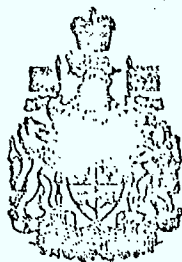


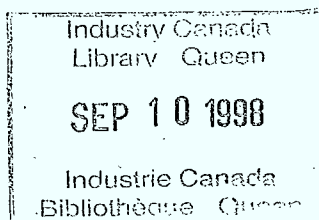
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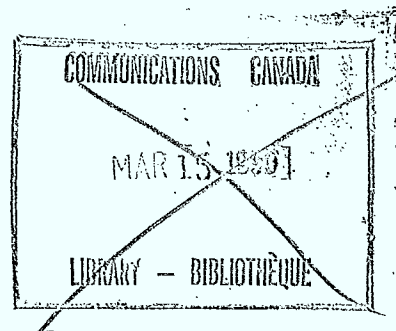
CANADA
DEPARTMENT OF COMMUNICATIONS
OTTAWA



D.O.C.
RESOURCE CENTRE
WINNIPEG

② INTERFERENCE RELATIONSHIPS BETWEEN
TV CHANNELS 5 AND 4
IN THE TORONTO AREA

① BY
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TELECOMMUNICATIONS REGULATION BRANCH
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Abstract

The change of channel at CBC station CBLT-TV in Toronto from 6 to 5 is being made to make feasible the use of channel 6 to provide a necessary TV service in both the Belleville-Kingston and the London areas of Ontario. When this change occurs in July 1972, it is expected that there will be interference to the off-air reception of Channel 4 signals from WBEN-TV Buffalo on many TV sets near the CBLT antenna site. Along a contour extending approximately 3 miles east and west of the site and 8 miles to the north, reception on about 50% of typical TV sets may be affected to a certain extent; the proportion of sets affected, and the degree of interference, will be progressively less at increasing distances beyond this contour, and will increase at points closer to the antenna site. However, satisfactory reception of WBEN-TV signals can be obtained on all TV sets through the use of a simple filter at the set antenna terminals. Laboratory tests on such a filter indicated its effectiveness in adequately reducing the Channel 5 signal.

These conclusions are based on an analysis of calculated and measured TV signals in the Toronto area, along with selectivity tests on a sample of typical TV sets. Channel selectivity measurements made on new and used TV receivers, when receiving Channel 4 signals in the high intensity field of Channel 5, have indicated that, for a particular subjective grade of picture, not only does the Channel 5 to Channel 4 rejection ratio vary from set to set, but that the rejection ratio is a function of the desired signal level, i.e. the higher the desired Channel 4 signal, the lower the Channel 5 rejection characteristics of the receiver for the same grade of picture.

Reception tests undertaken in Pembroke, Ontario, by observing the picture quality of Ottawa station CBOT on Channel 4 in the high intensity field of Pembroke station CHOV-TV on Channel 5 support the above findings.

Index

1. Introduction
2. Summary of Laboratory and Field Tests.
3. Review of Toronto Ch. 5/Ch. 4 Signal Relationships
4. Analysis of Ch. 5/Ch. 4 Interference in Toronto
5. The Effect of Filters to Reduce the Ch. 5 to Ch. 4 Interference
6. Discussion
7. Conclusions

Appendix 1 - Laboratory Tests on TV Receivers

Appendix 2 - Ch. 5/Ch. 4 Reception Tests in Pembroke, Ontario

Figure 1 - Percentage of TV Sets which have Ch. 5/Ch. 4 Rejection Ratios Greater than that indicated for 3 grades of pictures. (Ch. 4 signal 100 μ V).

Figure 2 - As for Fig. 1, but Ch. 4 signal = 200 μ V

Figure 3 - As for Fig. 1, but Ch. 4 signal = 500 μ V

Figure 4 - Block Diagram of Equipment to Simulate Ch. 5 Interference to Ch. 4 Reception.

Figure 5 - Calculated Field Strengths VS Distance for WBEN-TV Channel 4 Buffalo and CBLT Channel 5 Toronto.

Figure 6 - Calculated Contour within which Received CBLT/WBEN TV (Ch. 5/Ch. 4) Signal Ratio is Greater than 42 dB at the TV Set.

Interference Relationships Between TV Channels 5 and 4 in the Toronto Area

1. Introduction

TV station CBLT Toronto, presently operating on Channel 6 from a transmitting site in downtown Toronto, has recently made application to operate on Channel 5 using the same transmitting site. This proposal, which would permit a desirable TV service on Channel 6 in the Belleville-Kingston area, as well as in the London area, has been accepted by the Canadian Radio-Television Commission. Station WBEN-TV Buffalo, N.Y. operating on Channel 4 and located 80 miles from Toronto, has a sizable viewing audience in Toronto as a result of its being "on-air" many years before station CBLT. Because of the considerable interest expressed by Toronto viewers in continuing to receive WBEN-TV "off-air", questions have been raised as to the possibility of interference to the off-air reception of this channel by CBLT on Channel 5.

To study the probable effect on a Channel 4 TV signal when viewed in the presence of a much stronger Channel 5 signal, similar to that which would occur in Toronto, the following tests and analyses were performed:

- 1) Laboratory tests on 30 typical new as well as used TV sets were performed to obtain data on the rejection performance with respect to a Channel 5 signal when receiving Channel 4 transmissions.
- 2) Reception tests were made in Pembroke, Ontario on the signal from CBOT Ottawa on Channel 4 in the vicinity of the transmitting site of CHOV-TV Pembroke on Channel 5, where a high intensity field occurs.
- 3) Channel 5/Channel 4 signal strength analysis in Toronto was performed using calculated field strengths, and taking into account the laboratory and field measurements noted above, as well as previously measured WBEN-TV signal levels in Toronto.

2. Summary of Laboratory and Field Tests

The detailed results of the laboratory tests on 30 TV receivers and the reception tests performed in Pembroke are contained in Appendix 1 and 2 of this report. In performing the tests the subjective effect of interference was assessed according to the following picture definitions, in relation to adjacent channel type interference.

<u>Grade</u>	<u>Quality</u>	<u>Description</u>
1	Good	Picture is of good quality. Adjacent channel interference is just perceptible.
2	Passable or Acceptable	Picture is of acceptable quality. Interference is not objectionable.
3	Inferior	Picture is poor in quality. Interference is objectionable.

The above description of TV picture quality was selected to agree with the rating scale used by the Television Allocation Study organization (TASO) for defining a fine, passable and inferior grade of picture.

The reception tests at Pembroke, which consisted of viewing CBOT Channel 4 Ottawa in the presence of the high intensity field from CHOV-TV Channel 5 Pembroke, at selected field locations as well as in individual TV homes, indicated that at high Channel 5 to Channel 4 signal ratios, interference becomes perceptible. These results in Pembroke could not be applied directly to the Toronto situation because of different antennas and antenna orientations in Pembroke, as well as the limited range of ratio values which occurred at the test locations found suitable. However, it is shown that for a Channel 5/Channel 4 signal ratio above 44 db, the TV picture on most TV sets is reduced below a grade 1, or a good quality picture.

The results of the laboratory tests on 30 TV receivers (monochrome and color) are shown plotted in Figs. 1, 2 & 3 following Appendix 2 of this report. The results as plotted on probability graph paper which show the percentage of TV sets that have Channel 5/Channel 4 rejection ratios greater or less than the values shown. The following are the median rejection ratios as extrapolated from the graphs in Figs. 1, 2 & 3 for the desired Channel 4 signal levels of 100, 200 and 500 uV at the 300 ohm TV set terminals.

<u>Picture Grade</u>	<u>Ch. 5/Ch. 4 Signal Ratios (db) for Ch. 4 levels shown</u>		
	<u>100 uV</u>	<u>200 uV</u>	<u>500 uV</u>
1 (Good)	35 dB	34 dB	31.5 dB
2 (Passable)	43 "	42 "	40 "
3 (Inferior)	51 "	50 "	46.5 "

3. Review of Toronto Channel 5 to Channel 4 Signal Relationships

The expected signal strength versus distance for CBLT Toronto on Channel 5 was calculated using the F(50,50) field strength allocation curves and the proposed antenna parameters of Channel 5. This is shown

plotted on a graph in Fig. 5 following Appendix 2 of this report. The signal strength for WBEN-TV Channel 4 Buffalo, N.Y. 80 miles distant is also shown as calculated in the same manner. For comparison, spot measurements taken by DOC in June 1967 on WBEN-TV, are also shown. It is noted that the actual field strength of WBEN-TV in Toronto is approximately 6 db above that calculated. It is believed the signal path between Buffalo and Toronto, consisting of Lake Ontario and the terrain on which Toronto is located, increasing in elevation towards the north, favours the reception of the Channel 4 signal.

The typical receiving antenna in Toronto for the reception of WBEN-TV Channel 4 Buffalo is an 8 element all band antenna mounted at a height of approximately 30 ft. above ground, and generally oriented toward Buffalo. This antenna is specially designed for the Toronto area and is made by at least two manufacturers. The antenna has a gain of 4 to 5 db over a dipole with a front-to-back and a front-to-side ratio of approximately 12 to 15 db on Channel 4. The gain of this all-band antenna on Channel 5 is assumed to be the same as for Channel 4, although it is recognized its actual gain is slightly less on Channel 5 reception. This antenna, when used at an elevation of 30 ft. and oriented for maximum reception of WBEN-TV Channel 4, gives a calculated voltage at the TV set 300 ohm antenna terminals (allowing for lead-in losses) from approximately 535 uV to 170 uV in the Toronto area.

4. Analysis of Channel 5/Channel 4 Interference in Toronto

To determine the area where the Channel 5 signal is expected to cause interference to the reception of Channel 4, a TV set having a Channel 5/Channel 4 rejection ratio of 42 db was used. This ratio corresponds to the mean value of all TV sets measured in the laboratory for a picture rated as passable or acceptable. This corresponds to a grade 2 picture using a Channel 4 signal of 200 uV at the antenna terminals. Since the ratio was derived from measurements performed on used as well as new TV sets, and since it is also representative of the results derived from the picture quality versus Channel 5/Channel 4 signal ratios in Pembroke, it is believed to be applicable for the Toronto area.

Using the directivity of the typical Channel 4 receiving antenna as described in section 3 and a TV set having a mean Channel 5/Channel 4 rejection ratio of 42 db, which was found to correspond to a Grade 2 or acceptable picture, the distance at which interference is expected to 50% of the TV sets was derived from the CBLT/WBEN-TV field strength curves shown in Fig. 5. (For the WBEN-TV signal the measured values which averaged 6 db above the calculated values was used). The calculated distance extends about 8 miles to the north and approximately 3 miles to the east and west from CBLT. A map of the Toronto area in Fig. 6 shows this contour, which is defined as the boundary within which the Channel 5 to Channel 4 ratio is calculated to exceed 42 db. At all locations within this contour higher ratios will exist and a greater percentage of receivers will be affected.

5. The Effect of Filters to Reduce the Ch. 5 Interference to Ch. 4

To determine methods which could be used to reduce the expected Channel 5 interference, measurements were made on a Channel 5 filter manufactured by Delta Electronics Ltd. which was used by householders in the Pembroke area. The measurements indicated that approximately 40 db of attenuation at the Channel 5 visual carrier can be obtained. This filter would eliminate any possible interference to the Channel 4 signal even for locations near the CBLT transmitter site. The Delta Channel 5 filter is available at a cost of approximately \$8.00 and has a negligible effect to the Channel 4 signal level. Measurements showed that a stub filter consisting of a short length of antenna twin lead, if accurately cut to 0.25 wavelength at the Channel 5 visual frequency, will attenuate the frequency by as much as 30 db. This filter would be effective for most locations except within one mile of CBLT. Unfortunately, this filter reduces the Channel 4 signal by approximately 8 db and therefore may not be suitable for some locations where the signal is weak i.e. in the northern part of Toronto. It is understood that similar filters made by other manufacturers are equally satisfactory.

An additional requirement for good Channel 4 reception is that any spurious frequency responses from the CBLT transmitter which could fall within the Channel 4 frequency band would be required to be more than 60 db below the Channel 5 visual carrier level. This may require additional filtering at the transmitter.

6. Discussion

The assigning of Channel 5 to Toronto and thereby making Channel 6 available for TV stations at Kingston and London, Ontario, represents an improved use of the TV frequency spectrum. Unfortunately, the present location of CBLT, now operating on Channel 6, places a large number of TV viewers in the high signal strength of this station. With the frequency change to Channel 5 at the same site, the frequency separation from WBEN-TV Channel 4 is reduced from 16 MHz to 10 MHz, with the result that many TV sets cannot adequately reject the stronger Channel 5 signal and thereby avoid objectionable interference. For this reason, additional filtering will be required for areas with strong Channel 5 signals.

On the map of Toronto in Fig. 6 is shown a contour along which the interference from CBLT Channel 5 is expected to degrade the "off-air" TV reception of WBEN-TV Channel 4 from a "good" quality to a passable or acceptable picture grade. This is assuming a median receiver as determined from the laboratory tests. Outside of this contour, progressively less interference would be noted on the median receiver at increasing distances from CBLT, while a smaller number of receivers would be affected by the interference. At distances closer to CBLT a greater number of receivers will be affected, and the picture quality on the median receiver would be degraded further.

This area represents a sizable portion of metropolitan Toronto and contains many TV homes. However, when it is recognized that a large number of TV viewers live in apartments, where MATV systems are available, and since CATV is serving an increasing number of households, (CATV saturation in Toronto is currently about 29%) the number of TV viewers that will be affected by the change of channel is reduced considerably. In Toronto, with an increasing number of high rise buildings, more and more home owners are subscribing to the CATV service to obtain "ghost free" pictures. The change of channel by CBLT, even for areas near the transmitter site, will not force TV viewers to subscribe to the CATV service, since a relatively inexpensive filter will permit Channel 4 to be satisfactorily received at all receiver locations.

7. Conclusions

The results of this study, which includes laboratory tests on the rejection characteristics of a number of TV receivers as well as reception tests in the Pembroke area, where high Channel 5/Channel 4 signal ratios also occur, indicates that in Toronto, for CBLT operating on Channel 5, interference to the "off-air" reception of WBEN-TV Channel 4 can be expected for a majority of TV sets within an area close to the CBLT antenna site. However, interference within this area will not be experienced to the same degree for all receivers, as the rejection ratio varies from set to set and the Channel 5 to Channel 4 signal strength ratio varies from location to location. Taking a median receiver as a reference together with its receiving antenna, the map of Toronto in Fig. 6 shows a contour along which it is expected that a passable picture will be received when viewing WBEN-TV Channel 4 Buffalo directly "off-air". This area extends approximately 8 miles to the north of CBLT and approximately 3 miles to the east and west. Within this contour, the degree of interference and the proportion of sets affected is expected to increase at distances closer to the CBLT antenna tower.

Interference free reception can be obtained within the area, however, by using a filter at the antenna terminals of the TV set. In this study, two types of filters were investigated and each was found effective in reducing the level of the Channel 5 signal. One filter, used in the Pembroke area, made by Delta Electronics Ltd. and which costs approximately \$8.00, will provide sufficient attenuation so that Channel 4 can be received satisfactorily in all parts of Toronto. Similar filters are available from other sources. A second and less expensive filter, consisting of a 0.25 wavelength stub of 300 ohm transmission line, will be sufficient in most cases except within approximately one mile of CBLT. This filter unfortunately reduces the Channel 4 signal about 8 db, and may not be practicable at locations where the Channel 4 signal is weak.

Laboratory Tests on TV Receivers

Introduction

Laboratory tests were carried out on 30 commercially available TV sets (17 mono & 13 color) to determine at what ratio of Channel 5/Channel 4 signal input the picture on each set would be judged to be of a particular grade or quality. The test sample consisted of new as well as used TV sets. For the tests, three grades of picture were defined in terms of adjacent channel interference only (the random noise was not considered in this rating), and the rejection ratios for each picture grade was determined. The three grades together with the description of each grade is as follows;

<u>Grade</u>	<u>Rating</u>	<u>Description</u>
1	Good	Picture is of good quality. Adjacent channel interference is just perceptible.
2	Passable or Acceptable	Picture is of acceptable quality. Interference is not objectionable.
3	Inferior	Picture is poor in quality. Interference is objectionable.

Since the level of the desired signal (Ch. 4) has an effect on picture quality, the test was performed for three levels of the Channel 4 signal.

Test Procedure

To measure the Channel 5/Channel 4 rejection ratio for each TV set, the test equipment was set up as shown in Fig. 4. Two Rohde & Schwarz 0.5 watt transmitters tuned to Channel 5 and Channel 4 respectively were each fed through a variable attenuator to a combining network. The output of the combining network, which has two equal signal outputs, was fed to a HP Spectrum Analyser and to the antenna terminals of the receiver under test. For the desired signal, a color bar signal generator was used to modulate the Channel 4 transmitter. For the interfering signal, a demodulated off-the-air signal was used to modulate the Channel 5 transmitter. In the initial test, off-the-air programming was used for the desired Channel 4 signal, but because of the varying modulation levels it was found that more consistent results could be obtained if the desired signal consisted of a stationary picture. Consequently, all tests were done using the color bar signal as the desired signal.

In performing the tests, each TV set was tuned to Channel 4 and the signal was adjusted to the selected level at the TV antenna terminals using the variable attenuator. Signals levels of 100, 200 and 500 μ V

for the Ch. 4 visual carrier were used. The voltage was measured using the calibrated input of the spectrum analyser after compensating for the loss in the 50/300 ohm matching network at the input to the TV set. The signal level of 100 uV across 300 ohms at the antenna terminals was first selected and the level of the Ch. 5 signal was increased until just perceptible interference was evident to the picture on the TV set. This picture quality was subjectively established as Grade 1. The Ch. 5 signal was further increased, and two additional grades of picture were subjectively established for each TV set. The tests were then repeated with the Ch. 4 signal increased in turn to 200 and 500 uV at the TV set input. In total, 30 TV sets were tested, and the Ch. 5 to Ch. 4 rejection ratios for three grades of picture at three levels of Ch. 4 signal were established for each set.

Test Results

Shown in Fig. 1 to Fig. 3 inclusive is a statistical analysis of the Ch. 5/Ch. 4 ratios for the 30 TV sets tested. In plotting the distribution curve, the mean and the deviation of the data was mathematically calculated. It is noted that the individual measurements, when grouped and plotted as a percentage of the total data, approximate a straight line. This line is called the distribution curve, and when the line is straight it indicates a normal distribution. The graphs shown in Fig. 1 to Fig. 3 inclusive show the percentage of TV sets which have Ch. 5/Ch. 4 rejection ratios greater than a specific value for the three grades of picture at three levels of the desired Ch. 4 signal. The results indicate that while there is variation between sets at which perceptible interference is evident, this ratio decreases as the desired level increases; i.e. the median ratio for grades 1, 2 & 3 for 100 uV signal input is higher than the median for the same grades using the 500 uV signal input. This fact was confirmed in the DOC Technical Report BTRB-2 "Interference Rejection Ratio Measurements on TV sets receiving strong Ch. 6 Signals for one and two Interfering Signals on FM Channels".

The following are the median rejection ratios as extrapolated from the graphs in Figs. 1, 2 & 3 for the desired Ch. 4 signal level of 100, 200 and 500 uV at the 300 ohm TV set terminals.

<u>Picture Grade</u>	<u>Ch. 5/Ch. 4 Signal Ratios (db) for Ch. 4 levels shown</u>		
	<u>100 uV</u>	<u>200 uV</u>	<u>500 uV</u>
1 (Good)	35 dB	34 dB	31.5 dB
2 (Passable)	43 "	42 "	40 "
3 (Inferior)	51 "	50 "	46.5 "

Ch. 5/Ch. 4 Reception Tests in Pembroke, Ontario

Introduction

Reception tests in Pembroke consisted of viewing TV station CBOT Ch. 4 Ottawa in close proximity to station CHOV-TV Ch. 5 Pembroke. Viewing was done at three selected locations using three TV sets in the Department of Communications vehicle. Viewing was also done in individual households in Pembroke.

Test Procedure and Results of Field Survey

At each of the three points selected for viewing the CBOT signal, the receiving antenna, consisting of a folded dipole mounted on top of the DCC vehicle, was oriented for maximum desired signal response. The level of the Ch. 4 and Ch. 5 signal was measured at the TV antenna terminals and the quality of the picture was subjectively judged as viewed on three TV sets. The incident field strengths of CHOV-TV and CBOT was also measured using a calibrated dipole. The procedure was repeated at two additional locations. The following are the results of the tests at the three locations using the three TV sets:

TABLE 1

<u>Test Point</u>	<u>Ch. 5/Ch. 4 Incident Field Ratio (db)</u>	<u>Ch. 5/Ch. 4 Signal Ratio (at set) (db)</u>	<u>TV Picture Quality</u>
1	44	11	Good pictures on all 3 sets.
2	51	48	Good picture on one set. Passable picture on one set. Inferior picture on one set.
3	54	53	Passable picture on one set. Inferior picture on two sets.

The three TV sets used for these tests were later included in the laboratory tests performed on 30 TV receivers. The Ch. 5/Ch. 4 rejection ratios of the three sets had a mean value which was within 2 db of the mean value for all sets.

For the house-to-house survey, three geographic regions were selected at which the TV picture received on Ch. 4 was judged subjectively. For each region the Ch. 5/Ch. 4 incident field ratio was calculated using the F(50,50) signal propagations curves for CBOT and CHOV-TV. Since each

region is at a different bearing with respect of the Ch. 5 transmitter site, an estimate of the average antenna rejection of the Ch. 5 signal is also shown. In estimating the Ch. 5 rejection for the type of antennas used in Pembroke, i.e. multi-element Ch. 4 antennas oriented towards CBOT, the frequency response of the antennas on Ch. 5 was also taken into consideration. The following are the results of the tests, including the Ch. 5/Ch. 4 signal ratio as calculated at the TV set.

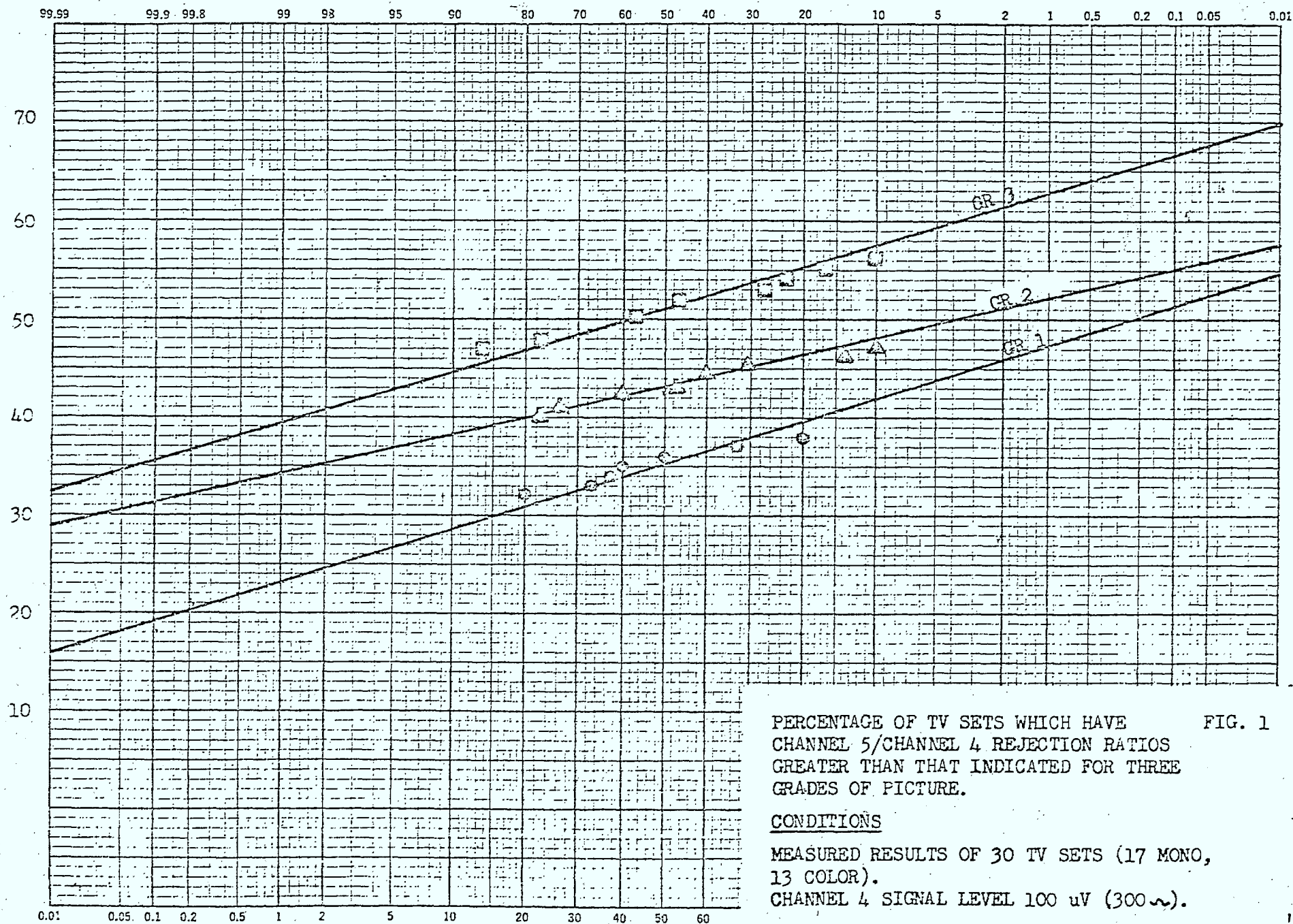
TABLE 2

Region	Calculated Ch. 5/Ch. 4 Field Strength(dB)	Antenna Rejection(dB)1/	Calculated Ch. 5/Ch. 4 Signal Ratio(dB)	TV Picture Quality
1	61	15	46	Good picture in 3 homes. Acceptable in 3 homes. Inferior picture in 4 homes.
2	55	15	40	Good picture in all 4 homes.
3	54	10	44	Good picture in all 3 homes.

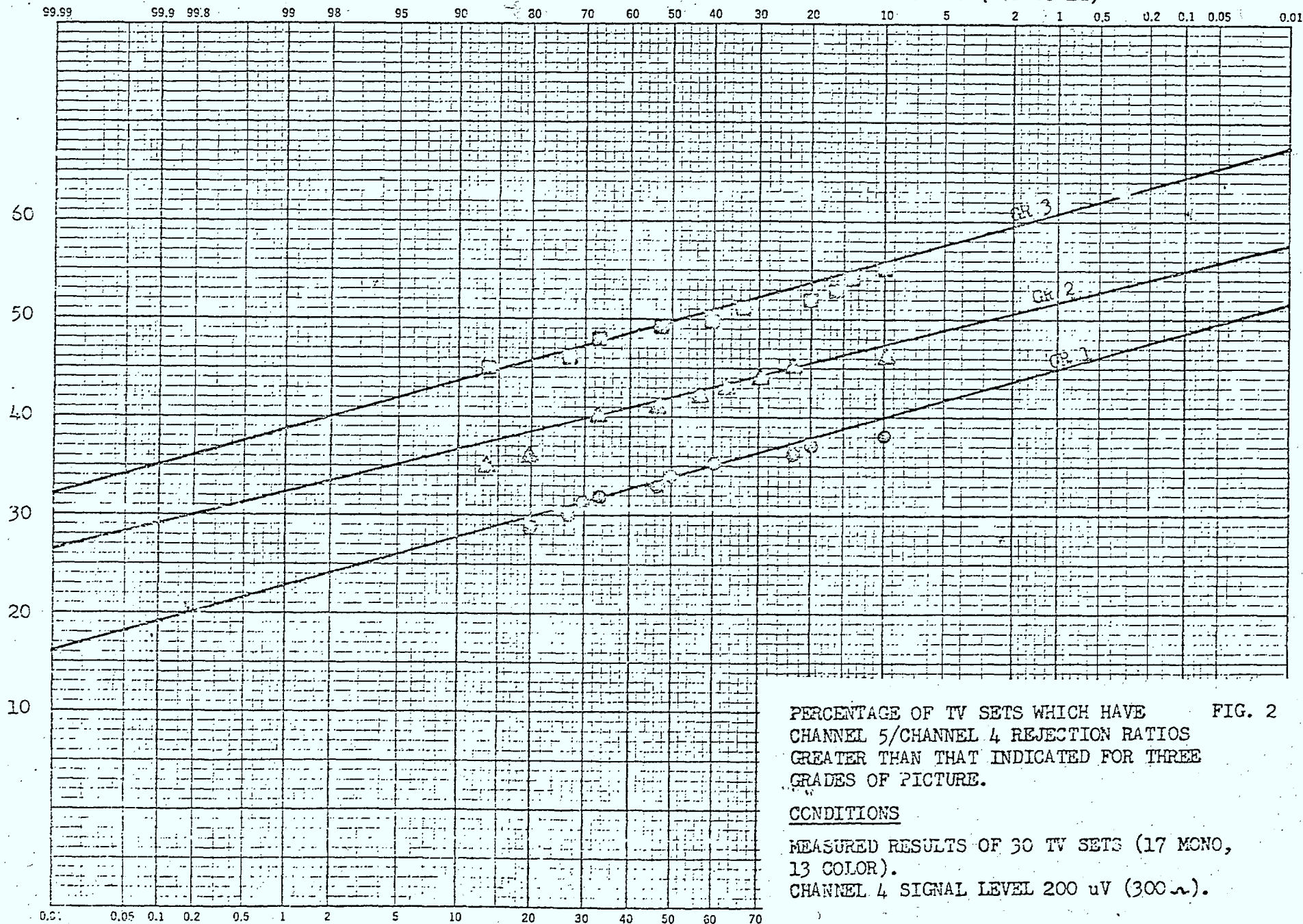
1/ It is assumed that the antennas used in receiving Ch. 4 and which also pickup Ch. 5 have a Ch. 5 to Ch. 4 rejection ratio of 10 db as well as a front-to-back or front-to-side ratio of 5 db.

By comparing the results of the individual field tests in Table 1 with the results of the house-to-house survey in Table 2, it can be seen that when the Ch. 5 to Ch. 4 signal ratio exceeds 44 dB inferior grades of picture were found on one or more TV sets.

PERCENTAGE OF TV SETS WITH REJECTION RATIOS GREATER THAN INDICATED (TOP SCALE)



PERCENTAGE OF TV SETS WITH REJECTION RATIOS GREATER THAN INDICATED (TOP SCALE)



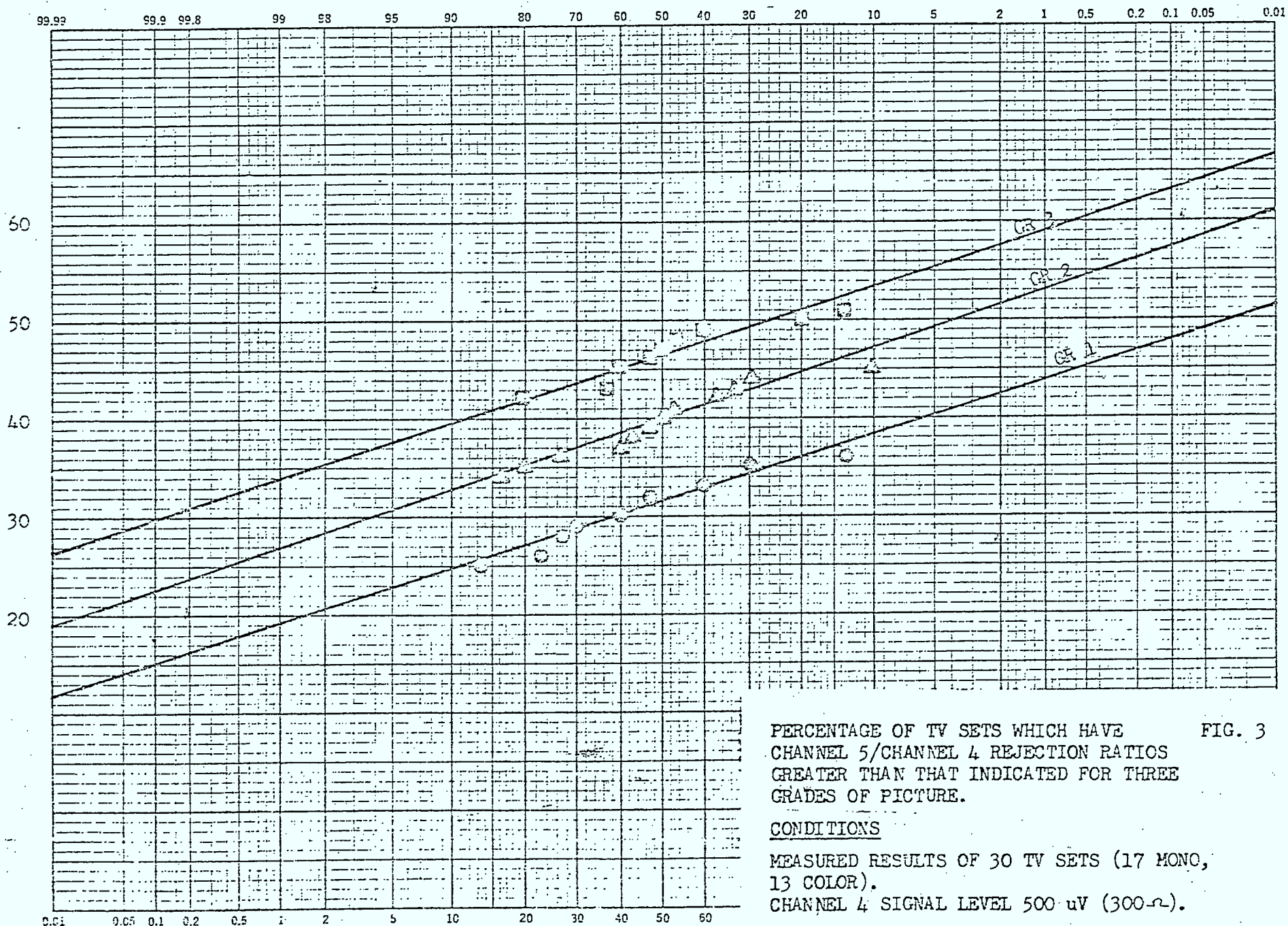
PERCENTAGE OF TV SETS WHICH HAVE CHANNEL 5/CHANNEL 4 REJECTION RATIOS GREATER THAN THAT INDICATED FOR THREE GRADES OF PICTURE.

FIG. 2

CONDITIONS

MEASURED RESULTS OF 30 TV SETS (17 MONO, 13 COLOR).
CHANNEL 4 SIGNAL LEVEL 200 μ V (300 \sim).

PERCENTAGE OF TV SETS WITH REJECTION RATIOS GREATER THAN INDICATED (TOP SCALE)



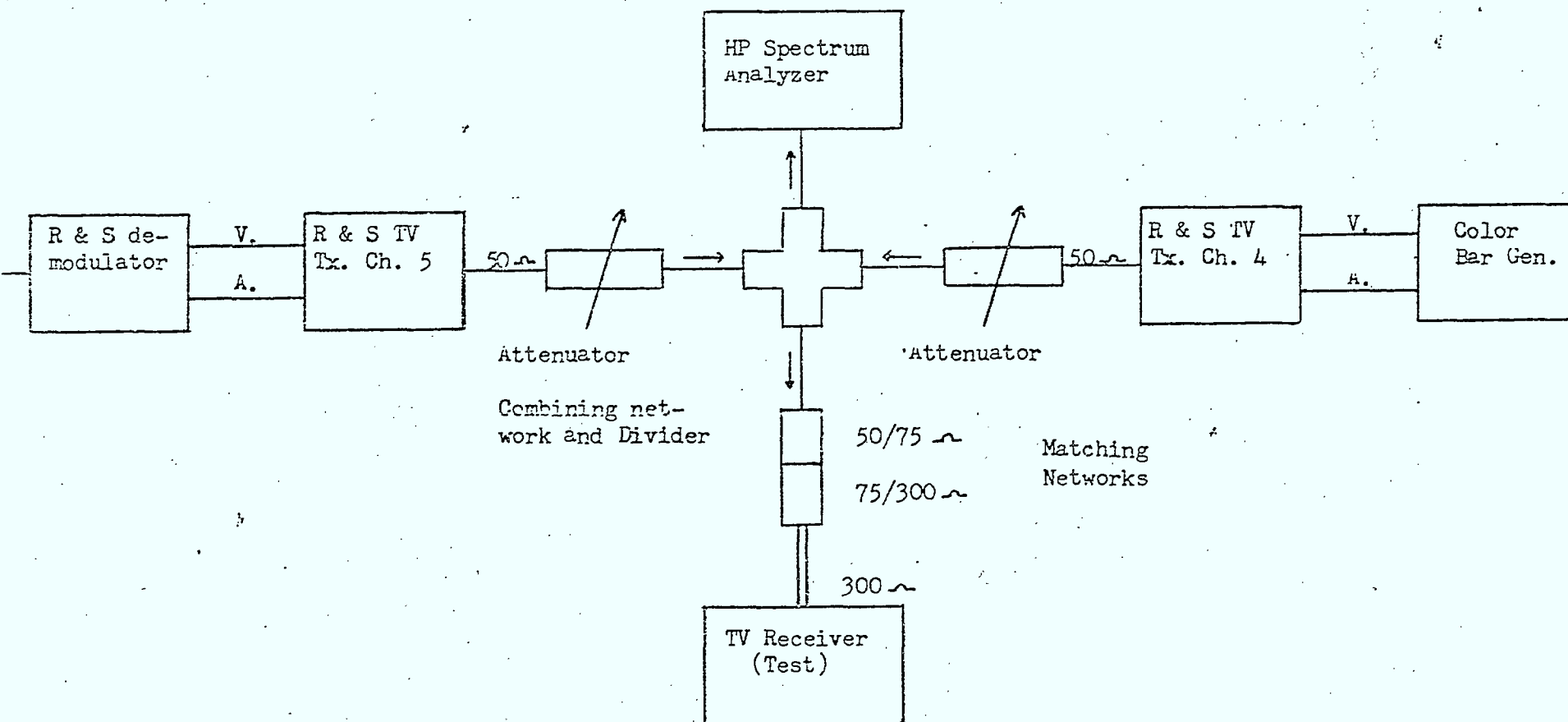
PERCENTAGE OF TV SETS WHICH HAVE
CHANNEL 5/CHANNEL 4 REJECTION RATIOS
GREATER THAN THAT INDICATED FOR THREE
GRADES OF PICTURE.

FIG. 3

CONDITIONS

MEASURED RESULTS OF 30 TV SETS (17 MONO,
13 COLOR).
CHANNEL 4 SIGNAL LEVEL 500 uV (300-ohms).

one off-
5.



BLOCK DIAGRAM OF EQUIPMENT USED TO SIMULATE CHANNEL 5 INTERFERENCE TO CHANNEL 4 RECEPTION.

FIG. 5

CALCULATED FIELD STRENGTHS VS DISTANCE FOR
WBBN-TV CHANNEL 4 BUFFALO AND CBLT CHANNEL 5
TORONTO.

CBLT CHANNEL 5 TORONTO

FIELD STRENGTH - DBU

MILES FROM CBLT

MILES FROM CBLT

110 100 90 80 70 60 50 40 30 20 10

WBBN-TV CHANNEL 4 BUFFALO