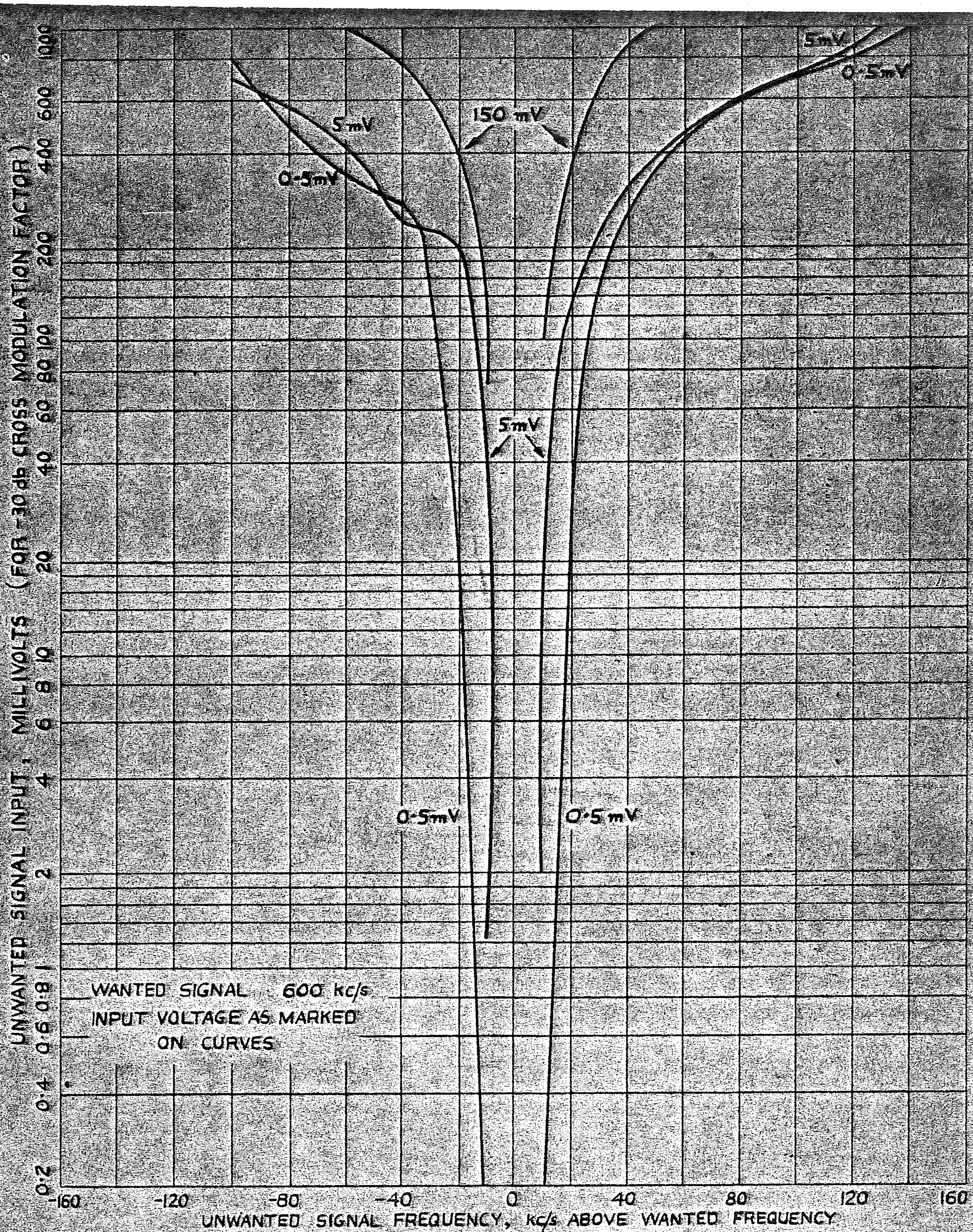


AUSTRALIAN BROADCASTING CONTROL BOARD

# CROSS MODULATION TESTS ON M.F. BROADCAST RECEIVERS RECEIVER "B"

PART OF REPORT NO 12.

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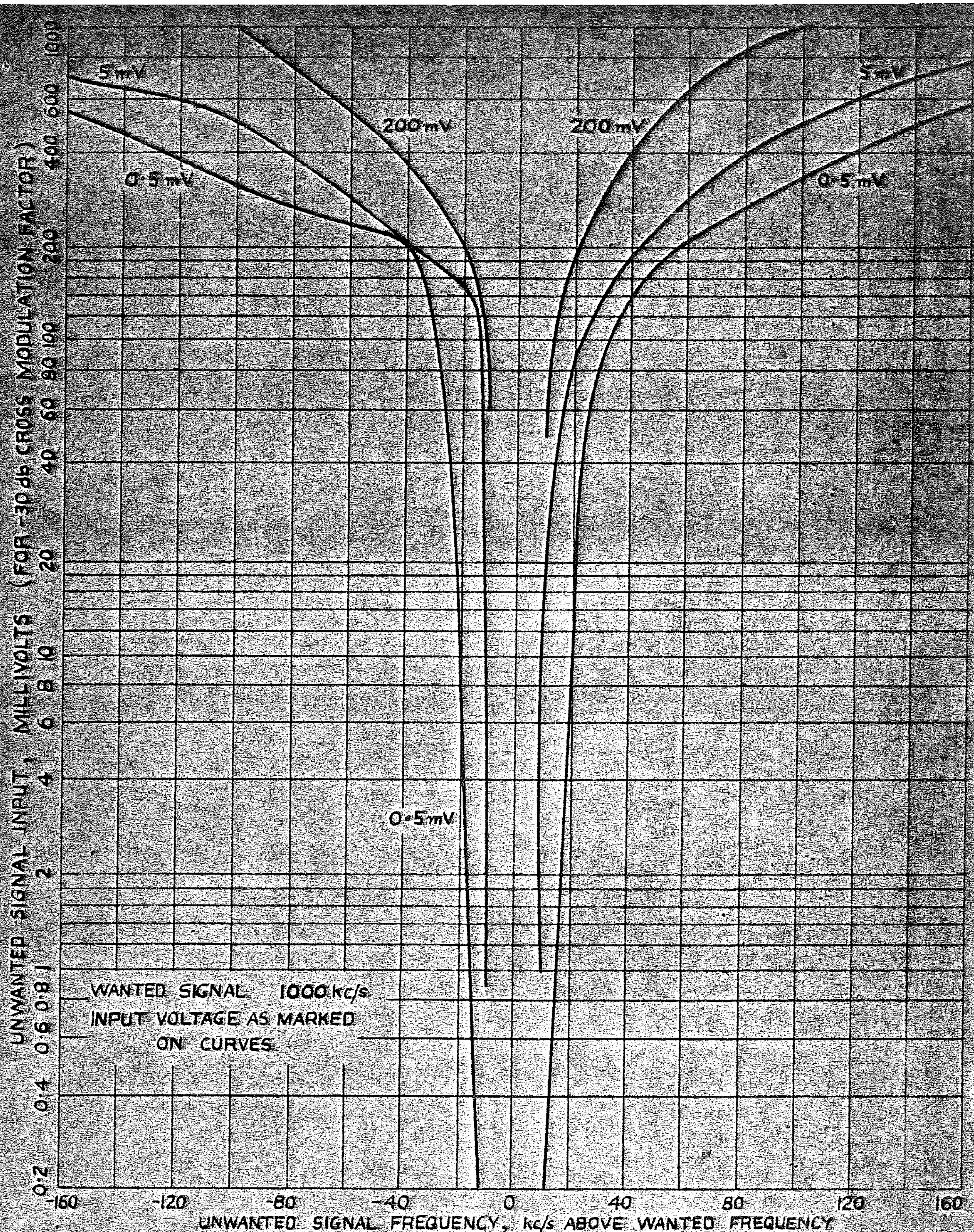
GC-3

SHEET 4 OF 12 SHEETS

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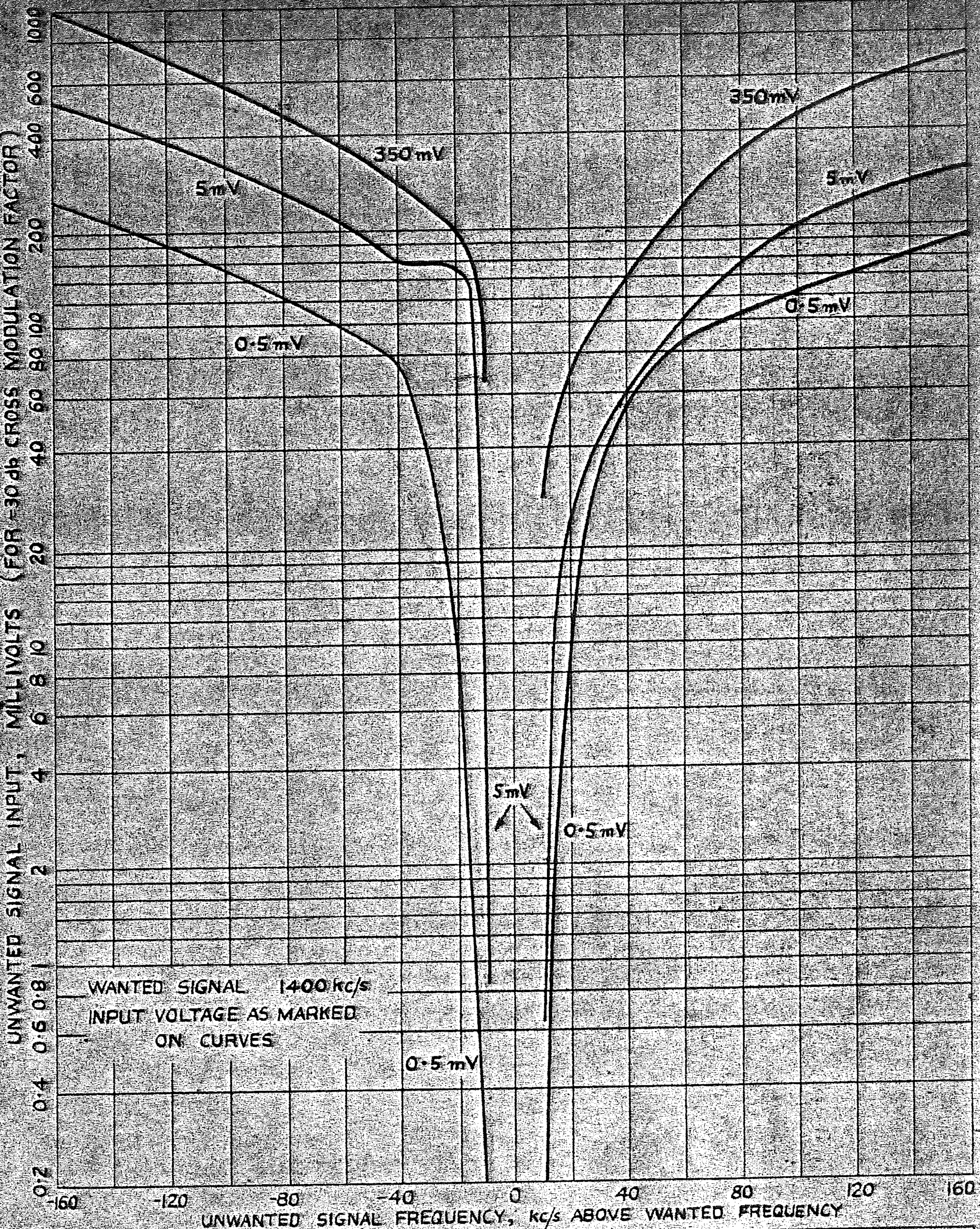
| AUSTRALIAN BROADCASTING CONTROL BOARD<br>CROSS MODULATION TESTS ON<br>M.F. BROADCAST RECEIVERS<br>RECEIVER "B"<br>PART OF REPORT NO 12. | DRAWN J. N. H<br>APPROVED W.R.B. 2-5-57<br>GC-3<br>SHEET 5 OF 12 SHEETS |




| AUSTRALIAN BROADCASTING CONTROL BOARD<br>CROSS MODULATION TESTS ON<br>M.F. BROADCAST RECEIVERS<br>RECEIVER "B"<br>PART OF REPORT NO 12 | DRAWN J. N. H<br>APPROVED W.R.B. 2-5-57<br>GC-3<br>SHEET 6 OF 12 SHEETS |
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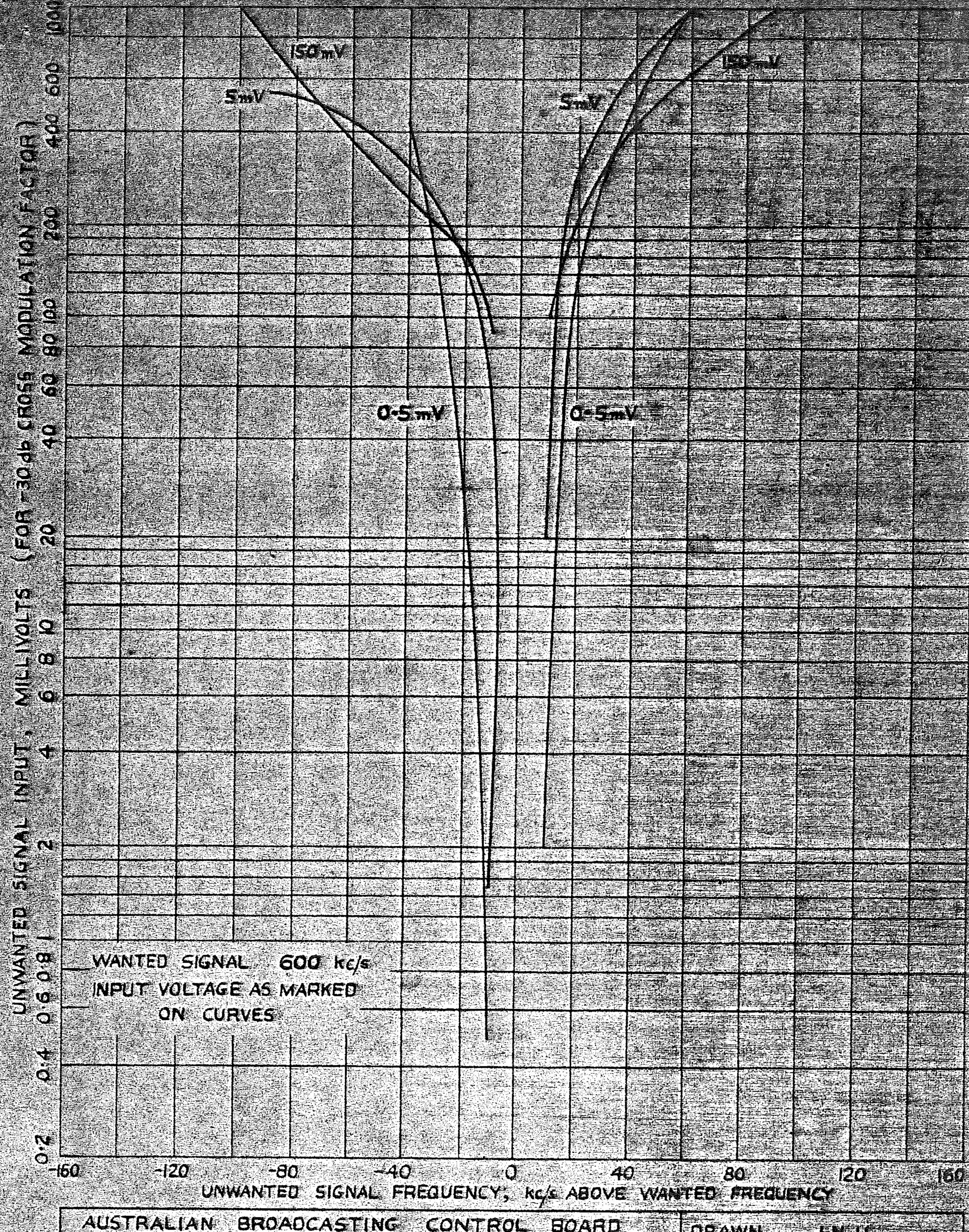


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# CROSS MODULATION TESTS ON M.F. BROADCAST RECEIVERS RECEIVER "C"

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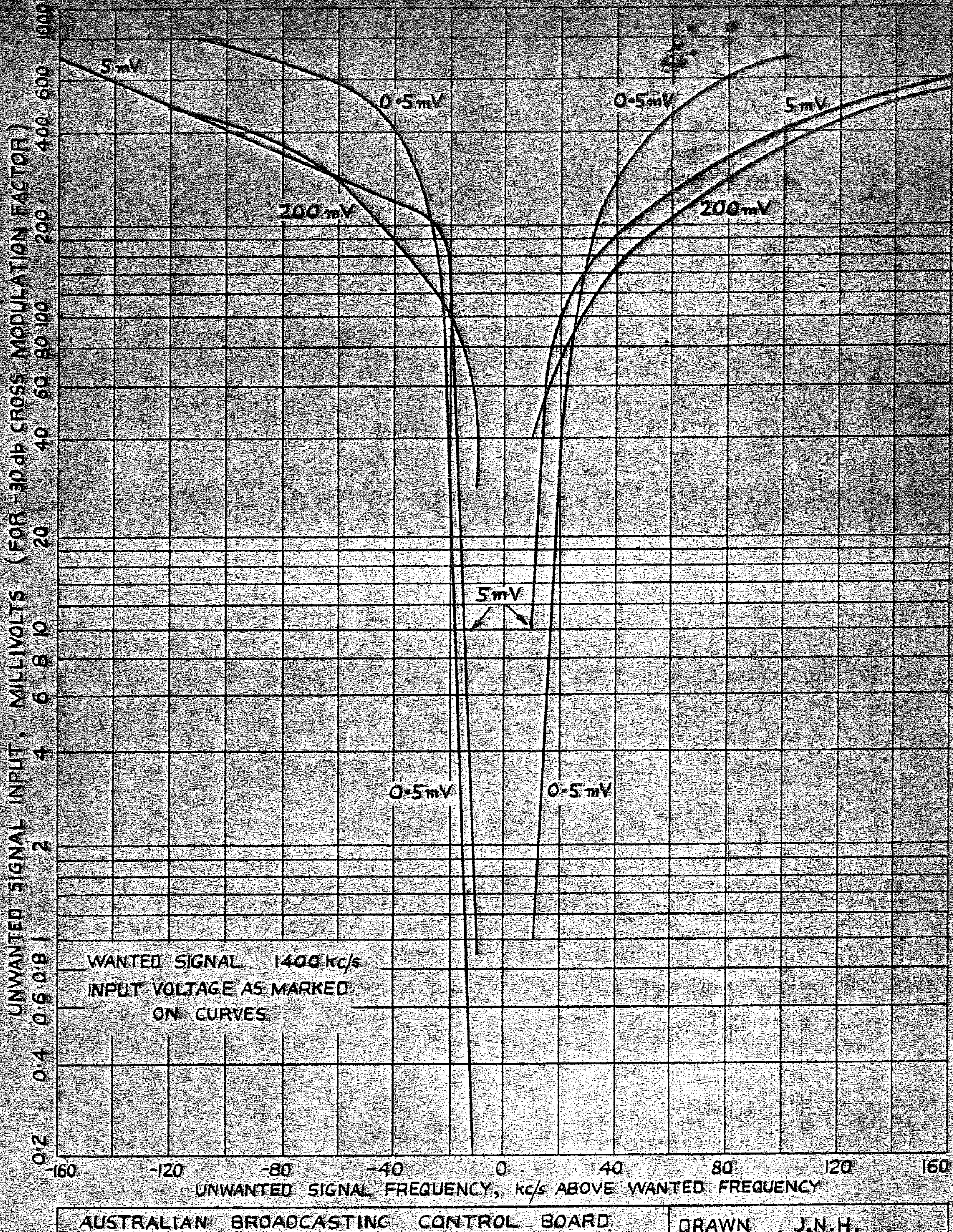
**GC-3**

SHEET 7 OF 12 SHEETS

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CROSS MODULATION TESTS ON M.F. BROADCAST RECEIVERS

RECEIVER "C"

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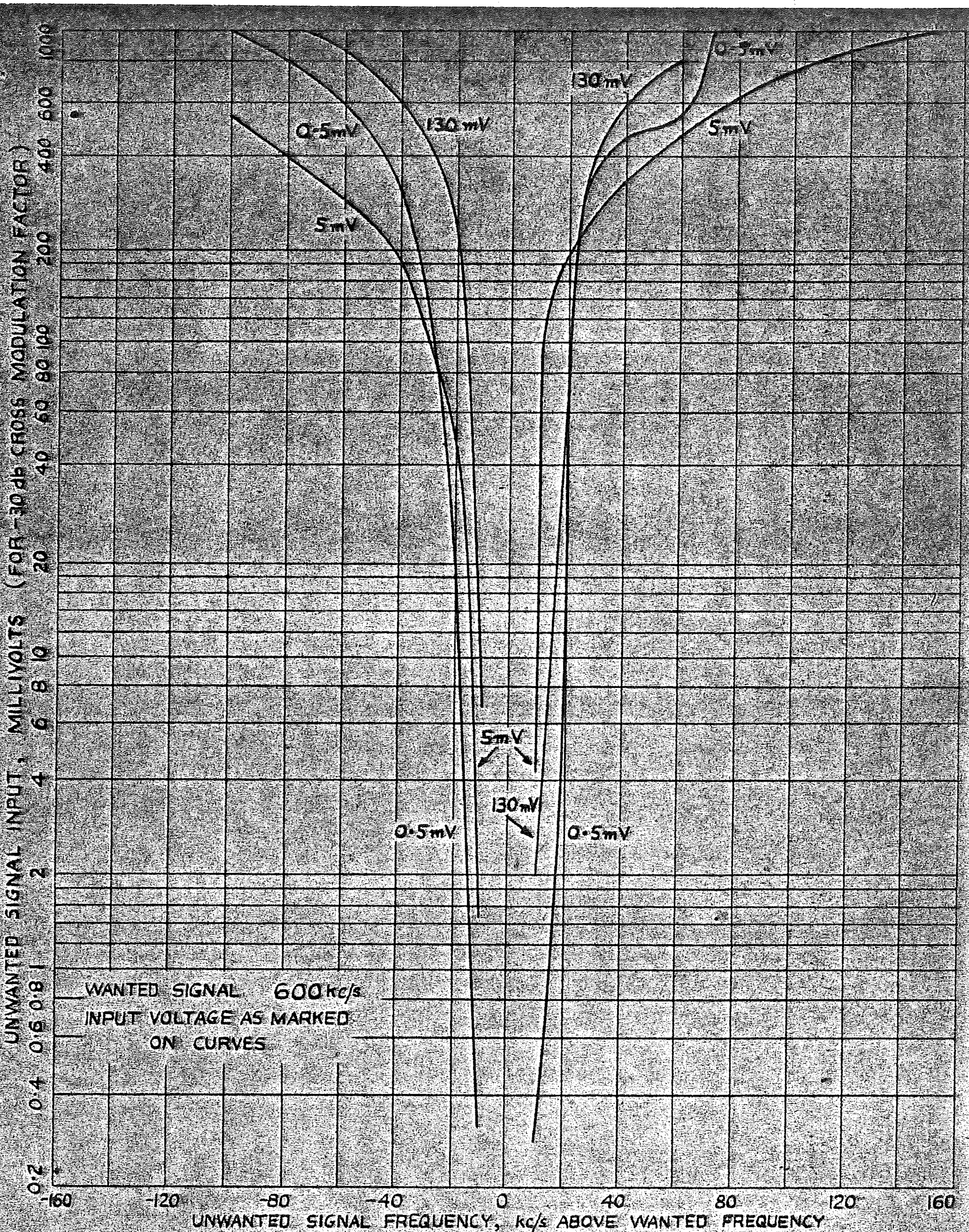
SHEET 8 OF 12 SHEETS

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CROSS MODULATION TESTS ON
M.F. BROADCAST RECEIVERS
RECEIVER "D"

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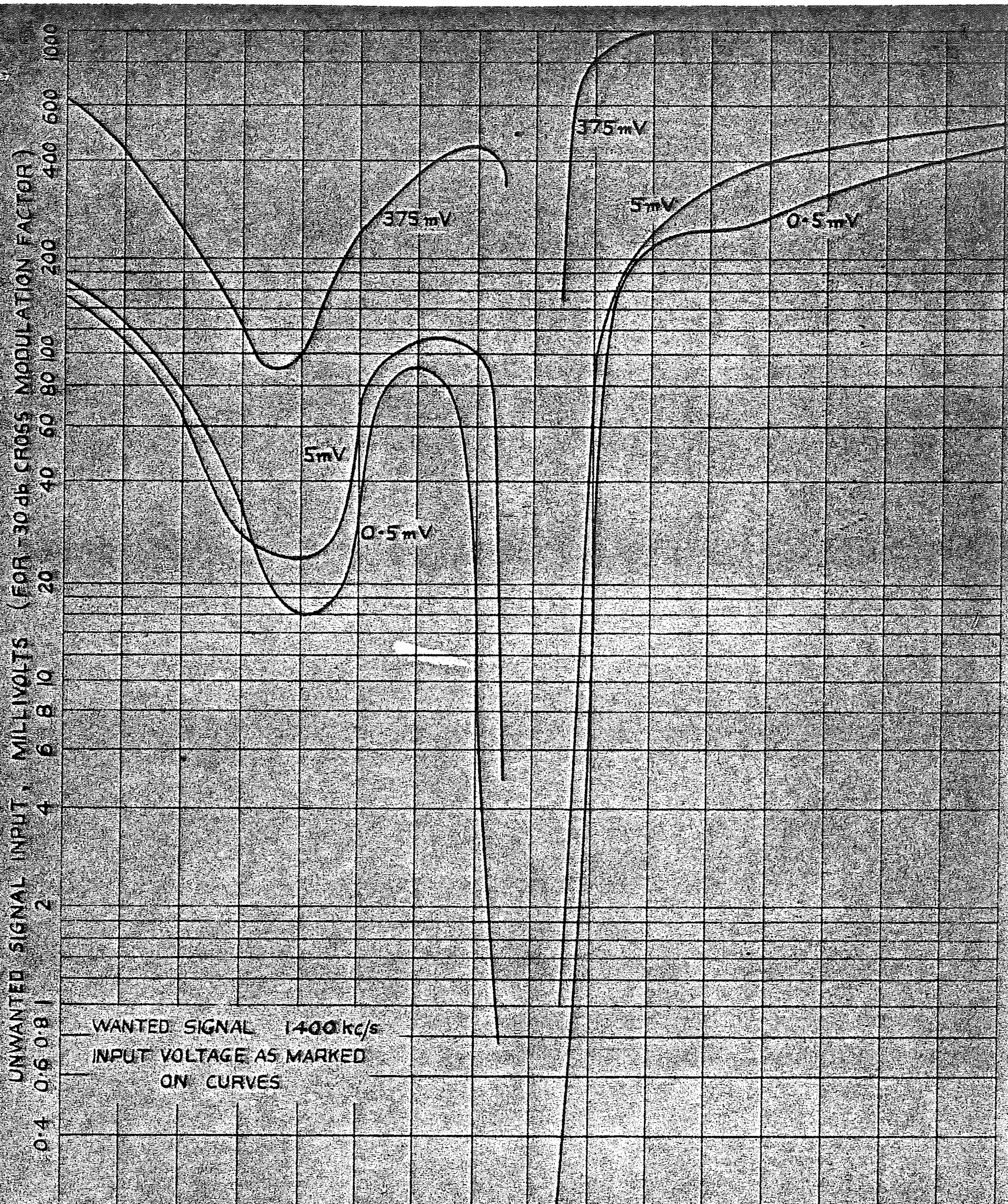
SHEET 9 OF 12 SHEETS

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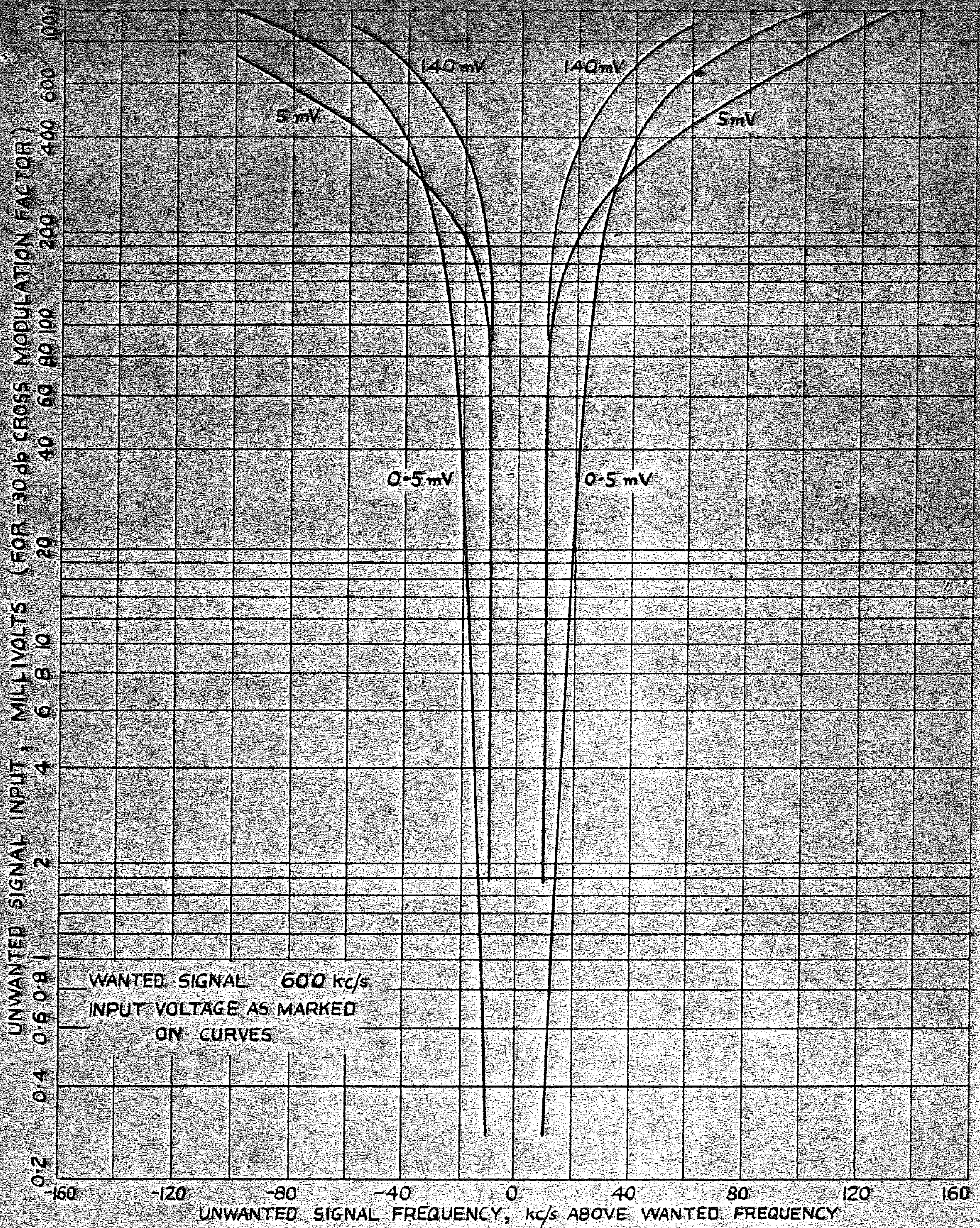


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**CROSS MODULATION TESTS ON M.F. BROADCAST RECEIVERS AVERAGE OF RECEIVERS TESTED**

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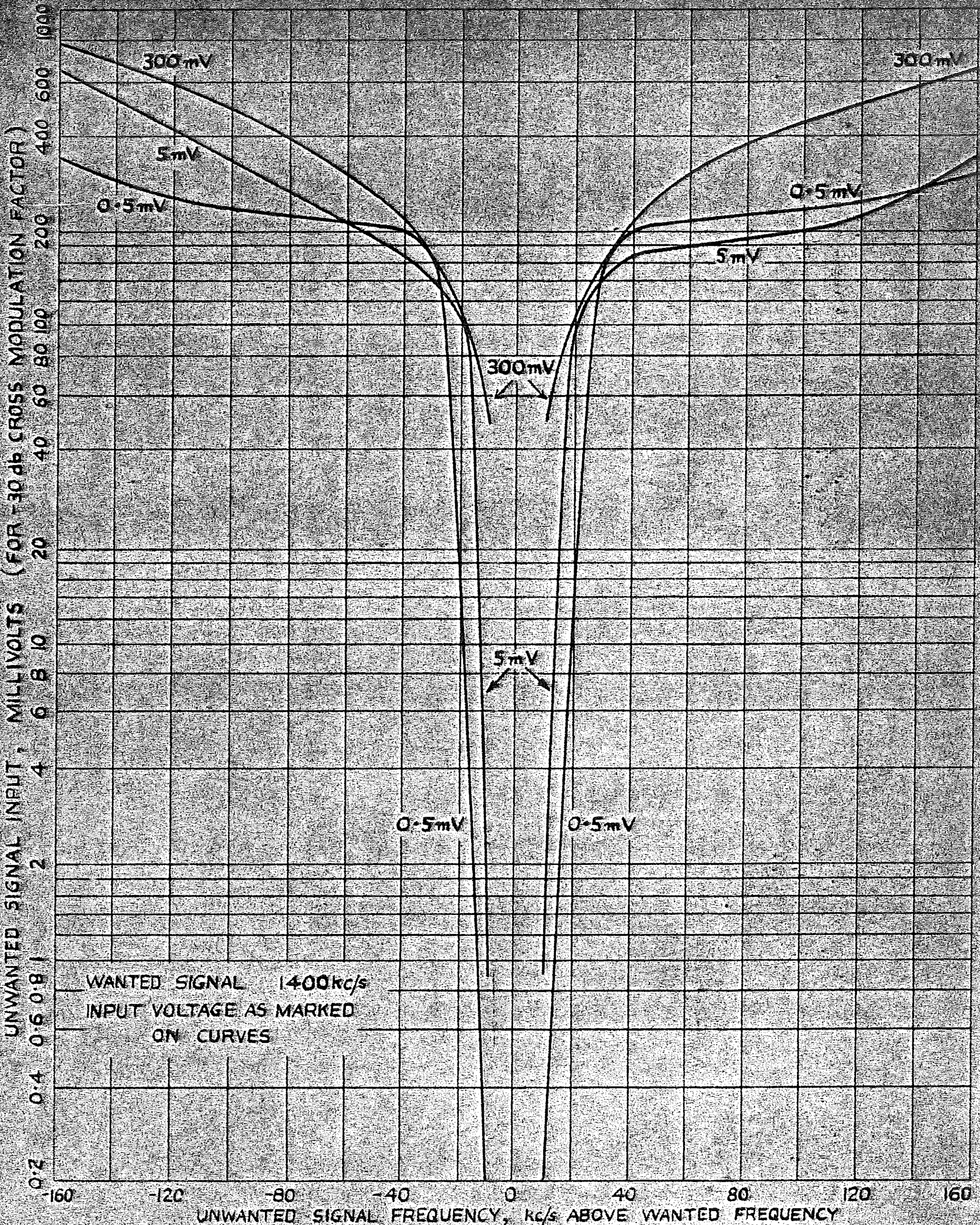
**GC-3**

SHEET 11 OF 12 SHEETS

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# CROSS MODULATION TESTS ON M.F. BROADCAST RECEIVERS AVERAGE OF RECEIVERS TESTED

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**GC-3**

SHEET 12 OF 12 SHEETS