RELIABILITY THROUGH TOTAL AUTOMATION OF CATV SYSTEM DESIGN

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I. INTRODUCTION

Within the past few years Network Analysis Corporation's computer CATV design service has established itself as the most economical CATV system designer in existence. Repeated comparisons, contests and competitions against individual designers, manufacturers and system owners of all sizes and varieties have confirmed the economy of NAC's computer designs; examples of these savings are well documented.[1-4] However, we often encounter the mistaken notion that these hardware savings are made by, in some sense, sacrificing reliability or flexibility inherent in human design. Logical appraisals of the question, and all available experience indicate the contrary. In fact, this notion indicates a serious lack of understanding of what constitutes a "good" design. Because of the increasing complexity in new system designs, such a misconception can have disasterous consequences for the system owner. Therefore, with some examples we will illustrate how the system owner obtains a significantly more reliable design, with more flexibility for system modification and expansion, and with better overall control of his design process--through use of NAC's computerized CATV system design service.

II. INCREASED RELIABILITY AND FLEXIBILITY THROUGH AUTOMATIC DRAFTING

To augment its CATV design service NAC has recently completed an automated drafting program. With this new feature, layouts developed by NAC's design program are drawn as complete final construction maps by an automatic drafting machine under direct command of the computer. With this drafting program the system owner is now able to achieve levels of reliability, control and flexibility previously unavailable in the industry; the automated plotter provides another bonus for using NAC's design service. The specific advantages of automatic drafting are numerous:

1. Elimination of Drafting Errors. One time-consuming factor in the past has been the drafting and checking of maps. Once a human is introduced into the design-drafting process, errors are introduced and hence there is a need for a long checking process. To check a typical 100-mile system for every tap value and location, as well as all amplifiers, power supplies etc. takes a checker about one week, and still drafting errors slip by. With the

automatic plotter,the layout is drafted exactly as designed. The net result is less headaches for construction crews and better systems for owners.

2. Faster Layouts. The 10-mile system shown in Figure 2 was drafted by the computer in 15 minutes, including all linework symbols and lettering. A typical 100-mile system is drawn automatically at 200' to the inch, in about four hours of plotter time. In other words, the time to produce correct drawings has been reduced by a factor of 20 over the efforts of a draftsman and checker.

3. Complete Flexibility in Drawing Modifications. As any system designer knows, very few layouts remain untouched once they are completed. Strand changes are discovered. Telephone poles seem to move with a life of their own and people are found to live on unmapped streets. Often these sections are redesigned on the spot. The new information can then be fed to the program which will modify the appropriate sections of layout or redraw a whole map, or a whole system as the user wishes.

4. Complete Flexibility in Presentation. The computer can make the drawings to any scale. You may want one drawing at 200' to the inch and another overview drawing at 400' or 1000' to the inch. Instead of resorting to microfilm and photo reduction methods, the plotter will simply produce the required drawing. It can isolate any section of the design and draw it to any required scale. For example, it can break out the trunk routing as a separate drawing.

5. Complete Flexibility in Format. The program has a library of symbols that can be used for any particular device. If the system owner wishes a different symbol, it can easily be added to the library. At present we have all the NCTA standard symbols in the library as well as many variations of these symbols in use by our clients. Thus, for example the symbols for trunk bridgers and directional couplers shown in Figure 3, are all in the library, even though the last symbol for the trunk bridger is not a standard NCTA symbol.

In summary, automated drafting produces its results faster than humans without introducing drafting errors. The system owner does not have to choose speed or reliability; he gets speed and reliability.

III. INCREASED RELIABILITY AND FLEXIBILITY THROUGH COMPUTER DESIGN

One of the most persistent misconceptions fostered by manual designers is that they "overdesign" a system by putting extra amplifiers in so that they have more reliability and more slack for flexibility. This is absolutely false. There is indeed extra equipment and more cost. But, obviously, with more electronics there are more failure-prone elements in the system and less overall reliability.

For example, the design in Figure 4.a. shows an industry manual design for one section of a larger 100-mile system. The computer design for the same section is shown in Figure 4.b. The manual design has 4 more extender amplifiers than the computer design. Furthermore, there are 3 places where there are 3 extenders in cascade in the manual design whereas there are none in the computer design. The computer design is obviously more reliable. In general, if reliability data is available for different types of amplifiers, such as trunk and extender amplifiers, the computer will take them into account trading off amplifiers for the best design.

The claims for added slack and flexibility in manual designs also turn out to be patently false upon examination of the available evidence. As an example, the minimum input level to extender amplifiers in the design in Figure 4 was 20dBmV. For the computer design, signal levels are high enough so that the feeders could be extended or taps could be added if necessary without adding extender amplifiers. In the manual design, some of the end levels are tighter even though there are more amplifiers. Furthermore, the computer designed system is easier to expand or change because there are only two extenders in cascade.

The net result is that the manual design with more electronics is, in every sense, a poorer design--more expensive, less reliable and less flexible. The manual design has wasted electronics which in no sense adds to the system performance--only the system cost. The way to improve system reliability is to first adopt more rigid system specifications. With computerized design, it is actually possible to design to significantly tighter specifications with no additional cost over a more poorly performing manual design.

Reliability in Meeting Design Specifications

In addition to drafting errors and poor designs, one of the primary hazards of manual designs to system owners, builders and users are good old-fashioned errors and blunders. Sometimes these are errors in bills of materials, but more often, and more seriously they are technical errors which make the system unreliable, or indeed, incapable of meeting contractual specifications.

The types of errors made by manual designers, of course, include every possible error that can be made. Some of the more prevalent and representative types that we have come across are shown in the examples below. Needless to say, the computer cannot make these errors.

a. Signal levels at subscriber taps. In the portion of the industry design shown in Figure 5, the output levels of the taps are given. The required tap output level is 10 dBmV. Note that on one tap the signal level is 3 db too low--the customer is receiving only one half his required signal power. This is one of the most persistent types of industry fudges. In one industry design the signal at over 20% of the taps did not meet the required output level. With proper design this type of fudge is unecessary.

b. Trunk spacing. In Figure 6 is an industry design in which the required 22db trunk spacing is exceeded by .97 db. Errors on the trunk of this sort are truly unfortunate since the resulting distortion propagates throughout the remainder of the system. In major markets where cable signals are competing with off-the-air pickup, the resulting poor quality pictures are particularly serious.

c. Power requirements. Figure 7 shows an industry design with 6 extender amplifiers drawing power from one output of a trunk bridger amplifier thereby exceeding the power passing capability of the bridger. This means that subscribers will not be getting decent service until a section of the system is rebuilt.

Our experience has shown that these types of errors occur repeatedly in manual designs. Why are there so many errors in layouts produced by industry designers? There is probably no single reason although there are obviously many critical factors.

The quality of designers in the industry varies greatly. A designer with five years experience is usually superior to a designer with one year of experience. With the rapid turnover of designers and the rate of introduction of new lines of equipment many designers don't get much experience with particular equipment. With those that do, the "Peter Principle" takes its toll: good designers don't usually end up being good designers --they end up being managers. So the really good people are probably not doing your design. For example, in tests that we have seen, one manufacturer ran the same system through ten designers and had a 15 percent variation in cost among his own staff. As another example, for our tiny 1971 NCTA Convention contest system of 2.9 strand miles there was a 17% variation in cost among the entries of the human designers and 35% of them were incorrect because of significant errors either in the bill of materials or actual design. This shows just how inconsistent the output of a designer really is.

The time factor is also critical. The contest winners told us they had spent 50 hours to design the three-mile system. When a professional designer tells you he designs five to ten miles a day, you should suspect that you are not getting the best design. For example, in many cases the designers may realize that to properly eliminate an extender amplifier that is a few hundred feet from the end of a feeder would require some straightforward but laborious manual redesign. Rather than do this, he will eliminate the amplifier anyway by cheating on some tap outputs and the system owner gets an inferior system.

If the situation is bad now, there are indications that it will become worse. If the recent FCC rulings lead to a spurt in construction, the present designers are clearly going to be swamped. The typical design will be even poorer and may take longer to produce. The FCC decision makes the computer not only a useful tool but a vital one. It's a lot easier to manufacture twice as much equipment as it is to create twice as many good designers and designs. If manufacturers and MSO's were to try to staff up to handle the new volume, the lack of training and experience of the new designers would only magnify their existing difficulties due to normal time pressures and unfamiliarity with new equipment.

IV. INCREASED CONTROL THROUGH NAC'S COMPUTER CATV DESIGN

Because of its speed, reliability and flexibility, NAC's CATV design service offers the system owner more control of his system through a more precise and complete understanding of his system cost and performance. This applies at every stage--proposal, system design and system construction.

1. Proposal. NAC's design service enables an MSO bidding for a franchise to obtain fast, accurate and reliable bills of materials. Repeated designs can be made for different lines of equipment, different head end locations, different population densities and different trunk routings. The computer can generate several bills of materials and the plotter can draft error-free, all parts of the design, such as trunk routing, to any desired scale for each design. Instead of having to rely on one partial design and rule of thumb estimates, the MSO can proceed with confidence that he has accurately evaluated all cost-performance tradeoffs.

Since the program and automatic plotter are so fast, they can be of great assistance at even the most preliminary stages of system evaluation. Suppose you have a street map, the locations of poles and an estimate of the number of houses to be fed from each pole --but you do not yet have a strand map. The computer will draw a best system design along with the strand map that goes with it. This strand can then be fed to the computer and the appropriate parts of the layout can be redesigned. Thus, the program is even useful in formulating a strand map.

If you do not have pole locations but the street map is drawn to scale or you have an aerial photograph, the program can design with poles spaced on an average pole span basis to obtain a dedicated design. Designs can be made for different population densities and saturations. Our experience has been that even if only the street map, estimated population densities and selected equipment line are given, the computer estimate of hardware cost is within 10% of the cost of the final design.

2. System Design. At the design stage the MSO has the assurance that he has the best design at every step and that it is free of design and drafting errors. Changes to the strand map or system requirements, can be fed to the computer and the design modified according to the current information. Because of the speed of the design process, the MSO can have a firm idea of his system progress at an earlier stage.

To do a computer design we input more data than needed so the computer can cross check the information. With this automated checking, the computer can produce designs in roughly a half to a third of the time that human beings would require. With most customers we have found that an acceptable arrangement is delivery of the first 100 miles in three weeks with each subsequent 100 mile section in two weeks. This fits in well with their construction and our production schedules. However, we work very closely with our clients and are responsive to their needs. If the system owner is rushed for a design, we can deliver 100 mile sections at the rate of one per week.

3. System Construction. Once the layout is completed and, for example, changes in strand occur there are several possible choices for handling it. (1) If the changes are extensive and nonlocal the data can be changed in a matter of minutes and the computer run to obtain a new design. (2) If the changes are localized, the computer redesign may be restricted to a portion of the layout. (3) If the changes are relatively minor, they can be fed to the program which will change the computer drawings. All these modes are made simply by the flexibility inherent in the computer design and drawing.

V. CONCLUSION

NAC has recently converted the output of its computer CATV design program to automatically drafted layouts. This automatic error-free drafting combined with the speed and reliability of the computer designs make NAC's computer CATV design service the most reliable and fastest CATV designer in existence--as well as the most economical.

REFERENCES

1) "A Computer Design of CATV Distribution Systems," Ivan T. Frisch, Bill Rothfarb, Aaron Kershenbaum, 20th NCTA Official Convention Transcript, July 6-9, 1971, Washington, D.C.

2) "A Computer Design of CATV Distribution Systems," Ivan T. Frisch, Bill Rothfarb, Aaron Kershenbaum, Cablecasting, Vol. 7, No. 5, July-August 1971, pp. 20-26.

3) "Network Optimization for Two-Way CATV System Design is Programmed on a Computer" in New Product Applications IEEE Spectrum, Vol. 8, No. 11, Nov. 1971, p. 82.

4) "Stranded in the Map Maze? A Computerized Way Out," Ivan T. Frisch, TV Communications, Vol. 9, No. 2, February 1972, pp. 34-42.

FIGURE CAPTIONS

1. A Calcomp plotter drawing a CATV layout under the control of NAC's Computer CATV design program.

2. A photograph of part of a 10 mile layout drawn at 200' to the inch by NAC's automated plotter. The automatic drafting time was 15 minutes.

3. Some of the symbols used by NAC's clients which are in NAC's computer library of sumbols. Others can be added easily.

4. Comparison of NAC's computer design with an industry manual design shows NAC's design more reliable because of fewer amplifiers --and with more slack and flexibility for modification and future growth. (a) An industry design. (b) NAC's computer design.

5. An industry manual design in which tap output levels do not meet specifications.

6. An industry manual design in which trunk spacing violates system requirements.

7. An industry manual design in which power passing capability of a trunk bridger amplifier is violated.

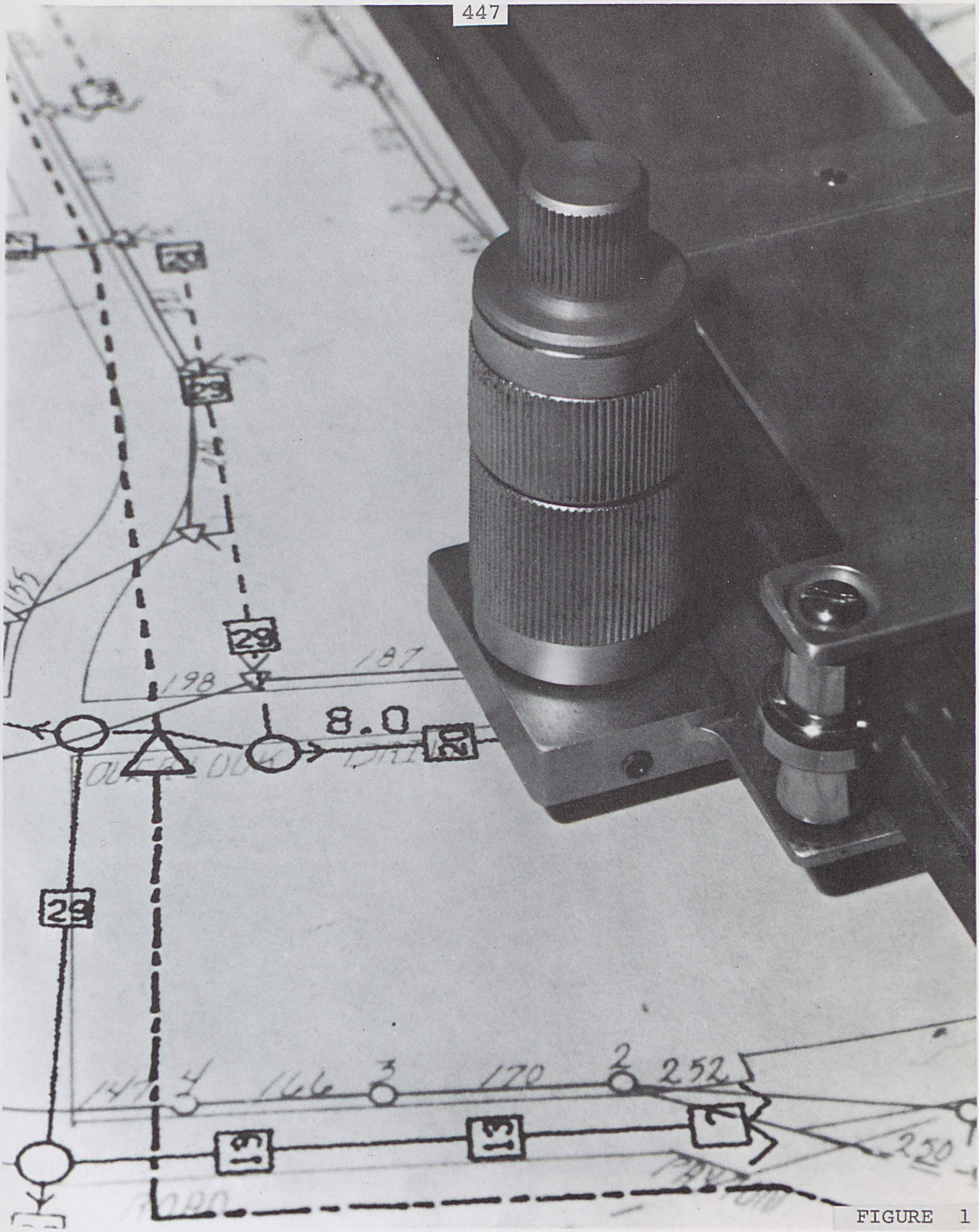

FIGURE 1

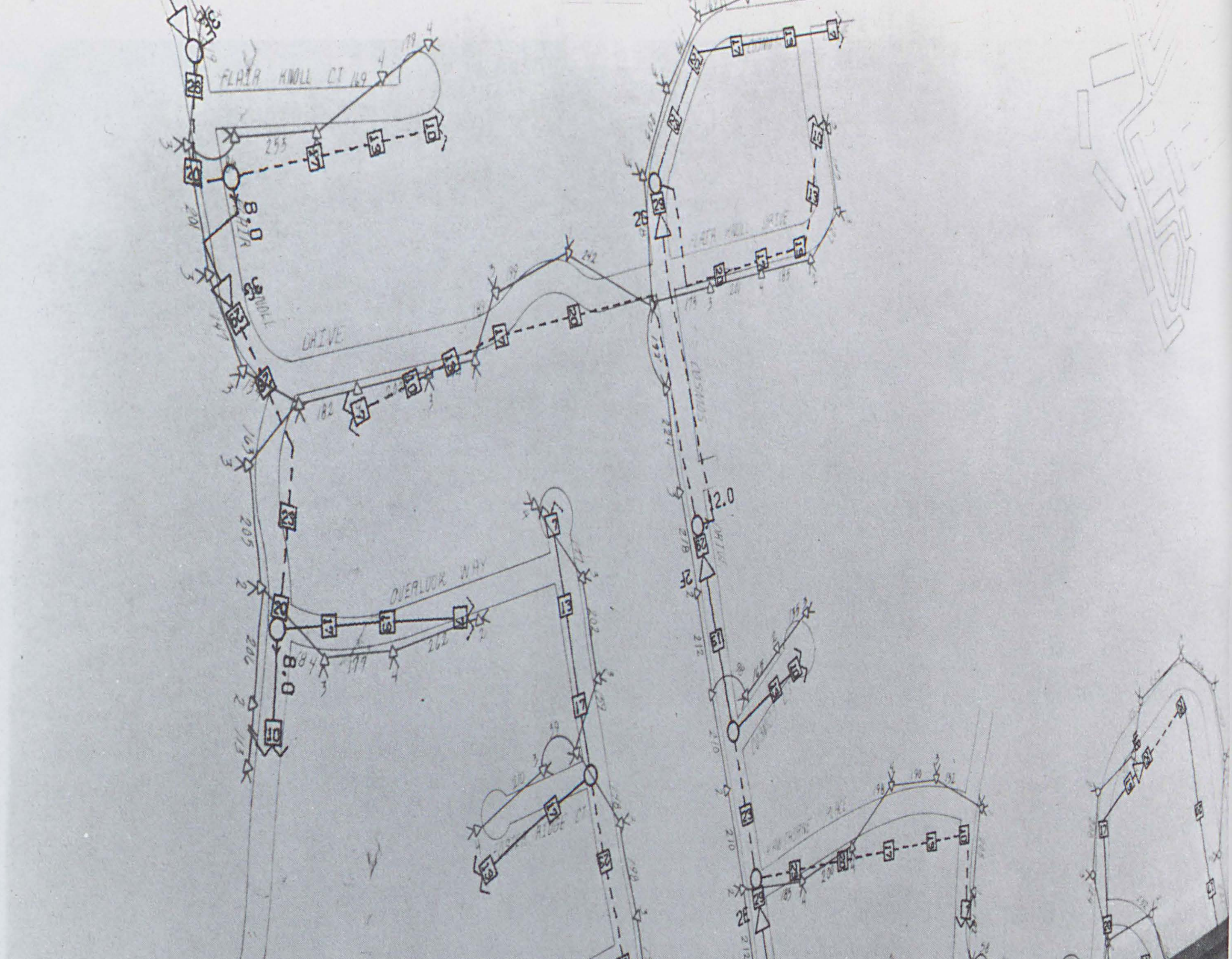
FLAIR KNOLL CT
FLAIR KNOLL DRIVE
DRIVE
OVERLOOK WAY
BROOKDALE DRIVE
8.0
12.0

FIGURE 2

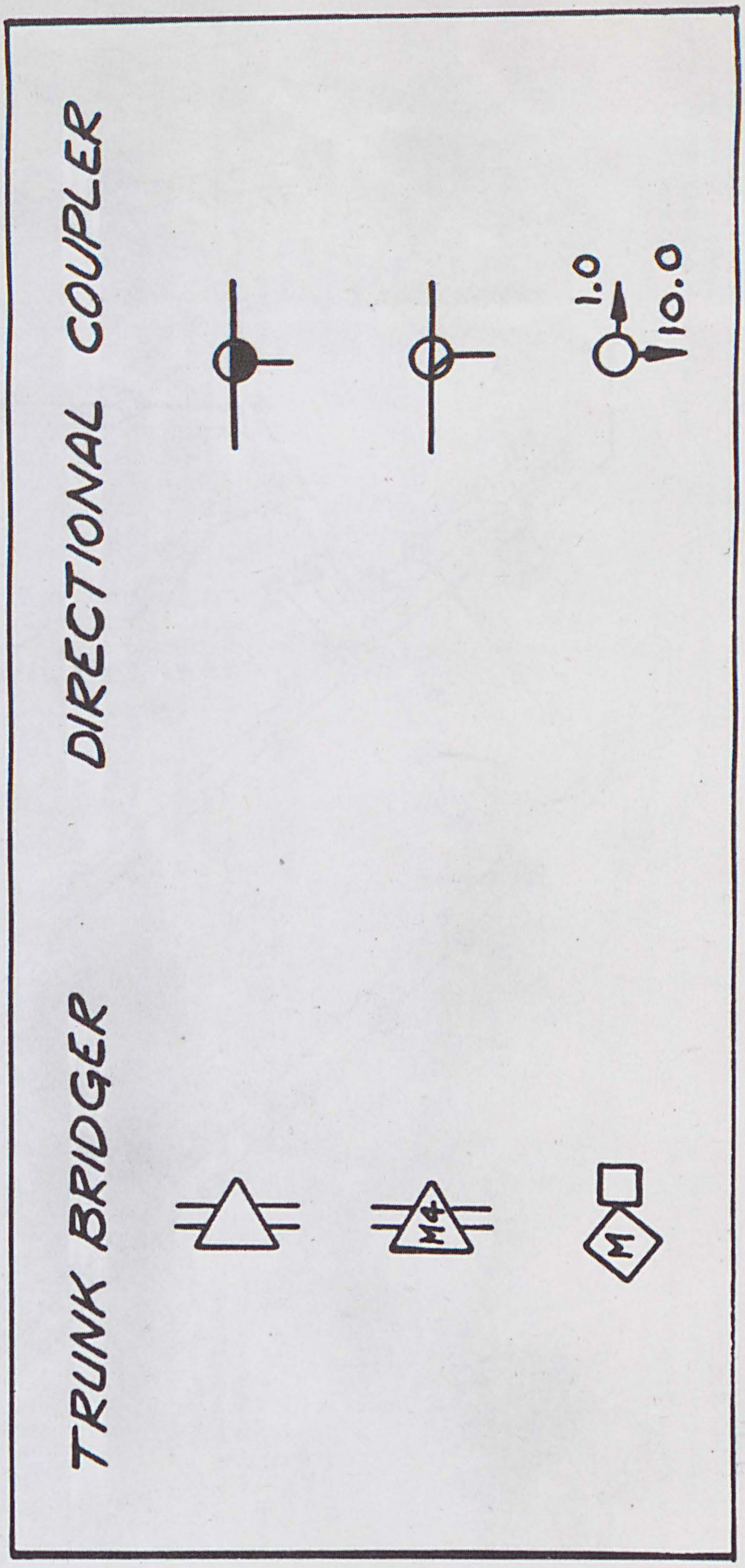

FIGURE 3

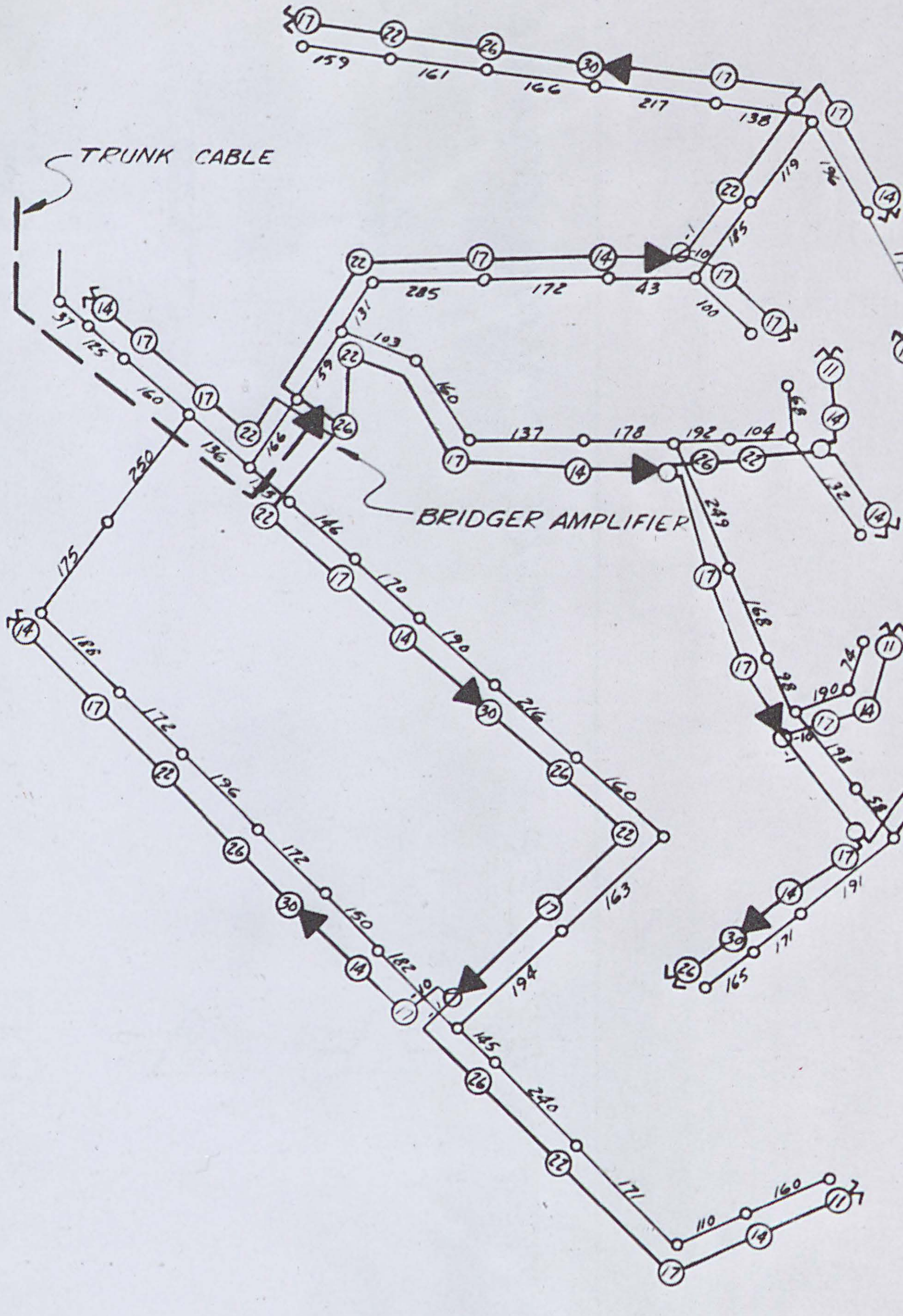

FIGURE 4

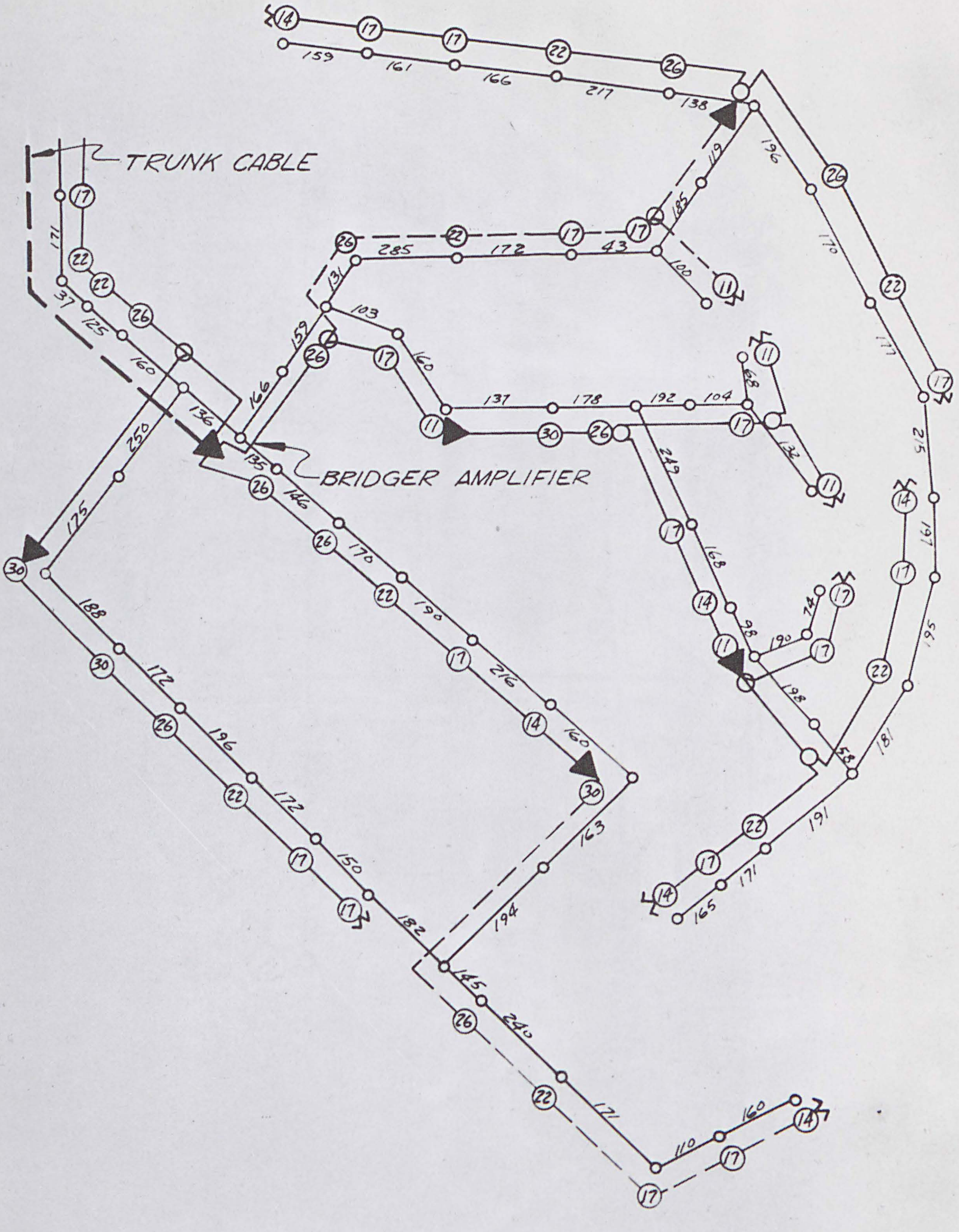
TRUNK CABLE
BRIDGER AMPLIFIER
14
17
17
22
26
159
161
166
217
138
196
26
119
185
170
22
177
17
26
22
17
17
285
172
43
100
11
131
103
159
166
26
17
160
137
178
192
104
11
68
17
11
30
26
132
11
171
17
22
22
26
37
125
160
136
250
135
26
146
26
170
22
190
17
216
14
160
30
175
30
188
30
172
26
196
22
172
17
150
17
182
163
194
249
17
168
14
98
11
190
74
17
17
198
58
22
14
17
212
197
195
181
22
17
14
191
171
165
145
26
240
22
171
110
160
17
14
17

FIGURE 4b

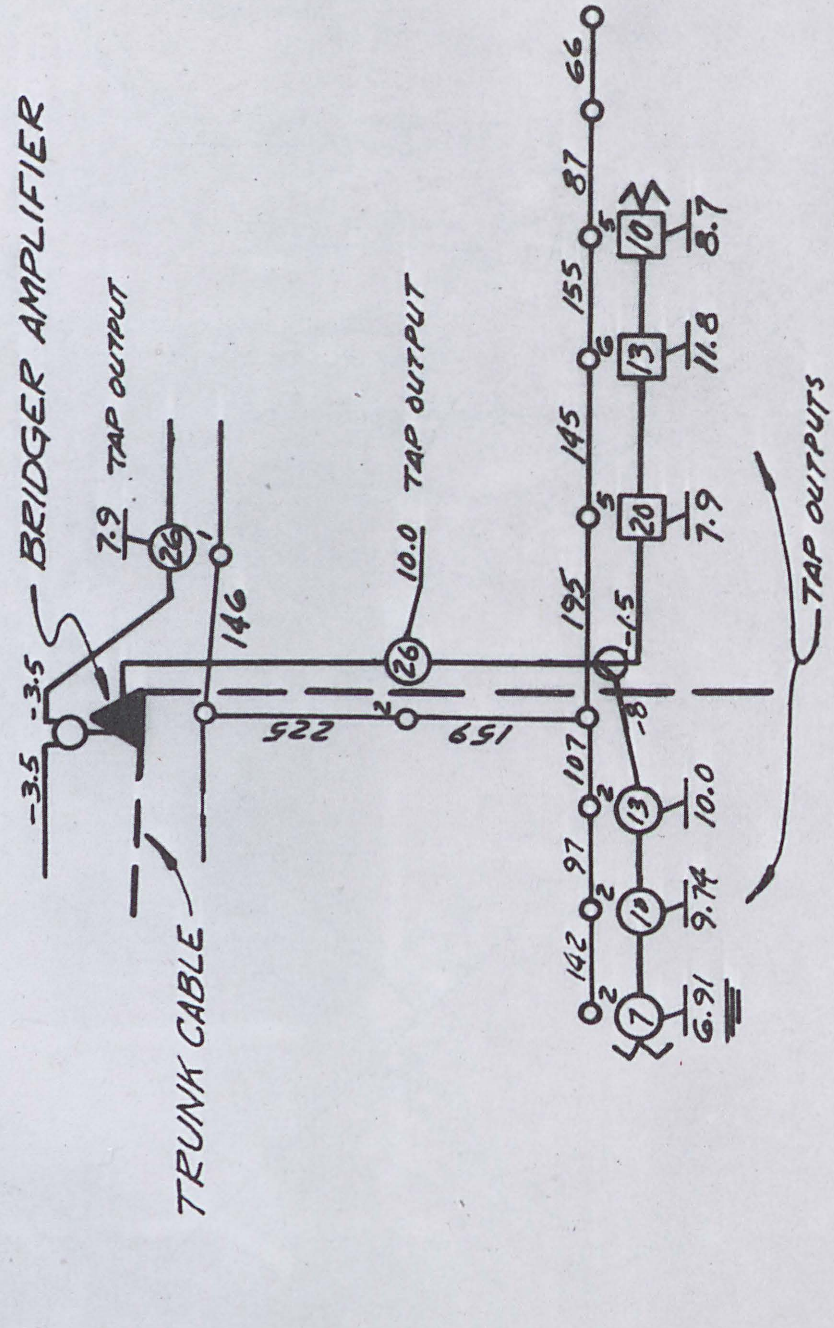
BRIDGER AMPLIFIER
TAP OUTPUT
TAP OUTPUT
TAP OUTPUTS
TRUNK CABLE
-3.5
-3.5
7.9
26
1
146
225
2
159
10.0
26
195
107
97
142
2
2
2
-8
-1.5
13
10
7
10.0
9.74
6.91
5
20
7.9
145
6
13
11.8
155
5
10
8.7
87
66

FIGURE 5

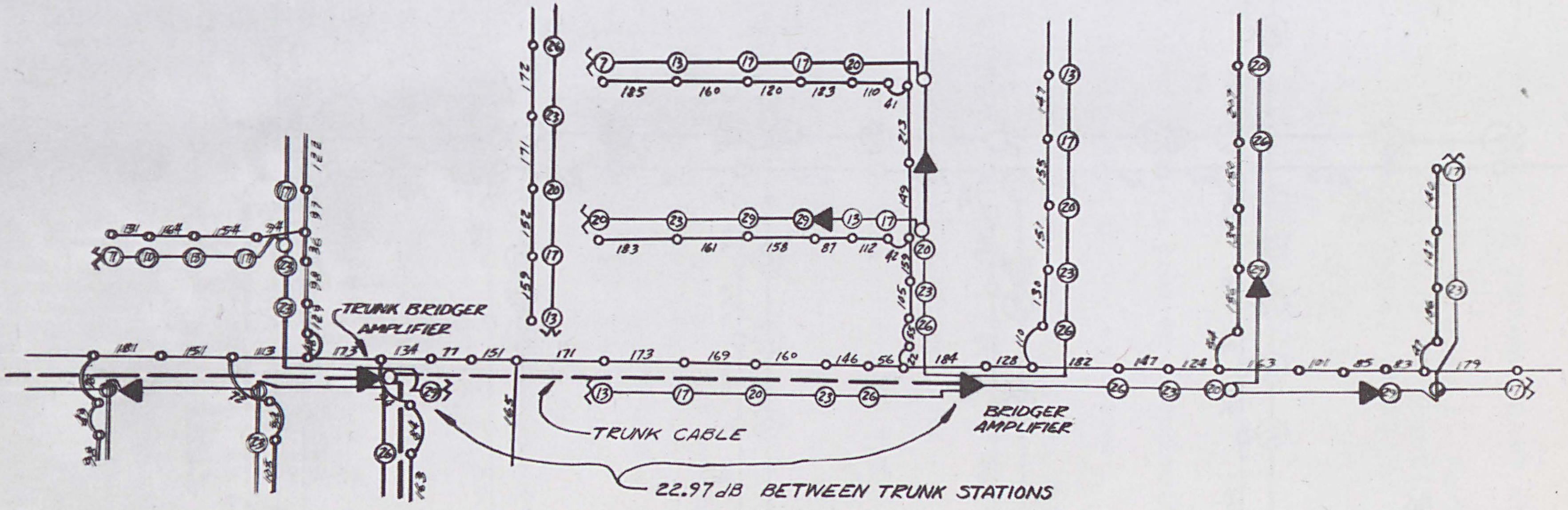
TRUNK BRIDGER AMPLIFIER
BRIDGER AMPLIFIER
TRUNK CABLE
22.97 dB BETWEEN TRUNK STATIONS

FIGURE 6

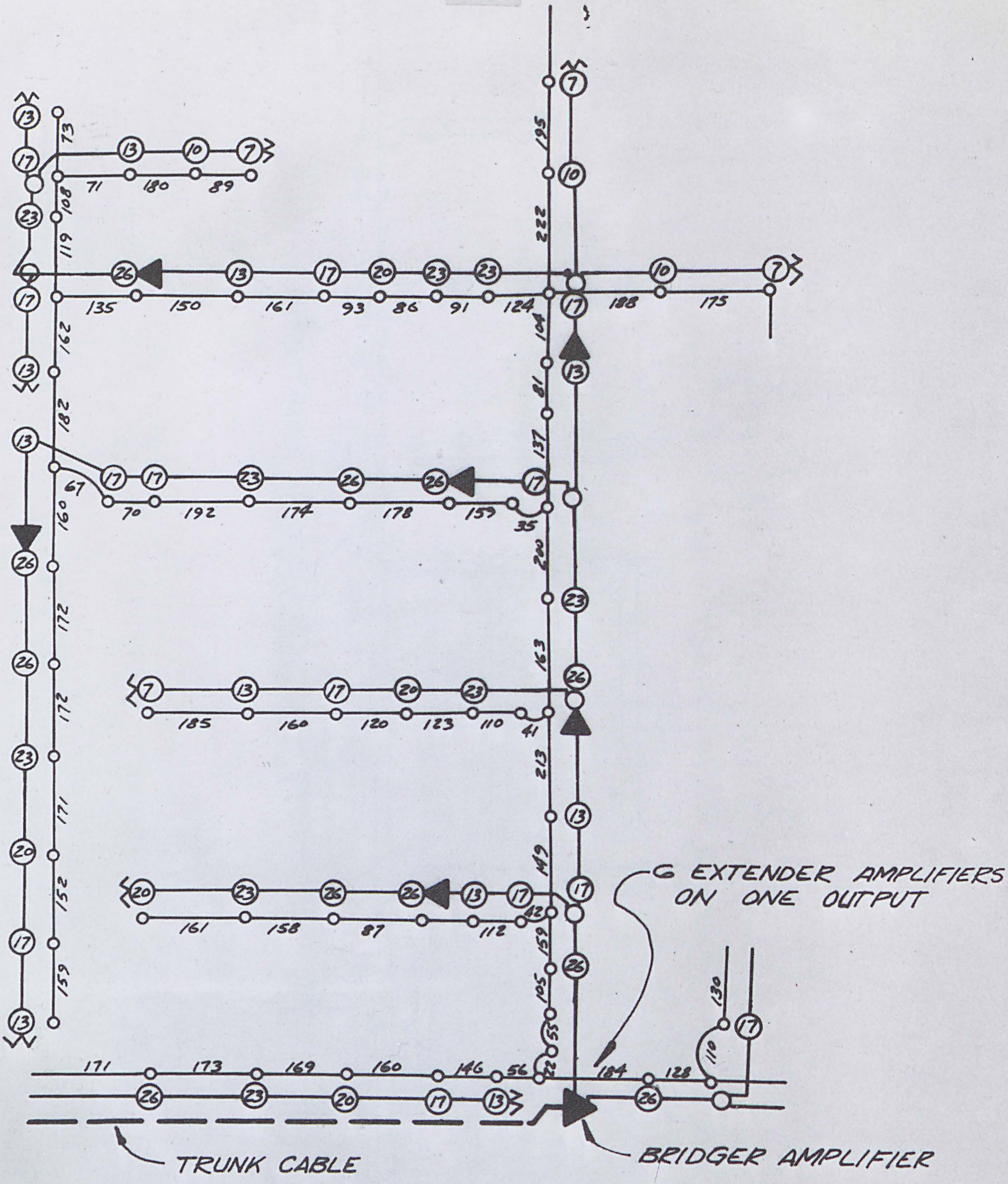
6 EXTENDER AMPLIFIERS ON ONE OUTPUT
TRUNK CABLE
BRIDGER AMPLIFIER
171 173 169 160 146 56 22 184 128
26 23 20 17 13 26
110 130 17
195 222 124 104 81 137 35 200 163 41 213 149 42 159 105 55
7 10 17 13 23 26 13 17 26
73 108 119 162 182 160 172 172 171 152 159
13 17 23 17 13 13 26 26 23 20 17 13
13 10 7
71 180 89
26 13 17 20 23 23 10 7
135 150 161 93 86 91 188 175
17 17 23 26 26 17
67 70 192 174 178 159
7 13 17 20 23
185 160 120 123 110
20 23 26 26 13 17
161 158 87 112

FIGURE 7