Cable TV System Calculator

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INTRODUCTION.

If someone who is not familiar with Cable T.V. would ask me what planning a Cable T.V. system is like, my answer would be: it is very much like playing chess. Before you make a move you have to consider all the consequences of that move, as well as the consequences of the moves you plan to take thereafter.
To illustrate this, fig 1 shows a typical situation.

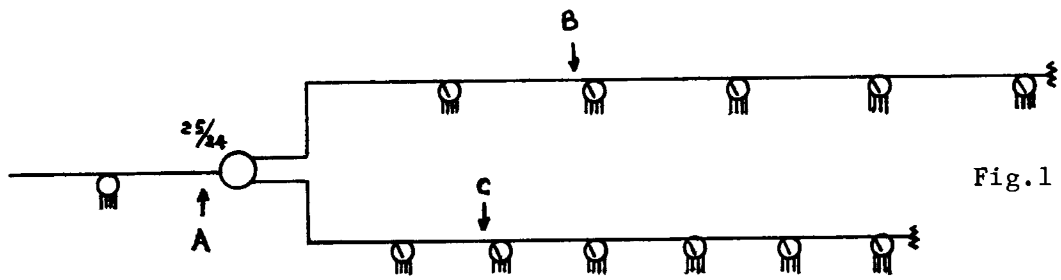


Fig.1

Signals arrive at the cable split with +25dBmV at ch 13 and +24dBmV at ch2. By merely splitting the signal amplifiers are required at point B and point C.
However, with one amplifier before the splitter at point A, this one amplifier is able to serve these two branches.
Fig. 2 shows the computation required to find out where the signal needs reamplification. Roughly three times as much effort is required to conclude that one amplifier would suffice.

CH 13 LINE	TAP	CH 2 LINE	TAP		CH 13 LINE	TAP	CH 2 LINE	TAP	
25.00		24.00			25.00		24.00		
3.30		3.30		SPLITTER	3.30		3.30		SPLITTER
-----		-----			-----		-----		
21.70		20.70			21.70		20.70		
1.70		.85		100FT .412	2.50		1.30		150FT .412
-----		-----			-----		-----		
20.00	10.00	19.85	9.85		19.20	9.20	19.40	9.40	
3.30		3.30		4-10 TAP	3.30		3.30		4-10 TAP
-----		-----			-----		-----		
16.70		16.55			15.90		16.10		
1.70		.85		100FT .412	2.50		1.30		150FT .412
-----		-----			-----		-----		
15.00	X	15.70	X		13.40	X	14.80	X	

Fig.2

From this example it is rather obvious that an aid to take over the time consuming calculations would be highly desirable.

COMPUTER ASSISTED DESIGN

A computer therefore, which in a split second could perform these calculations and come up with the optimum solution would be very helpful.
However, we must realize that the "Cable T.V. system computer" faces the same problems as his cousin the "chess playing computer".
The basic problem in programming a computer to play chess is in teaching the machine to be selective in the possible lines of play it considers. Where the human player is able to reject over 95% of possible continuations, the computer must labour through all variations before making a selection.
There are ofcourse more possible alternatives to consider by the "chess playing computer" than by the "Cable T.V. system computer".
To be precise there are six major alternatives to consider:

a. a splitter.
b. an amplifier followed by a splitter.
c. a directional coupler (-8dB) with the branch line pointing down.
d. a directional coupler (-8dB) with the branch line pointing up.
e. an amplifier + a dir.coupler (-8dB) with the branch line down.
f. an amplifier + a dir.coupler (-8dB) with the branch line up.

In a section of a distribution system with 16 cable splits, there are 6^{16} different combinations, (2.82×10^{12}). Allowing 1 m sec. for the computer to calculate the effect of one change we will have our answer in 89 years. This example illustrates that the computer, though fast, cannot consider all possibilities; it must therefore, as we stated earlier, be selective in it's choice removing the assurance that all possible alternatives were tried.

THE OPTIMUM SYSTEM.

In attempting to write specifications for an optimum design, four aspects need to be considered:

a. signal quality.
b. reliability.
c. maintenance cost.
d. initial cost.

A low cost system could have pieces of .412" and .500" intermixed, but for the sake of standardization this is not done. Each amplifier could be set to operate at nonstandard levels even while keeping an eye on distortion products. However, for the sake of standardization this too is unacceptable. House drops at -6dBmV could provide acceptable pictures, but out of consideration for older sets, safety factors, direct pick-up and possible second sets, this is not done. Even the most important cost factors such as amplifier operating and subscriber drop levels as well as the maximum number of "distribution line amplifiers in cascade" are compromises between these four previously mentioned aspects. Making these cost determining factors rigid, as one has to do when they are entered as design parameters in a computer program, may result in poor "trade offs".

Let me illustrate: Raising the minimum "tap Off" level by 1dB in a typical distribution line having seven 4 way tap off units spaced 100 ft. apart, will reduce the amplifier spacing by approximately 7%. Guaranteeing this new minimum level for 28 subscribers, based on an amplifier cost of $175.00 would cost approximately $\frac{7}{100} \times \$175 \times \frac{1}{28} =$ $ 0.44/dB/subscriber, which can be considered a reasonable compromise.
However, if at the end of a distribution line the signal would dip below its specified minimum, an additional amplifier would be required because 4 subscriber levels were .5dB below specification. Then the cost is $87.50/dB/subscriber, which should be considered a very poor trade off.
Had the "human touch" been involved this situation would have been spotted immediately, and one of the following possible alternative routes could have been taken:

a. permit the .5dB low subscriber level.
b. lower loss drop cable.
c. amplified tap.
d. indoor amplifier.
e. low power line extender.

Other areas where it is difficult to let the computer decide are where the requirements may alter because of:

a. new subdivisions.
b. possible rezoning of build-up areas.
c. difficulties in obtaining "right of ways".

To let the computer decide would require the programmer to establish probability factors which may be more difficult to determine than to solve the problem itself.

A CALCULATOR?

But up to now there has not been much choice. It is either a slow planner or a "fast" computer, and the cost per mile stayed somewhat the same. Yet a combination of a planner doing the design and a calculator performing the routine calculations appears to have merit. Such a calculator (preferably a desk type) must be capable of the following:

a. accepting input level information.
b. accepting cable type and length information between taps as well as from tap to TV set.
c. being programmed for required minimum level at TV set.
d. instantaneously providing tap off type and value.
e. working in reverse direction (from the end of a line).
f. retaining previously entered data when changes are made.
g. accepting a wide choice of dir.couplers and taps.
h. recording R.F. levels.

Almost all of these requirements could be met by a panel as shown in figure 3.

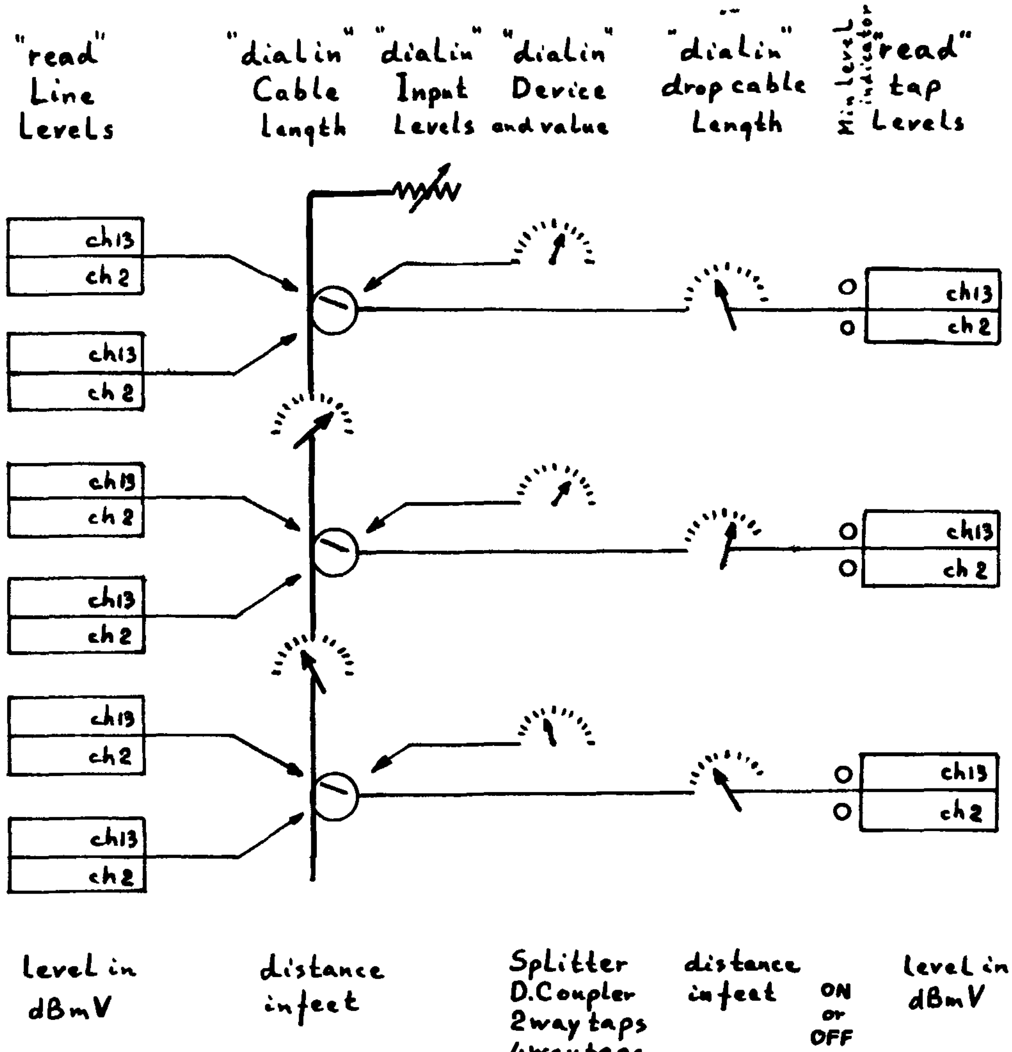


Fig.3

Input level is set with control and is displayed in the first window under "Line Levels". The largest drop cable length is "dialed in" for the first tap, and, subject to the setting of the "device knob" the tap level will now appear in the first window under "tap level". The "device knob" is set for the type of tap-off e.g. 2 way taps and then rotated to a value until both red lights have just extinguished. This process is repeated for each tap-off. When this calculator is requested to work in the reverse direction a feedback loop is required to maintain the last tap level at it's preset levels by controlling the input level.

a. In order to make a panel like this function, simulation can be achieved with RF through the use of high loss cable, switchable attentators, and digital read-cut RF level meters.

This possible solution is obviously too cumbersome.

b. Direct Current can be used. In order to prevent the wide dynamic ranges a current scale whould be chosen where each dB equals 10 mA.
   All attenuating devices can now be represented by parallel resistors which are connected to ground,(providing that a constant voltage source is used as a supply) assuring a fixed current through each component according to the attenuation in dB of the device it simulates.
   All contacts, plugs and sources need to be constructed in duplicate to simulate ch 2 & ch 13 operation simultaneously.
c. Similarly one dB can be represented by 1V, in which case a constant current source should be employed and each component be simulated by a series resistor, providing a fixed voltage drop according to the attenuation in dB of the device it simulates.

b and c are far simpler than the RF simulation technique; however these methods still leave much to be desired.

A MECHANICAL CALCULATOR?

Could it be that a mechanical-graphical method will out-perform electronics to serve RF distribution calculations?
The basis is a graph as shown in fig.4 with signal level at ch 2 p and ch 13 p plotted along the axes; each point on this graph will then represent a certain signal condition. The point marked A on this graph 41/34 respectively representing ch 13 p and ch 2 p carrier levels, is a typical output for a four way bridger amplifier.

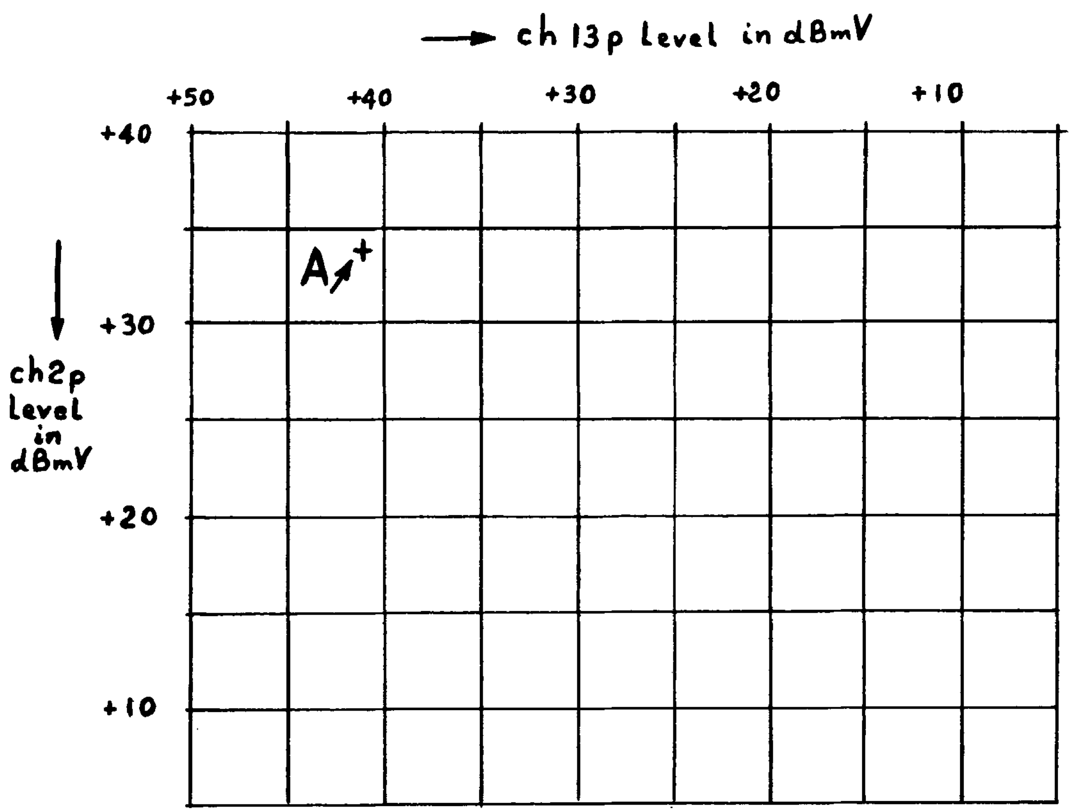


Fig.4

A cable run as shown in fig.5 can be plotted on the original graph. see fig.6

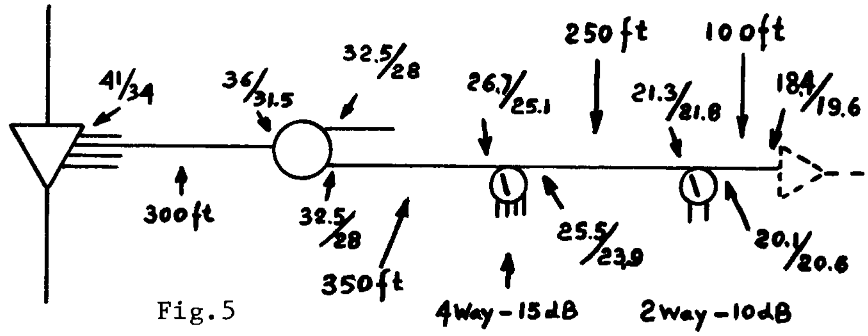


Fig.5

The first 300 ft. cable piece is represented by a straight line between it's input levels of 41/34 and it's output levels of 36/31.5. The 2 way splitter is represented by a straight line between it's input levels of 36/31.5 and it's output levels of 32.5/28. The other levels are represented similarly. It should be noted that the lines representing the flat losses of the splitter and taps have a 45 degree slope on the graph, while the lines representing cable are nearer 30 degree.

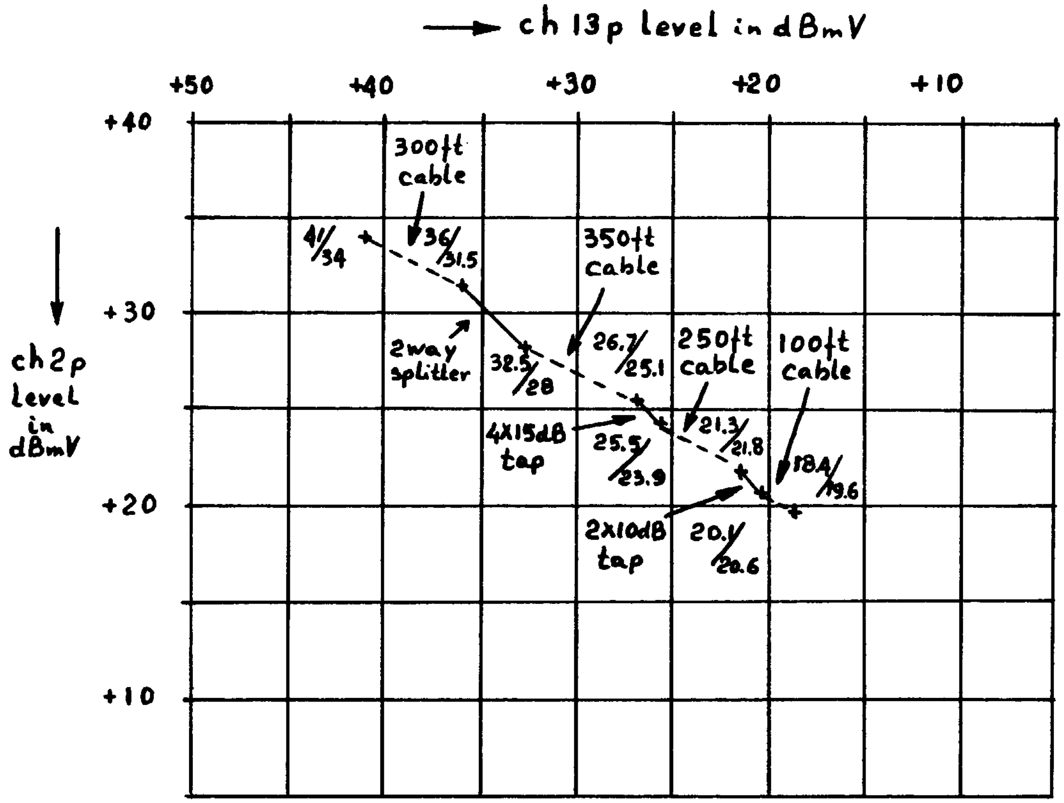


Fig.6

The graph can contain more information. Figure 7 shows the 2 way 10dB tap again; the horizontal dimension of that square represents the through loss at ch 13p; the vertical dimension represents the through loss at ch 2p.

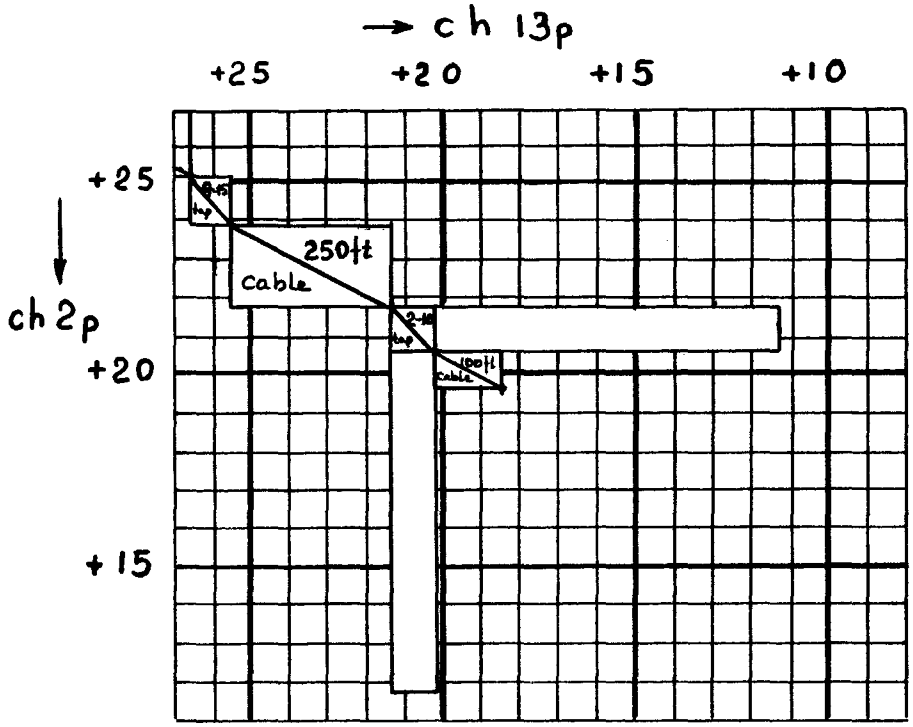


Fig.7

By changing the square to an L shape, through the addition of two rectangles as drawn, the tap off levels as well as the output levels can be read off the graph.
This is achieved by making the horizontal leg equal to the tap off loss at ch 13 and by making the length of the vertical leg equal to the tap off loss at ch 2.
A plastic module in the shape of an L can therefore be placed on the graph (see fig.8), indicating input, output, and tap off levels.
Other L shaped modules representing other taps, dir. couplers and cables can also be placed on the graph and by sliding them together the signal flow and levels can be observed.

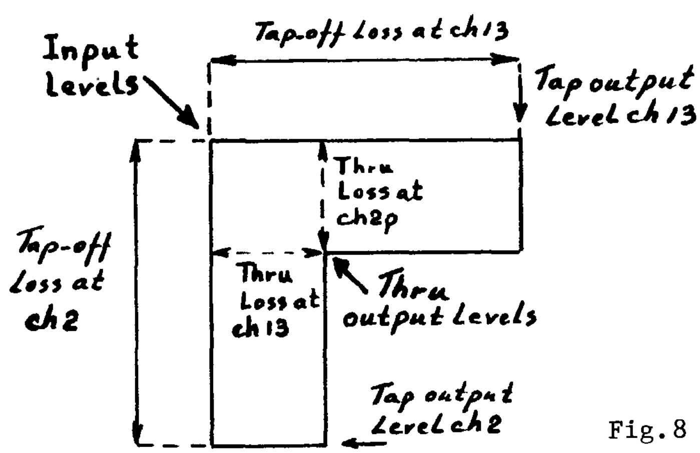


Fig.8

Once the required minimum tap off levels are established for the typical case (e.g. 100 feet of drop cable), it is possible to mark the area of levels on the graph where a 10dB device would be required, where a 15dB is required, etc. (see fig.9).

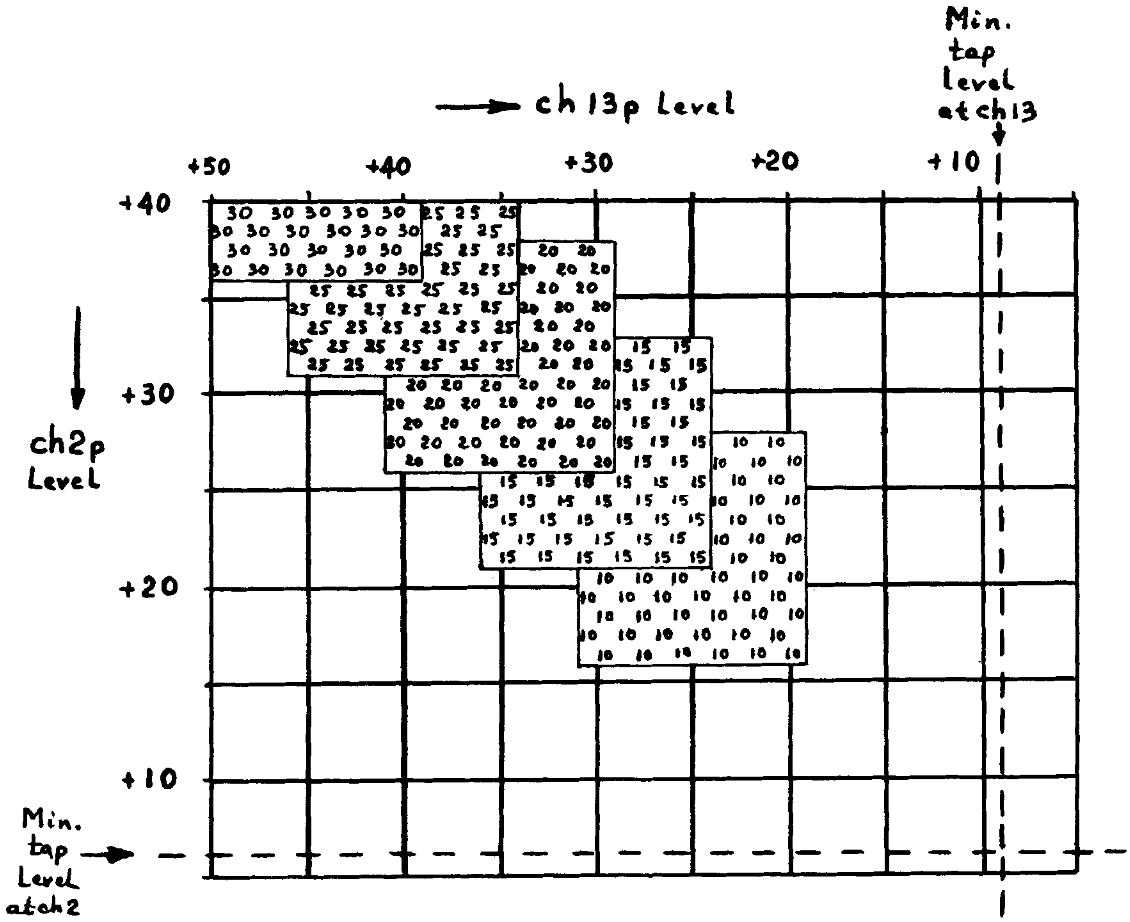


Fig.9

Since operators use different types of drop-cable and have different ideas as to what the tap levels should be, the area information and minimum required tap levels is printed on a transparent overlay and can be shifted to any operator's heart's content.

We have known for years that the tilt between ch 2 and ch 13 changes along the line between amplifiers and therefore a number of companies have marketed sloped taps.
However, it becomes difficult when designing in the conventional way, to decide if a sloped tap is desirable in a particular location and which frequency to choose first in order to determine the tap-off value. This problem can be solved because the overlay indicates whether a sloped tap or flat tap should be used and shows the value of the tap.(see fig.10)

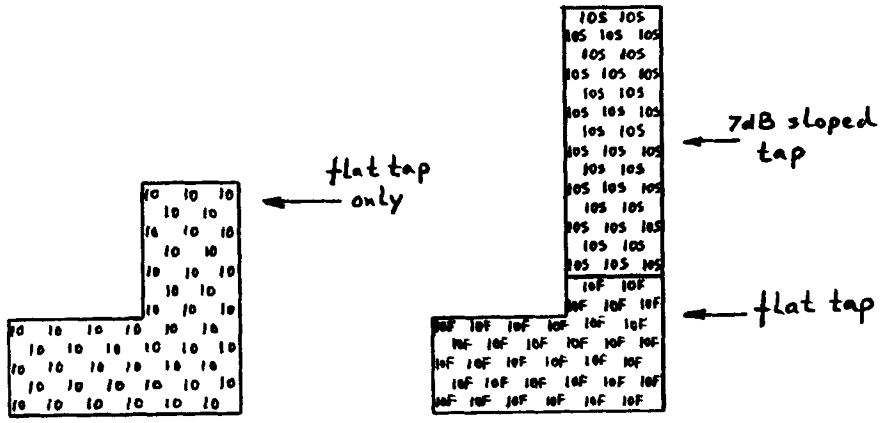


Fig.10

Yet there is more in this graph we can use. How does one determine which plug-in equalizer and, or pads to use in an amplifier when the input and output levels are known? Well, it takes some arithmetic. I have seen one techinician who carried a number of sheets around with all the tabulated data for two types of distribution amplifiers. It showed him what to do in regard to plug-in pads, switchable attenuators, and tilt and gain control for every conceivable input signal combination. Those days will soon be gone. Let us go through a little arithmetic again. Assume the desired output level is 40/36. A typical amplifier with all controls set for maximum gain provides 22dB at ch 13 and 20dB at ch 2. Minimum permissible input level therefore equals 18/16.(see fig.11)

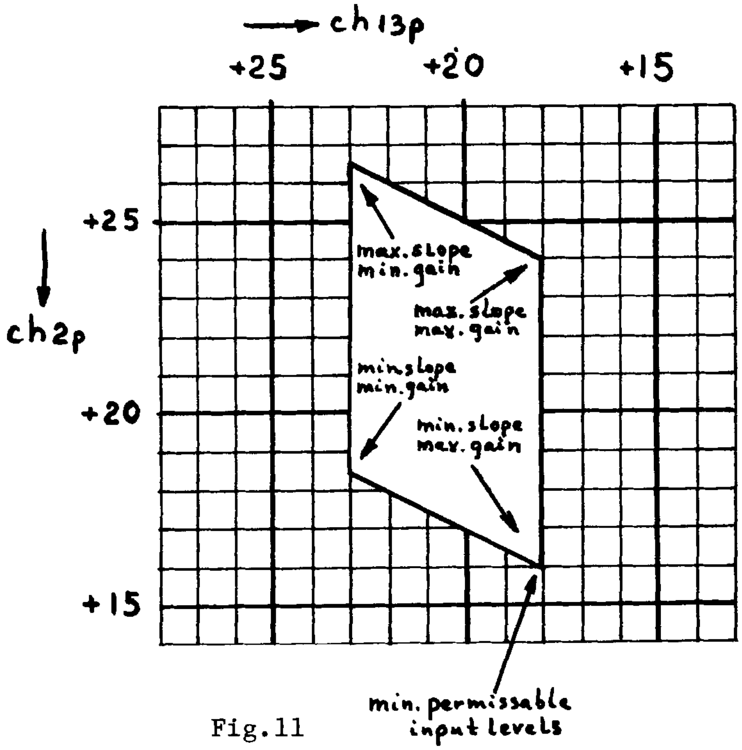


Fig.11

The internal slope control can reduce the gain at Ch 2 by 8dB. Therefore any point on the vertical line between 18/16 and 18/24 can be amplified to the desired output 40/36, by proper adjustment of the slope control. Similarly the gain control line between 18/16 and 23/18.5 indicates the levels which can be accomodated with the gain control.
Therefore any point within the drawn parallelogram can be amplified to the desired output levels
The shape of the usable area characterizes the behaviour of the controls, while the size indicates the control range. Fig.12 shows 4 possible amplifier characteristics.

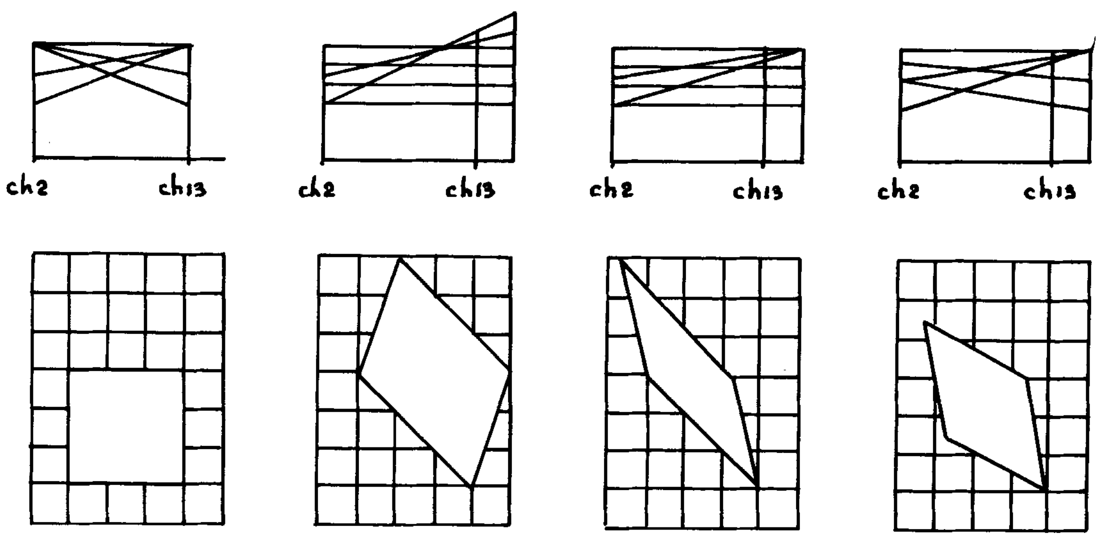


Fig.12

The addition of a switchable attenuator or "plug in" pads, results in a combination of parallelograms with overlapping areas. (see fig 13a) This permits the manufacturer to indicate a preference of one switch setting over another in these overlapping areas, resulting in one of the possible alternatives as shown in fig.13 b,c and d.

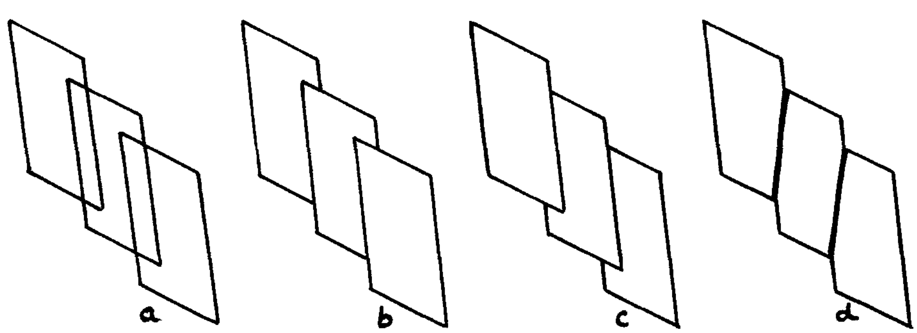
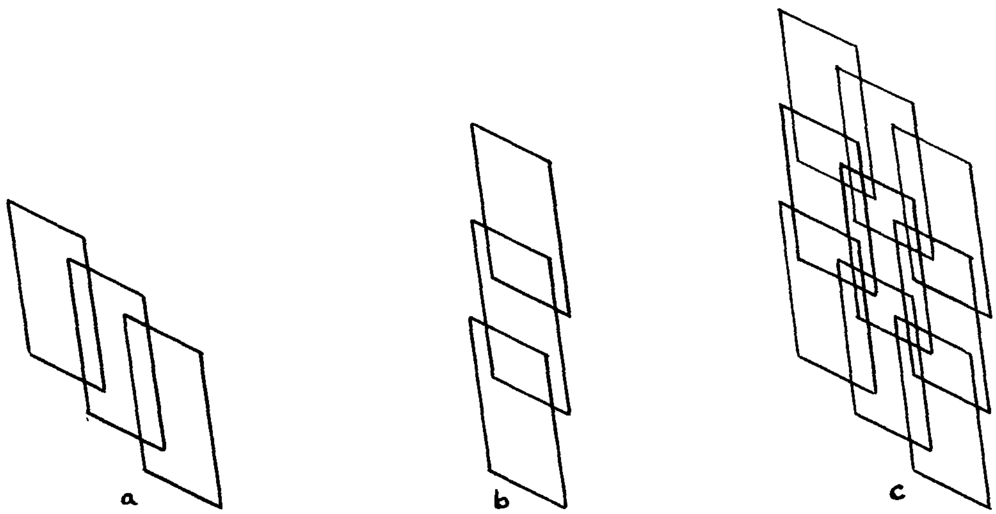


Fig.13

Similarly, switchable equalizers result in the effect shown in fig. 14b, while 14c shows the effect of the availability of plug-in equalizers and pads.
Here too it would be advantageous to know which setting to choose for optimum performance, especially where some input signals can be accomodated with 4 different combination "plug-ins".



a b c

Fig.14

CONCLUSION.

As can be readily seen, there is an enormous difference in the cost and complexity of a panel constructed with RF or DC simulation techniques as compared to the graph and module method. The Cable TV calculator furthermore is portable and meets all the goals set out earlier.
It does not require leased telephone lines, terminal rental or expensive computor programs, it is completely self-contained.
The calculator has given the manual planners a new lease on life by increasing their efficiency by an estimated 50%-100%.