PRACTICAL SYSTEM DESIGN BASED ON COMPLETE EQUIPMENT EVALUATION

by

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EQUIPMENT SET-UP AND TEST PROCEDURE

About eight months ago it became obvious to the engineering department of Tele-Vue Systems, Inc., that we were having too many disappointing experiences with the new solid state equipment. Such as, why was the tilt changing in the system, why were we getting beats, why the excessive noise, etc.?

We were planning on building about 1000 miles of new plant over the next two year period, plus modernizing our existing 600 miles. It was rather clear to me that we could not afford to make that kind of expenditure without knowing in advance whether the equipment would meet our specifications.

Our company is selling in areas where we are competing against from two to five channels of off air reception. We have found that we get deeper penetration by selling in these markets before the plant is built. To encourage the people to sign up at that time, the connect charge is waived. Under these conditions, because the prospective customer has nothing to lose, it is not unusual to achieve 60% penetration, and currently we are selling between 70% and 80% of the occupied homes. We cannot make any mistakes under these conditions. If we do, the customer disconnects.

Because of this highly aggressive sales philosophy, the trunk lines getting longer, more channels being carried, the competition of off air signals, all of these factors add up to one thing. We cannot afford to experiment in the field. We must confine our experiments to the lab under controlled conditions.

It was at this point that we set about to put together a testing facility that would enable us to accurately measure all parameters of CATV equipment. Although Tele-Vue Systems, Inc., for whom I work, financed this venture, Jerry Laufer, who is Vice-President of engineering for Tele-Cable, contributed a vast amount of time, energy and knowledge, in putting the test facility together. Without his help, we would not be where we are today in our testing program.

TEMPERATURE

For testing the effect of temperature we didn't feel that single unit tests without the associated cable and other accessories would tell us what we wanted to know. We purchased an 8' x 10' walk-in freezer which had a 2000 watt defrost coil built in. The freezer will hold a ten amp cascade and all its associated accessories and cable very nicely. To create the heat, the defrost coil is manually switched on and is held at some preset temperature with a thermostat. We are capable of going from minus 40 to plus 140 safely, but for the purposes of our test minus 20 to plus 120 is adequate. The cable presently used is bare .412 aluminum in 22 db lengths. We will be changing to 1/4 inch alum in the near future to give us more room for a possible additional 10 amp cascade. Also, with the smaller cable, it will not take as long to complete a cycle. It now takes about 30 hours to go from 70 to 120 to minus 10 and back to 70 degrees fahrenheit. Cross-modulation, noise and response measurements are made at these temperatures.

NOISE

Noise measurements are made as described on page 5.

CROSS MODULATION AND BEAT MEASUREMENT

The test set consists of two parts -- a 12 channel signal source, and a cross modulation and beat measurement set.

The 12 channel signal source at present consists of a Jerrold TM modulator operating on channel 6. The modulator is modulated by 15.750 KHz square waves from a Hewlett-Packard square wave generator. The modulated channel 6 carrier is suitably attentuated and converted to IF frequency by a Jerrold Channel Commander, tuned to channel 6. The IF output is split down into 12 outputs using hybrid splitters and made available at a co-axial patch-pannel. The patch panel also connects to the inputs of 12 Jerrold CCV up-converters, which convert the IF to the 12 standard VHF TV channels. The CCV outputs are combined in a filter network adapted for antenna mixing networks into a single 12 channel output. A final output step attenuator provides output level control. Individual level control on each channel is achieved by individual bias controls for each CCV unit. These are mounted on the patch panel. The signal substitution oscillator provides an unmodulated carrier at IF frequency. This unmodulated carrier is made available at the patch panel. Use of BNC connectors at the patch panel makes it possible to substitute modulated and unmodulated carriers quickly on any desired channel.

Output signal levels are measured with a Jerrold 704B field strength meter. A Hewlett-Packard 608C signal generator is available for calibrating the field strength meter before and after tests.

The Cross modulation and beat distortion measuring section is contained in a separate rack. A step attenuator controls input levels. A hybrid splitter splits the incoming signal. A Jerrold 704B field strength meter serves to measure levels and as a demodulator for the cross modulation measurements. The video output from the field strength meter goes through a passive 15.750 KHz preselective filter into a Sierra wave analyzer which acts as a tunable voltmeter with wide dynamic range. The wave analyzer is capable of separating the 15.750 KHz cross modulation fundamental and measuring it at microvolt levels. The cross modulation ratio is the ratio of 15.750 KHz fundamental when carrier is modulated at standard level to 15.750 KHz level when unmodulated carrier is substituted. This test set is capable of measurements down to about -75 db cross modulation. Accuracy at this level is improved and range extended to still lower cross modulation levels (-100 db) by use of a preselector filter in front of the 704B. Use of the preselector permits higher input levels to the 704B without generating excessive distortion in the 704B itself. The higher input levels are required to overcome noise which becomes a limiting factor at these low cross modulation levels.

A Jerrold TD demodulator is used for beat checks. The video output drives a conrac video monitor for visual observation of cross modulation and beats. The IF test point feeds a Nelson Ross spectrum analyzer which scans the demodulator IF for undesired spurious beats. Very low level beats at low frequency might be missed by this IF scan. If these are suspected they are checked with a low frequency wave analyzer examination of the video output. A low frequency spectrum analyzer will soon be installed for this function. The spectrum analyzer permits a 60 db dynamic range measurement of beats to be made, when used with the TD as a preselector. Precision level and frequency measurements are made by using the spectrum analyzer to compare test signals with reference signals from the H-P 608C signal generator or other standard sources such as marker generators.

NOISE MEASUREMENT

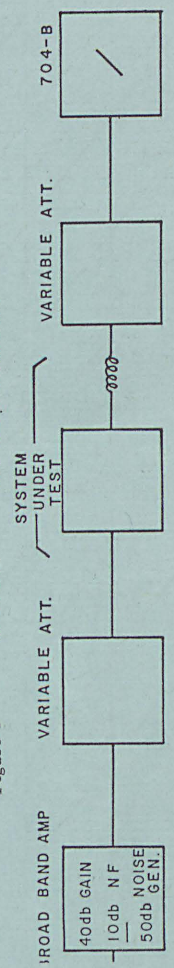


Figure 1

1. SET UP BROAD BAND AMPLIFIER AND VARIABLE ATTENUATOR AT INPUT TO 1ST. AMPLIFIER IN THE SYSTEM UNDER TEST.
2. TURN INPUT ATTENUATOR TO MAXIUM ATTENUATION.
3. WITH NO ATTENUATION IN OUTPUT OF ATTENUATOR AND 704-B IN MANUAL GAIN POSITION, ADJUST FOR + 8 db READING.
4. NOW SWITCH IN 3 db IN OUTPUT ATTENUATOR AND REMOVE ATTENUATION ON INPUT UNTIL THE SAME 8 db READING IS OBTAINED.
5. SUBTRACT REMAINING ATTENUATION ON INPUT ATTENUATOR FROM OUTPUT OF NOISE GEN. AND THAT IS THE NOISE FIGURE OF SYSTEM UNDER TEST.

NOTE: IF THE SYSTEM HAS AGC, BE SURE TO FEED IN THE PROPER SIGNAL FOR SYSTEM TO WORK, AT NORMAL OPERATING LEVELS USE ATTACHED CHART FOR COMPUTING SYSTEMS SIGNAL TO NOISE RATIO.

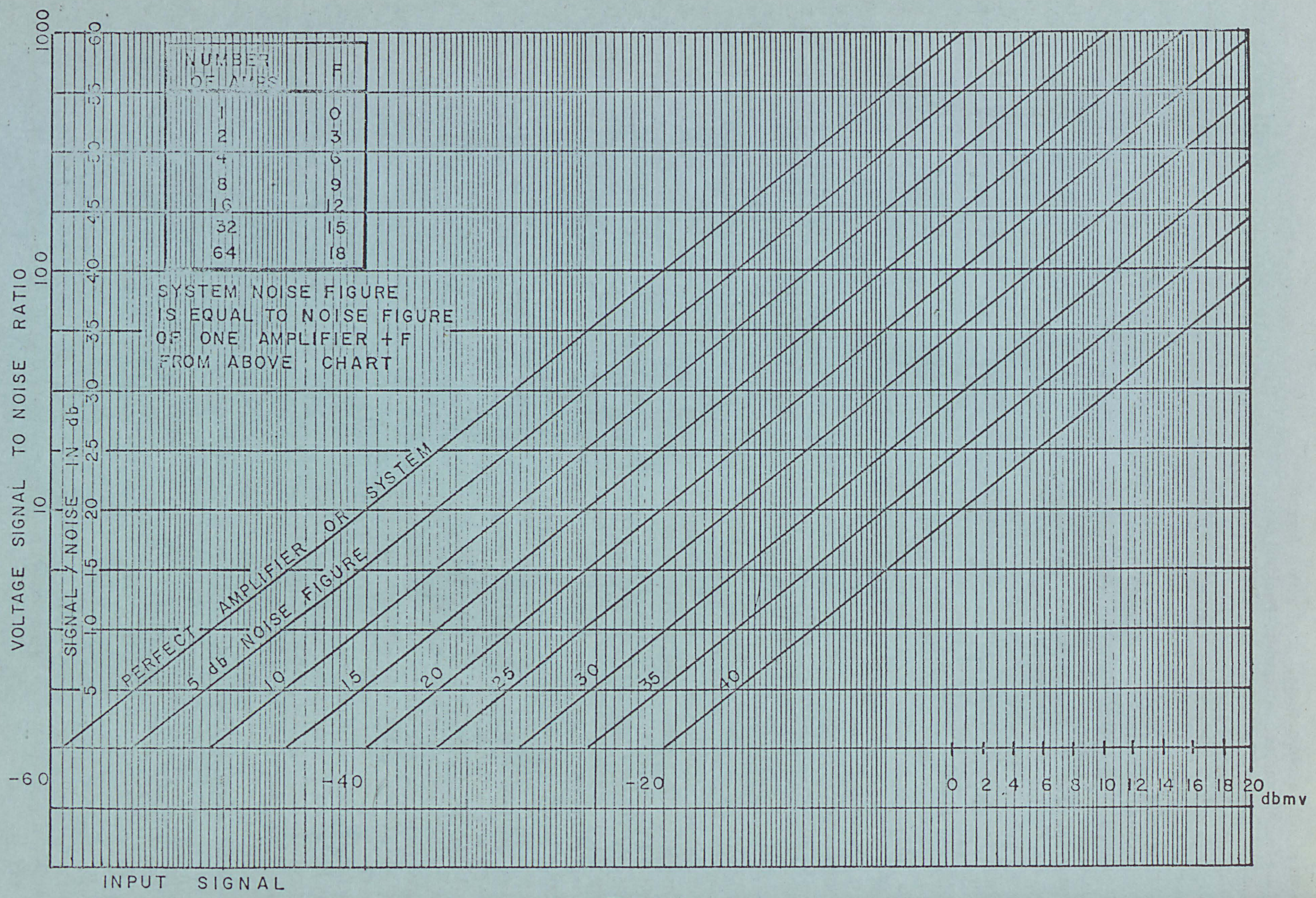

NUMBER OF AMPS
F
1 0
2 3
4 6
8 9
16 12
32 15
64 18
SYSTEM NOISE FIGURE IS EQUAL TO NOISE FIGURE OF ONE AMPLIFIER + F FROM ABOVE CHART
PERFECT AMPLIFIER OR SYSTEM
5 db NOISE FIGURE
10
15
20
25
30
35
40
VOLTAGE SIGNAL TO NOISE RATIO
1000
100
10
SIGNAL / NOISE IN db
5
10
15
20
25
30
35
40
45
50
55
60
-60
-40
-20
0 2 4 6 8 10 12 14 16 18 20
dbmv
INPUT SIGNAL

Figure 2

Figure 3

12 CHANNEL SIGNAL SOURCE

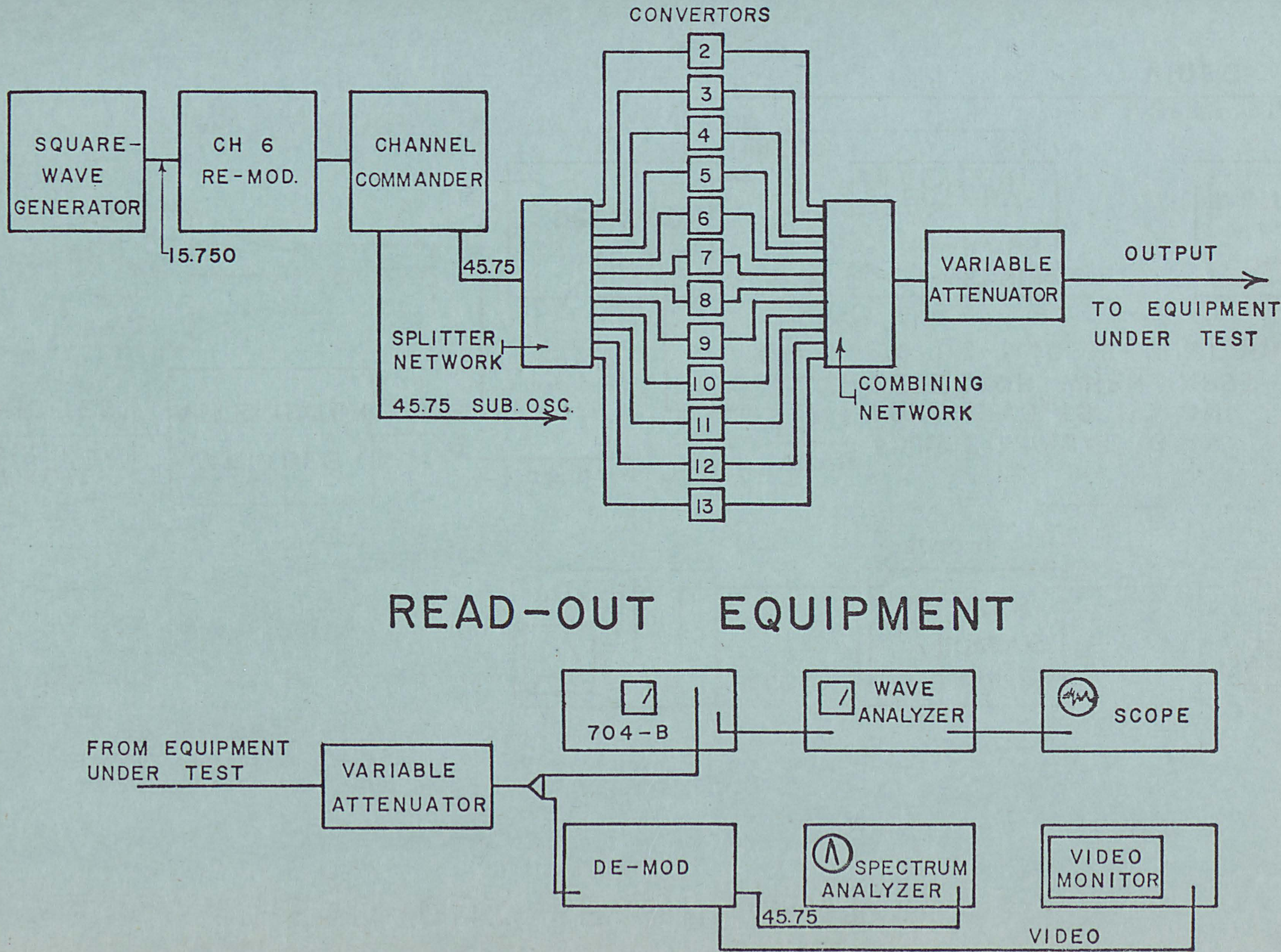


Figure 4

READ-OUT EQUIPMENT

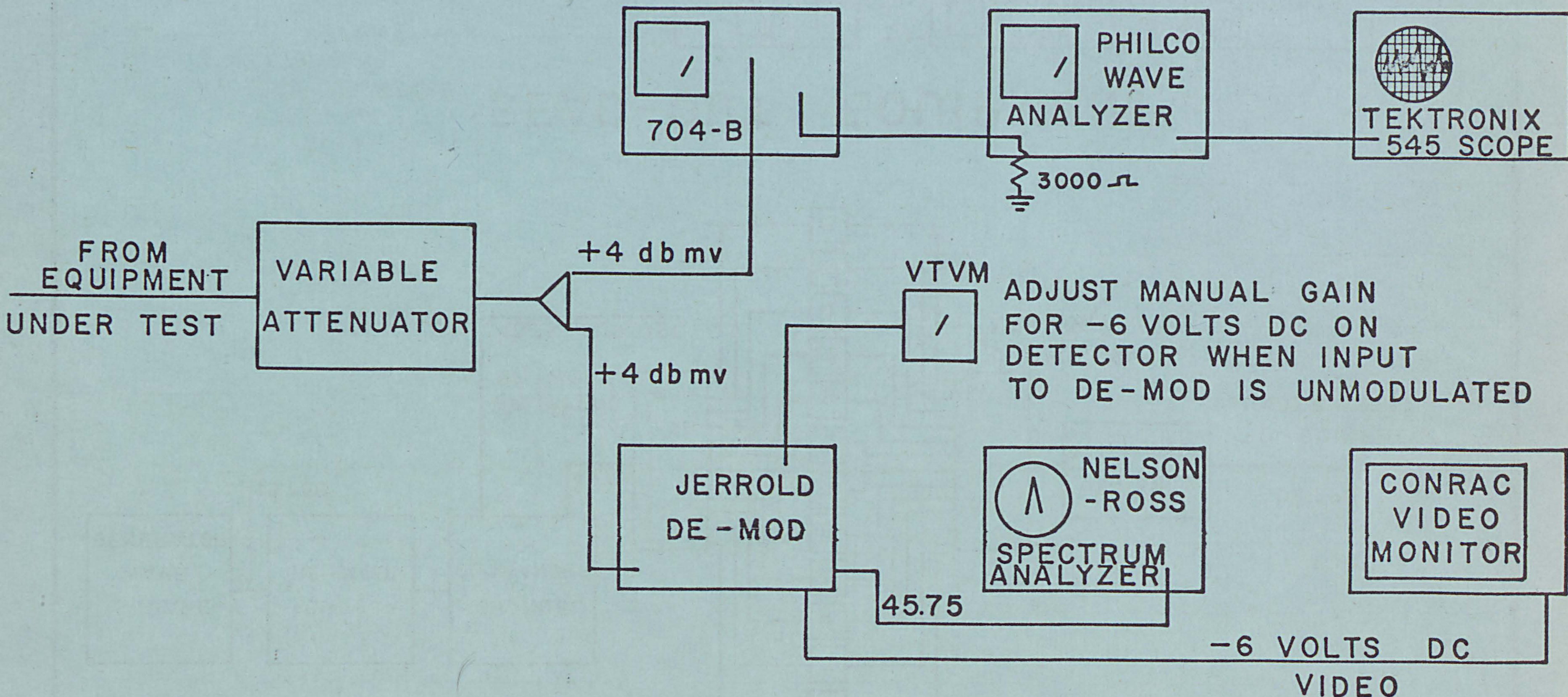
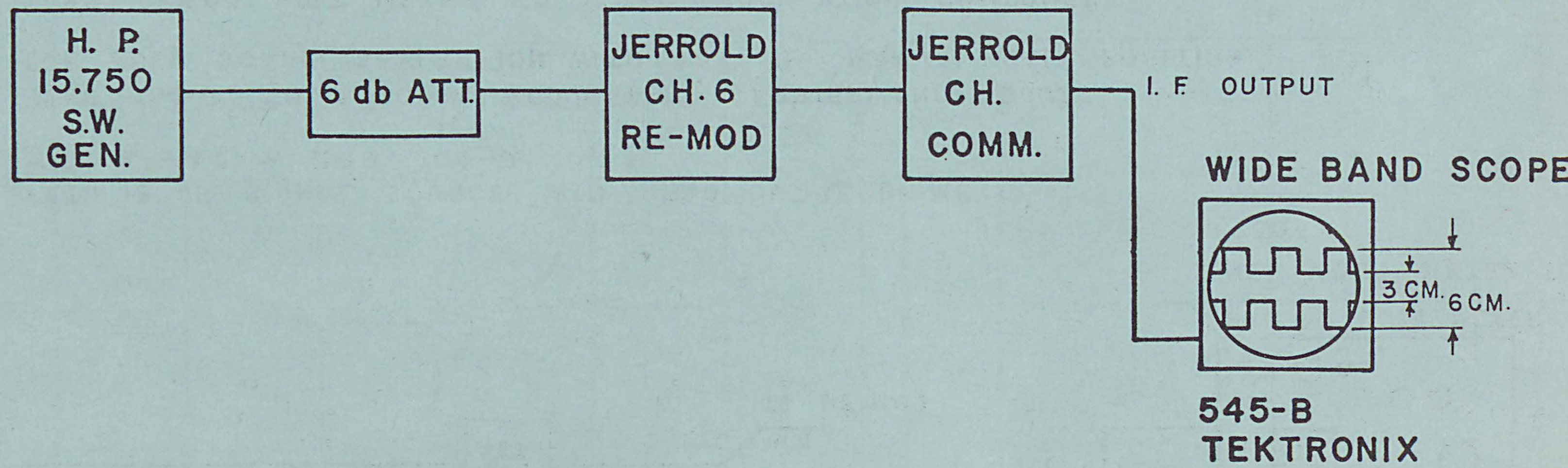


Figure 5

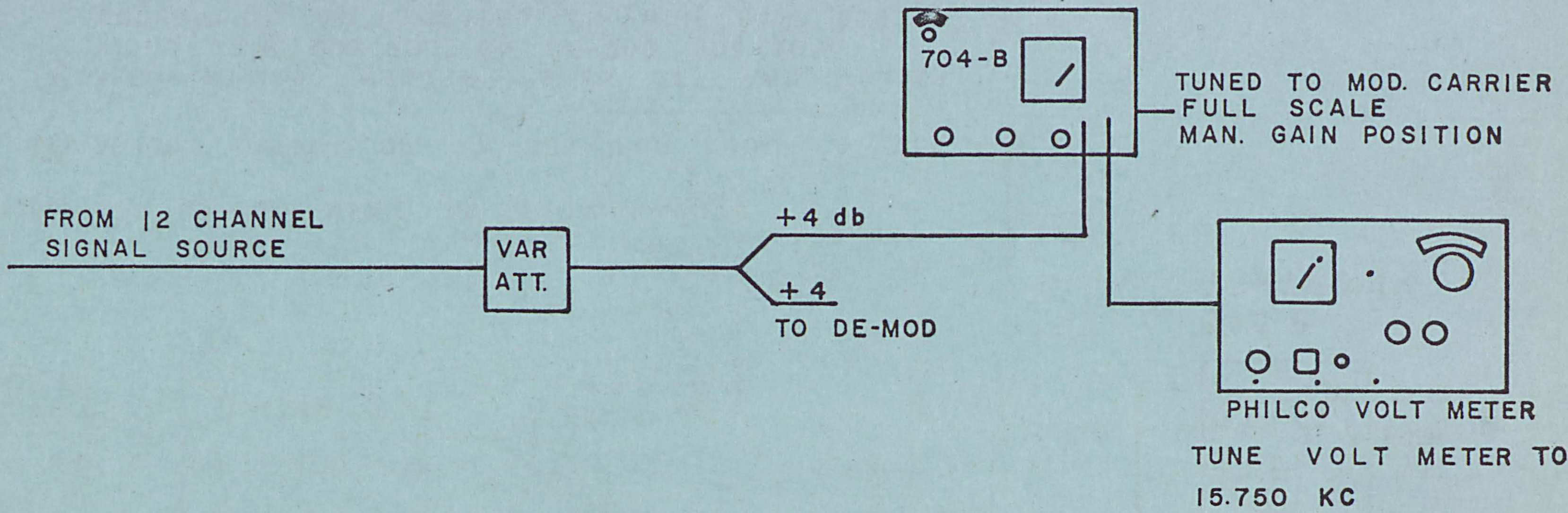
CALIBRATING % OF MODULATION



1. SET UP EQUIPMENT AS SHOWN ABOVE
2. ADJUST OUTPUT OF S.W. GEN. FOR ABOUT 1 VOLT
3. FEED RE-MOD THROUGH 6 db ATT. AND ADJUST VIDEO GAIN CONTROL ON RE-MOD FOR 50% MODULATION AS INDICATED ON WIDE BAND SCOPE
4. REMOVE 6 db ATT. MODULATION IS NOW 100%

Figure 6

CALIBRATING OUT ERRORS DUE TO THE NON-LINEAR 704 DETECTOR AND MODULATION ERRORS DUE TO INABILITY OF RE-MOD TO BE MODULATED AT 100%



1. FEED 12 CH. SIGNAL SOURCE INTO READ OUT EQUIPMENT WITH A +4 dbmv INTO 704-B.

2. TUNE 704-B TO A 100% MODULATED CARRIER AND ADJUST FOR FULL SCALE DEFLECTION WITH 704 IN MANUAL GAIN POSITION.

3. TUNE PHILCO VOLT METER TO 15.750 MODULATION COMPONENT.

4. SWITCH IN 60 db ATTENUATOR ON FRONT OF 15.750 S. W GEN.

5. SWITCH OUT 60 db OF ATTENUATION ON PHILCO VOLT METER AND ADJUST CALBRATION CONTROL FOR A "0" READING

6. RETURN ATTENUATORS TO NORMAL. AT THIS POINT THERE WILL BE A SLIGHT ERROR IN ATTENUATOR TRACKING DUE TO ERRORS STATED ABOVE, BUT EQUIPMENT HAS BEEN CALIBRATED AT THE MODULATION LEVEL AT WHICH IT WILL BE USED. (-60 db REGION)

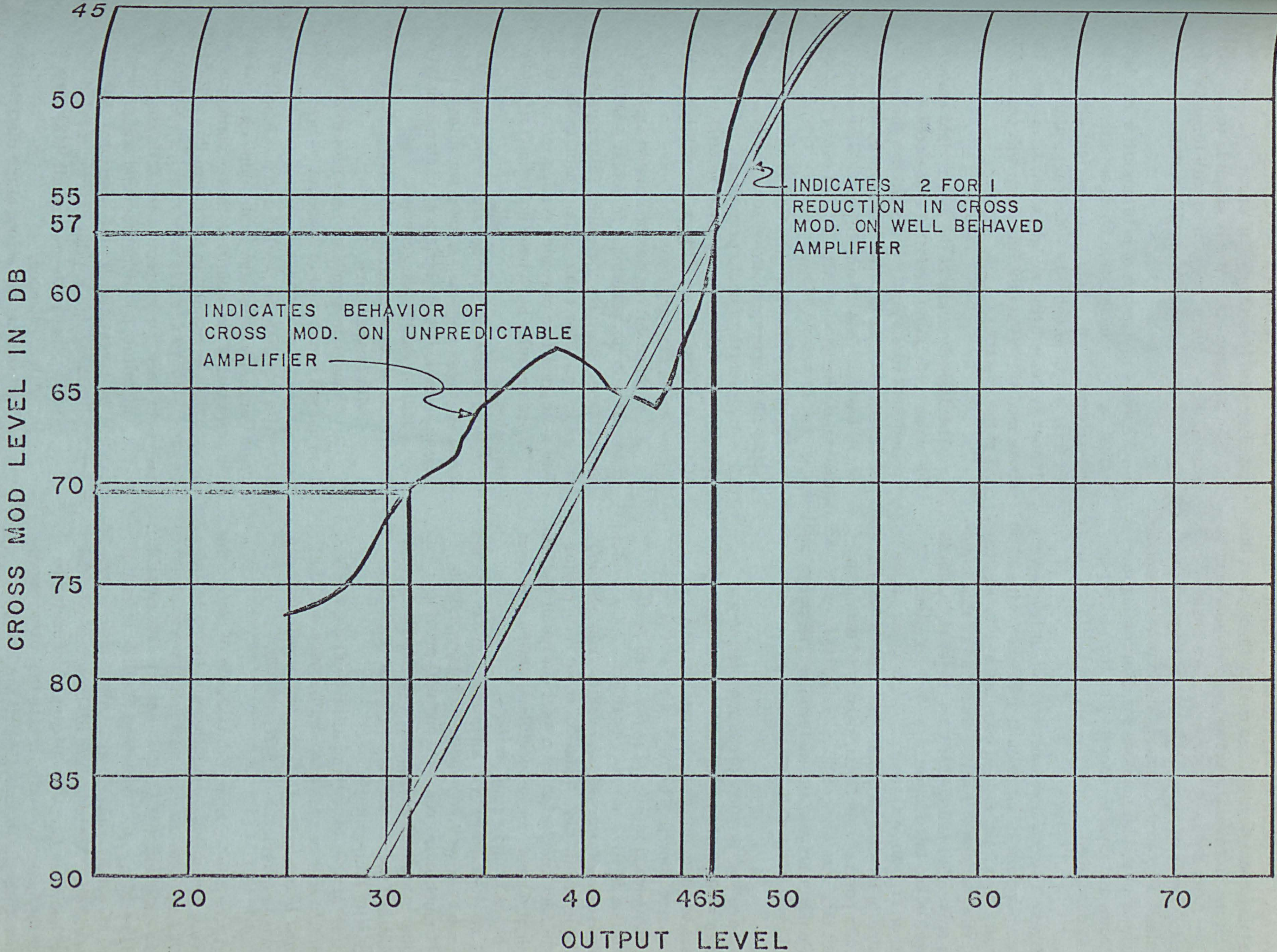

45
50
55
57
60
65
70
75
80
85
90
CROSS MOD LEVEL IN DB
20
30
40
46.5
50
60
70
OUTPUT LEVEL
INDICATES 2 FOR I REDUCTION IN CROSS MOD. ON WELL BEHAVED AMPLIFIER
INDICATES BEHAVIOR OF CROSS MOD. ON UNPREDICTABLE AMPLIFIER

Figure 7

We have experienced significant problems in maintaining consistent picture quality throughout the temperature extremes in our area. A typical day will vary from 35° to 65° which is more constant than many areas of the country. In attempting to understand why we were having these problems and to discover practical methods for overcoming them, Bob Brown and myself embarked on the project he has just described.

Figure 1 shows how input and output levels vary with temperature in a 3 amplifier cascade with 22 db spacings. The input is held constant at plus 31 dbmv. The variations are caused by changes in cable attenuation only. You will notice the largest variation is the input of the third amplifier which is a total change of 11.7 db AGC range. The largest output variation is the second amplifier which is 7.8 db. The main point of this illustration is to establish the fact that with perfect amplifiers, changes in cross modulation and signal-to-noise will occur due to cable variations only.

Figure 2 shows how cross modulation and signal to noise ratio varies with temperature in a cascade of 10 amplifiers. Three different systems are shown. The first is no AGC amplifiers, the second is AGC at every third position and the last is AGC at every position. In the system with no AGC, total cross mod varies from -84.5db to -37.8db or 46.7db. Signal-to-noise ratio varies from 58.35db to 42.97db or a total change of 16.38db. This is of course, an impossible situation even in a short cascade of 10 amplifiers.

If we AGC every 3rd. amplifier you can see that cross mod varies 7.7db and S/N changes 6.57db. This is much more realistic and will provide a practical system if temperature variations are not too wide and the amplifier's response doesn't change with temperature.

If we AGC at every amplifier position, cross modulation will remain constant because output at all amps is constant. Only the inputs will vary and this causes a variation in S/N of 3.9db.

Figure 3 is a graph with two sets of curves that illustrate how cross modulation and signal to noise ratio change with temperature and cascade length. This is a system that is AGC'd every 3rd. amplifier and all spacings are 22db. The amplifiers have a maximum output capability of 48dbmv and a noise figure of 8db. The top curve of the cross mod set is -20° and each curve is 30° steps increasing to 130° at the bottom. You will note that cross mod changes in the first amplifier, at the lower left corner of the graph, are almost as great as the cross mod changes at the tenth amplifier.

The curves become straight lines after the tenth amplifier with less than 0.5db error.

The primary point of this graph is to show that most of variations in cross mod with temperature occur in the first amplifiers in the system.

Figure 4 is a graph of a 10 amplifier cascade illustrating cross modulation changes with temperature and cascade length. This is a practical situation where the first length of cable is 40db long, which is typical of most systems using a high output head end. The total cross mod variation is 9.7db which will continue to the end of the system.

The dashed curves at the upper right corner, are the cross modulation variation that would occur if we applied AGC to the first six amplifiers thereby limiting the variation to 3.5db. The variation in cross mod for a longer cascade than 10 amplifiers will be approximately the same. Balance of amps AGC'd every 3 RD amp.

Figure 5 shows the variation of signal to noise ratio with temperature and cascade length. This also has a 40db length of cable preceding the first amplifier. We are using AGC at every third amplifier. If we use AGC at the first six amplifiers, we will have some improvement in the variations.

All of these curves assume stable amplifier performance with temperature. In actual practice this is not the case. We have measured an average of 6db errors in amplifier cable equalization in the chamber with a 10 amplifier cascade, cycling from 0° to 120°.

These results have been confirmed in actual system operation.

Most of our experience is with low band AGC systems. In these systems we have found that the low band remains stable but the high band varies with temperature. This is due to two reasons.

1. Improper system cable equalization changes with temperature.
2. Changes in amplifier response with temperature.

This causes cross mod to increase when the temperature drops and vice-versa.

The ideal solution would be to use amplifiers that would correctly follow the cable slope changes with temperature. I feel confident that manufacturers will be supplying equipment in the future that will do this. However, our problem is with existing systems. We have stabilized our system by the following methods.

1. Installing additional thermal equalizers where our layout allowed the additional insertion loss.
2. By changing the pilot carrier level at the head end to change the gain of all AGC units as temperature changes.
3. By lowering the output of the distribution amplifiers and line extenders that are past the 15th. trunk amp by 2db. This gives us a little more tolerance to the changing levels.

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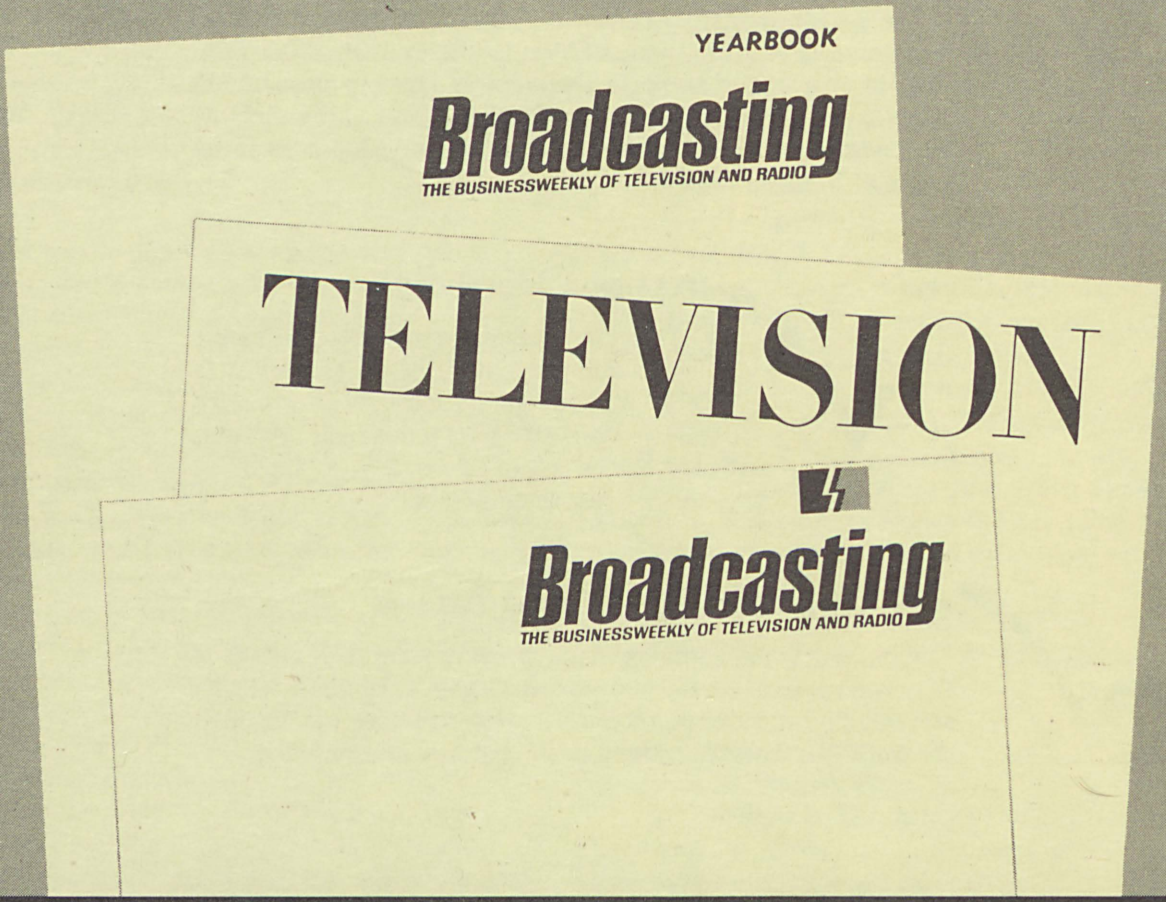

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A system with high band AGC, compared to a system with low band AGC that has the same temperature problems, will perform better. This is because the high band is operating at a higher level with more channels and is the major contributor to cross mod. % of contribution LO = MI =. By holding the high band constant with AGC and allowing the low band to vary, much less visible changes in picture quality will occur. I believe the ideal system is pilot carriers in both high and low bands with active closed loop control on both gain and tilt. This would allow much less critical amplifier design as far as temperature is concerned.

During the equipment evaluation program, the most outstanding fact that we confirmed is the lack of standard specifications between different manufacturers.

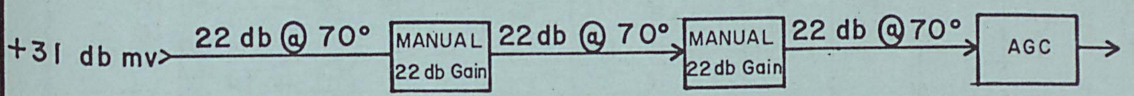
Cross modulation is the most serious difference we found. Our method of measurement, right or wrong, is at least the same for all amplifiers. We have evaluated most of the equipment available and found as much as 15db difference between published output capability and measured output capability. This tells us that it is impossible today to design a system by using published specifications and reliably predict the results, unless we know what basis the specifications are derived from.

We as an association must push hard for the final adoption of the NCTA standard for amplifier output capability and measurement techniques.

We have taken far too long in finalizing this standard. The final form that is adopted is not as important as getting it adopted.

I submit that we must move now to establish additional industry standards for total system performance as soon as possible. These should include system operation under all temperature conditions. The manufacturers could provide leadership in this area by providing more complete data on their equipment and it's application. I doubt very much if all CATV operators are willing to invest the time and money required to test amplifiers and determine for themselves what its limitations are.

Figure 1



TEMP.	IN	OUT	IN	OUT	IN	OUT
130°	7.35	29.35	5.70	27.70	4.05	31.00
100°	8.15	30.15	7.30	29.30	6.45	31.00
70°	9.00	31.00	9.00	31.00	9.00	31.00
40°	9.78	31.78	10.56	32.56	11.34	31.00
10°	10.50	32.50	12.00	34.00	13.50	31.00
-20°	11.25	33.25	13.50	35.50	15.75	31.00

TEMPERATURE		-20°	10°	40°	70°	100°	130°
CABLE ATTENUATION		19.75	20.50	21.22	22.00	22.85	23.65
10 AMPS NO AGC	CROSS MOD.	-37.8	-50.8	-61.2	-71.0	-79.0	-84.5
	S/N	58.35	56.30	53.73	50.00	44.12	42.97
10 AMPS 3 AGC	CROSS MOD.	-66.3	-67.7	-69.3	-71.0	-73.2	-74.0
	S/N	53.91	52.47	51.32	50.00	48.46	47.34
10 AMPS 10 AGC	CROSS MOD.	-71.0	-71.0	-71.0	-71.0	-71.0	-71.0
	S/N	52.25	51.50	50.78	50.00	49.15	48.35

ASSUME

1. 22 db SPACING AT 70°
2. MAXIMUM OUTPUT FOR -57 db CROSSMOD =+48 db mv
3. NOISE FIGURE =+ 8 db
4. AMPLIFIER DOES NOT CHANGE WITH TEMPERATURE
5. ALL LEVELS ARE CHANNEL 13
6. INPUT LEVEL TO ALL SYSTEMS =+31 db mv

Figure 2

Figure 3 NUMBER OF AMPS. IN CASCADE

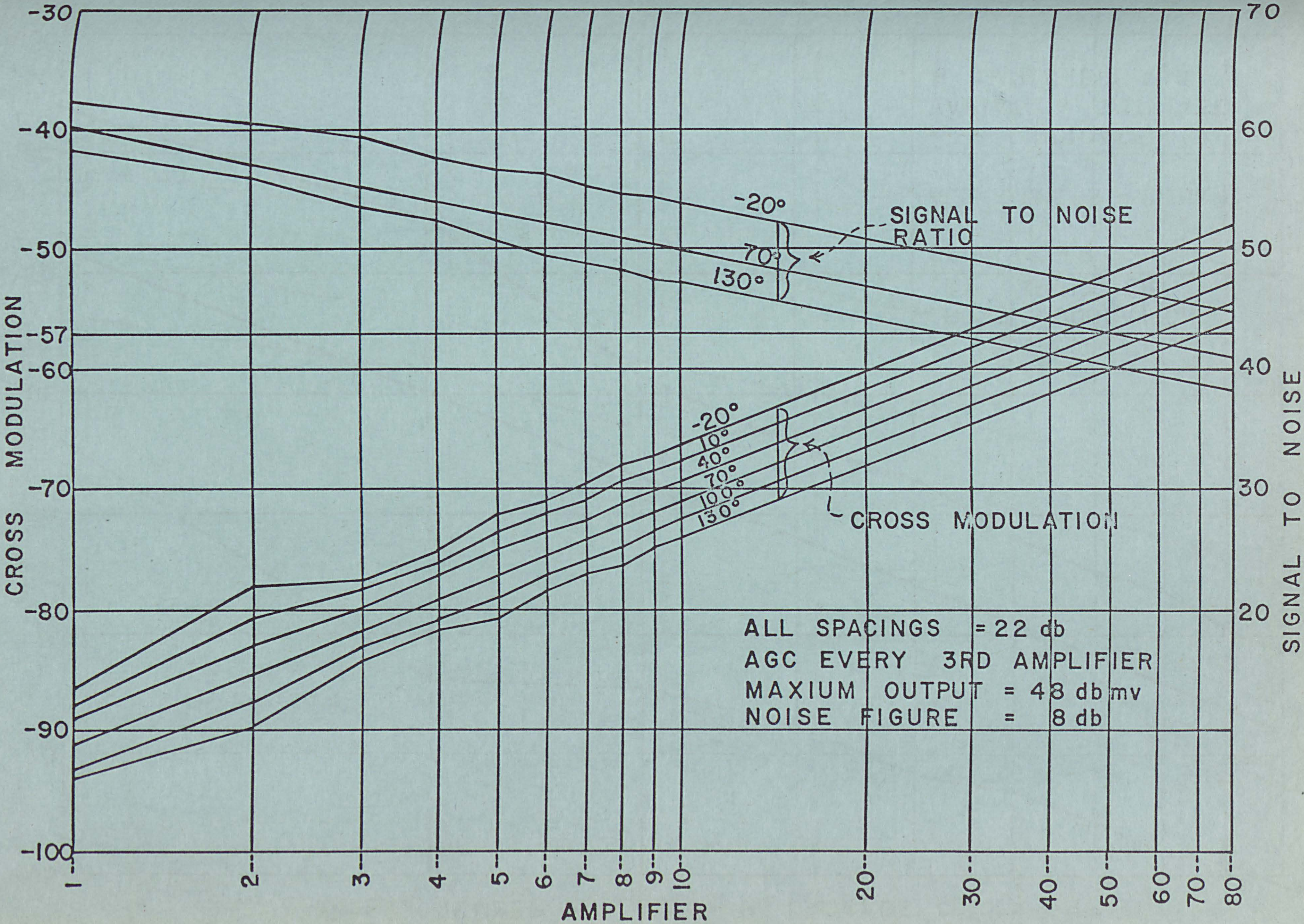


Figure 4 NUMBER OF AMPS. IN CASCADE

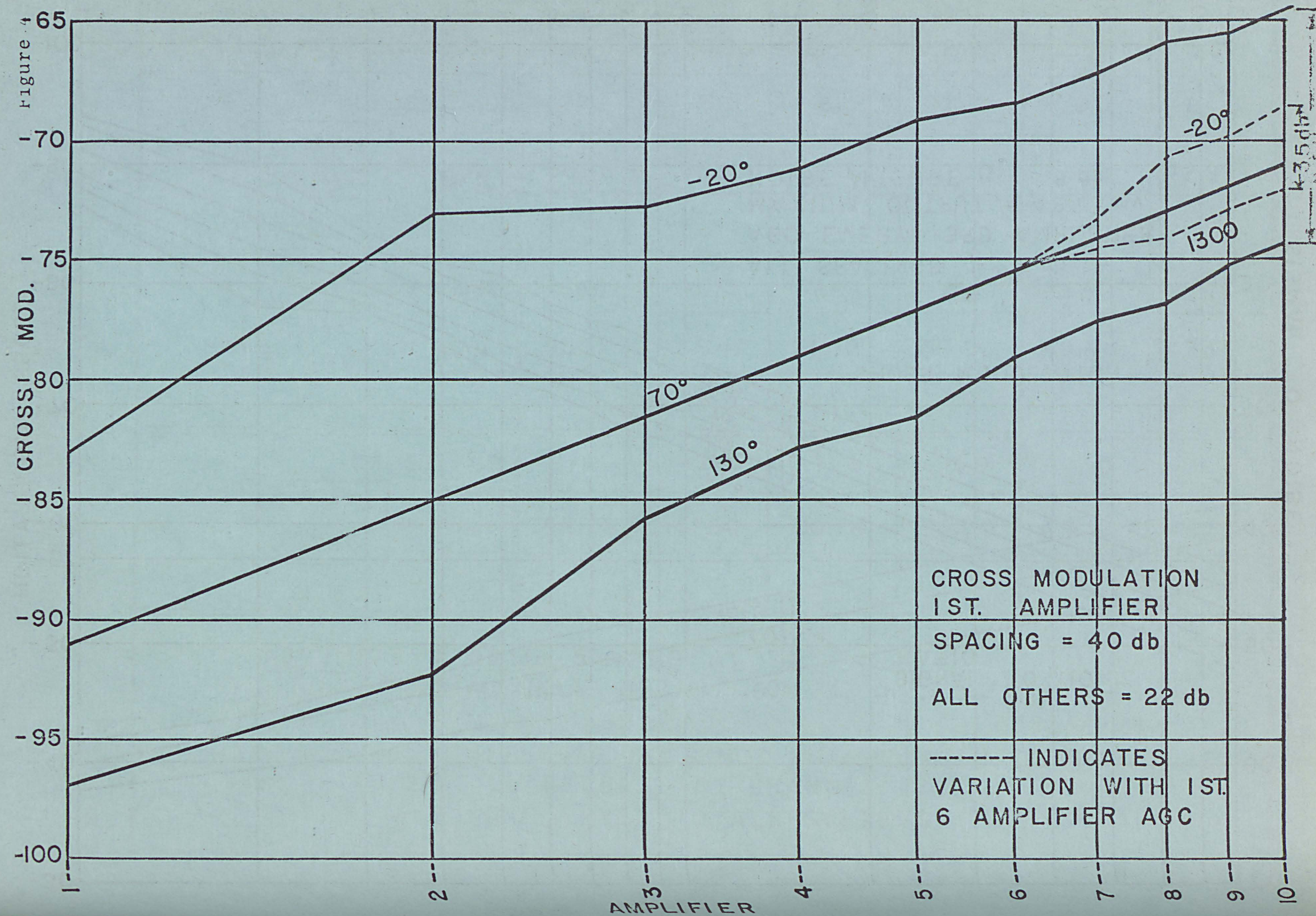
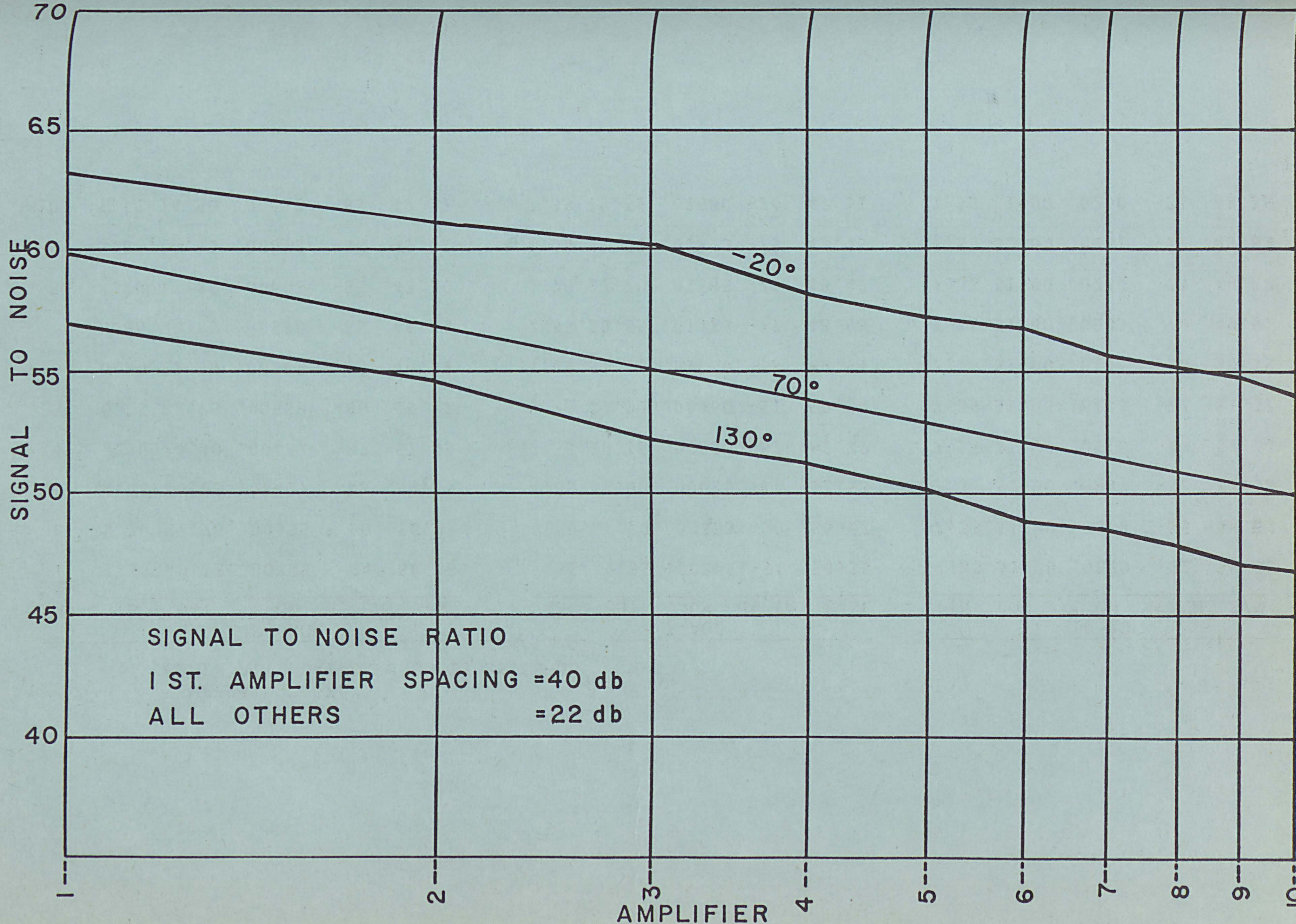


Figure 5 NUMBER OF AMPS. IN CASCADE



TEMPERATURE 130°
CABLE ATTENUATION @ CH-13 23.65 db

AMP	No AGC					3 AGC					10 AGC				
#	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N
1	7.35	29.35	.00205	-94	58.35	7.35	29.35	.00205	-94	58.35	7.35	31.00	.0029	-91	58.35
2	5.70	27.70	.00335	-90	56.07	5.70	27.70	.00335	-90	56.07	7.35	31.00	.0058	-85	55.34
3	4.05	26.05	.00427	-88	54.53	4.05	31.00	.00625	-84	53.53	7.35	31.00	.0087	-82	53.58
4	2.40	24.40	.00492	-87	52.03	7.35	29.35	.00830	-82	52.29	7.35	31.00	.0116	-79	52.34
5	0.75	22.75	.00538	-86	49.17	5.70	27.70	.00960	-81	50.94	7.35	31.00	.0145	-77	51.37
6	-0.90	21.10	.00567	-85	46.59	4.05	31.00	.01250	-78	49.51	7.35	31.00	.0174	-76	50.58
7	-2.55	19.45	.00588	-85	44.43	7.35	29.35	.01455	-77	48.95	7.35	31.00	.0203	-74	49.91
8	-4.20	17.80	.00603	-85	47.30	5.70	27.70	.01585	-76	48.27	7.35	31.00	.0232	-73	49.32
9	-5.85	16.15	.00612	-85	45.21	4.05	31.00	.01875	-75	47.45	7.35	31.00	.0261	-72	48.81
10	-7.50	14.50	.00619	-85	42.97	7.35	29.35	.02080	-74	47.11	7.35	31.00	.0290	-71	48.35

TEMPERATURE 100°
CABLE ATTENUATION % CH-13 22.85 db

AMP #	No AGC					3 AGC					10 AGC				
	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N
1	8.15	30.15	.00230	-93	59.15	8.15	30.15	.00230	-93	59.15	8.15	31.00	.0029	-91	59.15
2	7.30	29.30	.00435	-88	56.52	7.30	29.30	.00435	-86	56.52	8.15	31.00	.0058	-85	56.14
3	6.45	28.45	.00598	-85	53.94	6.45	31.00	.00725	-83	53.94	8.15	31.00	.0087	-82	54.38
4	5.60	27.60	.00728	-83	52.07	8.15	30.15	.00955	-81	52.79	8.15	31.00	.0116	-79	53.14
5	4.75	26.75	.00838	-82	50.53	7.30	29.30	.01160	-79	51.71	8.15	31.00	.0145	-77	52.17
6	3.90	25.90	.00930	-81	49.18	6.45	31.00	.01450	-77	50.67	8.15	31.00	.0174	-76	51.38
7	3.05	25.05	.01003	-80	47.96	8.15	30.15	.01680	-76	50.10	8.15	31.00	.0203	-74	50.70
8	2.20	24.20	.01061	-80	45.88	7.30	29.30	.01885	-75	49.49	8.15	31.00	.0232	-73	50.13
9	1.35	23.35	.01113	-80	45.00	6.45	31.00	.02175	-74	48.85	8.15	31.00	.0261	-72	49.62
10	0.50	22.50	.01154	-79	44.12	8.15	30.15	.02405	-73	48.46	8.15	31.00	.0290	-71	49.15

TEMPERATURE 70°
CABLE ATTENUATION % CH-13 22.00 db

AMP #	No AGC					3 AGC					10 AGC				
	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N
1	9	31	.0029	-91	60										
2	9	31	.0058	-85	56.99										
3	9	31	.0087	-82	55.23										
4	9	31	.0116	-79	53.98										
5	9	31	.0145	-77	53.00			S A M E					S A M E		
6	9	31	.0174	-76	52.22										
7	9	31	.0203	-74	51.55										
8	9	31	.0232	-73	50.97										
9	9	31	.0261	-72	50.46										
10	9	31	.0290	-71	50.00										

TEMPERATURE 40°
CABLE ATTENUATION @ CH-13 21.22 db

AMP #	No AGC					3 AGC					10 AGC				
	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N
1	9.78	31.78	.00365	-89	60.78	9.78	31.78	.00365	-89	66.78	9.78	31.00	.0029	-91	60.78
2	10.56	32.56	.00775	-83	58.15	10.56	32.56	.00775	-83	58.15	9.78	31.00	.0058	-85	57.77
3	11.34	33.34	.01295	-78	56.75	11.34	31.00	.01065	-80	56.75	9.78	31.00	.0087	-82	56.01
4	12.12	34.12	.01875	-75	55.85	9.78	31.78	.01430	-77	55.29	9.78	31.00	.0116	-79	54.77
5	12.90	34.90	.02605	-72	55.21	10.56	32.56	.01840	-75	54.17	9.78	31.00	.0145	-77	53.80
6	13.68	35.68	.03425	-70	54.75	11.34	31.00	.02130	-74	53.56	9.78	31.00	.0174	-76	53.01
7	14.46	36.46	.04455	-67	54.40	9.78	31.78	.02495	-73	52.80	9.78	31.00	.0203	-74	52.34
8	15.24	37.24	.05615	-66	54.12	10.56	32.56	.02905	-71	52.26	9.78	31.00	.0232	-73	51.77
9	16.02	38.02	.07095	-63	53.90	11.34	31.00	.03195	-70	51.85	9.78	31.00	.0261	-72	51.26
10	16.80	38.80	.08915	-61	53.73	9.78	31.78	.03560	-69	51.32	9.78	31.00	.0290	-71	50.78

TEMPERATURE 10°
CABLE ATTENUATION @ CH-13 20.50 db

	No AGC					3 AGC					10 AGC				
AMP #	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N
1	10.50	32.50	.00410	-88	61.50	10.50	32.50	.00410	-88	61.50	10.50	31.00	.0029	-91	61.50
2	12.00	34.00	.00980	-81	59.17	12.00	34.00	.00980	-81	59.17	10.50	31.00	.0058	-85	58.49
3	13.50	35.50	.01810	-75	57.95	13.50	31.00	.0127	-78	57.95	10.50	31.00	.0087	-82	56.73
4	15.00	37.00	.02970	-71	57.31	10.50	32.50	.0168	-76	56.65	10.50	31.00	.0116	-79	55.49
5	16.50	38.50	.04620	-67	57.00	12.00	34.00	.0226	-74	55.74	10.50	31.00	.0145	-77	54.52
6	18.00	40.00	.06920	-64	56.74	13.50	31.00	.0255	-73	55.20	10.50	31.00	.0174	-76	53.73
7	19.50	41.50	.10170	-60	56.56	10.50	32.50	.0296	-71	54.08	10.50	31.00	.0203	-74	53.06
8	21.00	43.00	.14770	-57	56.44	12.00	34.00	.0354	-69	53.55	10.50	31.00	.0232	-73	52.49
9	22.50	44.50	.20570	-54	56.36	13.50	31.00	.0383	-69	53.21	10.50	31.00	.0261	-72	51.98
10	24.00	46.00	.29570	-51	56.30	10.50	32.50	.0424	-68	52.47	10.50	31.00	.0290	-71	51.50

TEMPERATURE -20°
CABLE ATTENUATION @ CH-13 19.75 db

AMP	No AGC					3 AGC					10 AGC				
#	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N	IN	OUT	% CM	db CM	S/N
1	11.25	33.25	.00485	-87	62.25	11.25	33.25	.00485	-87	62.25	11.25	31.0	.0029	-91	62.25
2	13.50	35.50	.01305	-78	60.24	13.50	35.50	.01305	-78	60.24	11.25	31.0	.0058	-85	59.24
3	15.75	37.75	.02685	-72	59.36	15.75	31.00	.01334	-78	59.36	11.25	31.0	.0087	-82	57.48
4	18.00	40.00	.04985	-66	58.91	11.25	33.25	.01819	-75	57.56	11.25	31.0	.0116	-79	56.21
5	20.25	42.25	.08835	-61	58.66	13.50	35.50	.02639	-72	56.75	11.25	31.0	.0145	-77	55.24
6	22.50	44.50	.15235	-57	58.52	15.75	31.00	.02929	-71	56.34	11.25	31.0	.0174	-76	54.45
7	24.75	46.75	.26235	-52	58.44	11.25	33.25	.03414	-70	55.35	11.25	31.0	.0203	-74	53.78
8	27.00	49.00	.44735	-47	58.39	13.50	35.50	.04234	-68	54.86	11.25	31.0	.0232	-73	53.21
9	29.25	51.25	.75735	-43	58.36	15.75	31.00	.04524	-67	54.59	11.25	31.0	.0261	-72	52.70
10	31.50	53.50	1.33735	-38	58.35	11.25	33.25	.05009	-66	53.91	11.25	31.0	.0290	-71	52.25

Cable to first AMP = 40 db @ 70°, 35.8 db @ -20° and 43.0 db @ 130°
All other spacings = 22 db @ 70°, 19.75 db @ -20° and 23.65 db @ 130°

AMP #	-20° IN	-20° OUT	-20° % CM	-20° db CM	-20° S/N	130° IN	130° OUT	130° % CM	130° db CM	130° S/N
1	13.20	35.20	.0073	-83	63.20	6.0	28.00	.00147	-97	57.00
2	15.45	37.45	.0230	-73	61.15	4.35	26.35	.00250	-92	54.74
3	17.70	31.00	.0232	-73	60.27	2.70	31.00	.00540	-86	52.20
4	11.25	33.25	.0281	-71	58.14	7.35	29.35	.00745	-83	51.26
5	13.50	35.50	.0363	-69	57.24	5.70	27.70	.00875	-82	50.16
6	15.75	31.00	.0392	-68	56.76	4.05	31.00	.01165	-79	48.94
7	11.25	33.25	.0441	-67	55.68	7.35	29.35	.01370	-78	48.47
8	13.50	35.50	.0523	-66	55.14	5.70	27.70	.01500	-77	47.86
9	15.75	31.00	.0552	-66	54.85	4.05	31.00	.01790	-75	47.10
10	11.25	33.25	.0601	-65	54.13	7.35	29.35	.01995	-74	46.89

CHAIRMAN TAYLOR: Thank you both very much. (Applause) Are there some questions?

MR. KEN SIMONS: This is not exactly a question but I would like to take this opportunity to thank Jerry and Bob for an excellent paper. I would also like to express the hope that their pioneer effort shows the way toward a future in which CATV equipment will be sold based on specifications measured by both the supplier and the user. Our industry must grow past the era of extravagant claims into one of solid engineering accomplishment.

CHAIRMAN TAYLOR: Thank you again very much. Bob, please accept my apologies for omitting your name from the program.

We will now move on to the final paper of the afternoon. Mr. William Rheinfelder received his M.S.E.E. degree from the Institute of Technology in Munich, Germany. For the past two years he has been director of research and development at Anaconda Astrodata. From 1960 to 1964 he was with Ameco as director of research and development. Prior to his entry into the CATV field, Mr. Rheinfelder was staff scientist for communications research at Motorola Semiconductors. Mr. Rheinfelder is a senior member of the I.E.E.E., the S.M.P.T.E. and a member of the A.E.S. Mr. Rheinfelder will speak on the subject of "Distortion Measurement Techniques for CATV."