TRUNK NETWORK DESIGN

DETERMINATION OF COST RATIOS

NETWORK SWITCHING ENGINEERING—TRUNK ENGINEERING

NETWORK SERVICES METHODS

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1. GENERAL

1.01 The determination of cost data with respect to direct and switched route paths is an important aspect of network design. This relationship is referred to as a cost ratio. This section examines the variables involved in cost ratios and details the recommended procedures for determining them.

1.02 Whenever this section is reissued, the reasons for reissue will be given in this paragraph.

1.03 A basic consideration in network design is to determine how point-to-point loads should be allocated among the possible routes that could exist between two points. The various load allocation alternatives are explained in greater detail in Section 780-

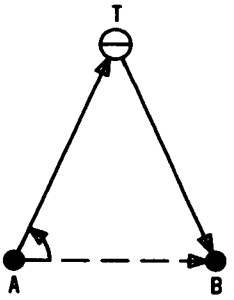
402-120. The basic algorithm for solving this problem includes both the costs and the efficiencies of the facilities in the possible routes. This section addresses the cost ratio portion of the basic algorithm and includes a detailed description of a "broadguage cost" method which has been developed to calculate cost ratios.

1.04 References in this section to methods, planning, data requirements, service levels, and equipment requirements are based on American Telephone and Telegraph Company (AT&T) recommendations.

1.05 For the standard meaning of terms and definitions used in this section, refer to Section 780-400-305, Glossary of Trunk Facilities Terms and Definitions.

2. DESCRIPTION OF THE COST RATIO

2.01 The term "cost ratio" applies to the relative costs of the facilities in two possible routes. A typical example involves determining the cost ratio for high-usage trunk groups in single stage alternate route configurations as shown below:



Here, the cost ratio is the ratio of the cost of a path on the alternate route, which includes the A → T and T → B trunk groups plus the switching cost at tandem T, to the cost of a path on the direct route, the A → B trunk group. The cost ratio can be stated as:

Cost Ratio = Alternate Route Path Facility Cost and Switching Cost/Direct Route Path Facility Cost

2.02 The resulting cost ratio is then used in the basic algorithm which expresses the balance between the costs and the efficiencies of the two routes. For trunk engineering based on a single hour of load, this results in the following equation:

Cost Ratio = Incremental Hundred Call Seconds (ICCS)/Economic Hundred Call Seconds (ECCS)

The ICCS represents the efficiency of the alternate route and the ECCS represents the efficiency of the direct route.

2.03 In the trunk engineering process, a value is stated for the ICCS and the equation is then solved to determine the ECCS. This procedure results in trunking arrangements which maintain objective levels of service at a minimum cost.

2.04 The usual practice in determining cost ratios has been to use average annual charges for the type of facilities and the switching systems involved. The existance of the switching systems and the trunk groups is assumed, thus permitting the use of incremental annual charges, ie, the charges associated with adding an additional path to an existing route. No getting started costs are considered and the calculations ignore any savings to another route which might be provided relief. Cost ratios historically have been assumed to be always greater than one because of the additional switching system on the alternate route.

3. OVERVIEW OF THE BROADGUAGE COST METHOD

A. Introduction

3.01 The calculation of cost ratios using conventional methods has become burdensome for most companies because of the large number of high-usage groups now in the network and complex because of the difficulty and expense of accurately determining the appropriate costs to be used. This, coupled with the fact that network costs are not particularly sensitive to minor cost ratio errors, has led to the use of various methods of estimating, or broadguaging, the costs and/or cost ratios.

3.02 As part of a Bell Laboratories study, it has been established that broadguaging of costs is appropriate because doing so can balance two opposing forces: the benefits in designed network costs which occur from more exact cost estimates and the costs associated with the development and maintenance of those estimates. However, broadguaging

must be done in a way which considers the individual high-usage group in relation to its alternate route. If this is not done, significant cost penalties will result where actual cost ratios differ widely from those indicated by the broadguage method employed.

3.03 Several candidate broadguage cost methods evolved and a subsequent study was initiated to select the method that was most practical for trunk engineering. The recommended broadguage cost method includes separate terms for termination and line haul costs, as well as the tandem switching costs. This method has a potential for saving 1 to 4 percent of the trunking network cost and will be implemented in the Trunk Forecasting System (TFS). It is sufficiently simple for manual use and should be used prior to its implementation in TFS. (Also, a time-shared computer program is available to perform the required calculations.) In addition to the network and administrative savings, the use of the broadguage cost will standardize cost ratio methods in the Bell System.

B. Basic Structure of the Broadguage Cost Algorithm

3.04 As stated earlier, the broadguage cost method includes the trunk group termination and line haul costs as well as the tandem switching costs. Clearly, the trunk group length is needed to accurately estimate the cost of a trunk group. For convenience, the following definitions are made:

C_R = cost ratio

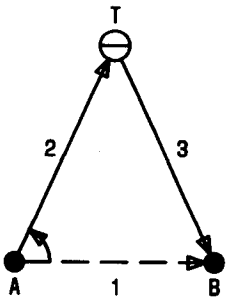
C_L = line haul cost/trunk mile

C_S = tandem switch cost/switched CCS

C_T = termination costs/trunk (both ends)

D = group length

3.05 The cost ratio for sizing the high-usage group in the sample network shown below would be determined as follows:



The costs for the alternate route include the termination cost, line haul cost, the distance for both the A → T and T → B trunk, and the tandem switch cost. The direct route cost includes the termination cost, line haul cost, and the distance for the A → B trunk group. Using the definitions from the previous paragraph and placing additional subscripts to indicate the appropriate trunk groups, the cost ratio can be expressed as:

$$CR = \frac{C_{T2} + (C_{L2} \times D_2) + C_{T3} + (C_{L3} \times D_3) + C_S}{C_{T1} + (C_{L1} \times D_1)}$$

3.06 Additional details pertaining to the different categorizations which must be performed by the user, the tables which identify associated costs, and the time shared computer program that is available are included in Part 4 of this section.

4. BROADGUAGE COST PROCEDURES

A. Inputs and Categories

General

4.01 The recommended broadguage cost requires the user to specify a few key parameters. Accuracy is gained by placing each trunk group into one of several categories based on originating and terminating switch types and the carrier type. By doing this the unit line haul, termination, and tandem switch costs may be varied to be representative of the facilities belonging to these categories. The trunk group length inputs should approximate the facility route mileage. Where it can be established that airline miles and facility miles are close, the mileage can be determined using building V and H coordinates.

4.02 The goal of categorization is not to represent every variation in cost that can be associated with a facility type. Rather it is to provide a set of defaults which keeps the total manual effort, ie, that needed to provide both standard inputs and manual overrides, at a minimum. To accomplish this, the categorizations must represent the most commonly used facilities and separate these into groups which differ significantly in cost. The categorizations which must be performed include the following:

- Switch category
- Facility Category.

Switch Category

4.03 The switch categories encompass all available switching system types. The basic switch types are electromechanical, analog electronic, and digital electronic. Costs for digital electronic switching systems are significantly different from those in the other categories because they have digital termination capabilities and they also have no tandem switching costs modeled on a per CCS basis. Thus the termination costs and tandem switching costs are quite different than for the other categories. The analog electronic category differs significantly from the electromechanical category in termination costs and in tandem switching categories.

Facility Category

4.04 The calculation of the cost per trunk is simplified by assigning each trunk group a facility classification: narrowband, digital broadband, or analog broadband. Carrier type has no effect upon the tandem switch cost but does affect both line haul and termination costs. Unlike switch types, which remain in service for many years, the type of carrier on a group can vary from year to year and from trunk to trunk. Also a trunk group may include mixed facilities. The further categorization of broadband as analog or digital is made because of significant differences between termination and line haul costs for these two facility types.

Costs

4.05 The cost elements to be used in broadguaging are listed in Tables A, B, and C. Table A includes the termination and line haul costs for the various categories. Table B provides the tandem switch costs. Table C includes the interface costs to be used when determining trunk group costs with mixed growth facilities. The costs shown represent long term replacement costs, ie, the incremental costs incurred in adding a trunk assuming sufficient time is allowed to carry this out efficiently.

4.06 Tables D, E, and F provide source information used to produce Tables A, B, and C. This information includes the component costs, some facility definitions, and models for switch to carrier connections and for mixed facility connections. This information should be helpful in understanding how the recommended costs were determined and for situations where the user wants to override the recommended costs with costs based on local data.

B. Procedures With the Time-Shared Computer Program

4.07 A time-shared computer program used for cost ratios (CRAT) has been developed as an aid to engineering personnel responsible for the development of the cost ratios used in trunk network design. This program is written in BASIC language. Paper tape copies of the program are available from AT&T.

4.08 Since each run of the program produces a cost ratio and an ECCS for a single high-usage trunk group, it will take some time to complete all groups. It is suggested that longer groups be done first since these groups tend to be more expensive and the potential exists for achieving a greater savings.

4.09 The use of the CRAT program is relatively straightforward. Figure 1 is a copy of a typical inquiry-response sequence. As shown, the user responds to each program inquiry in the following order.

- Trunk group name or identifier
- Distances of the direct route and each leg of the alternate route
- Carrier types for the direct route and each leg of the alternate route
- Switch types for each switching system
- Cost overrides, if desired.

4.10 The program then prints out the costs for the direct route, each leg of the alternate route,

and the tandem switch followed by the cost ratio and the ECCS. The ICCS used in the ECCS determination is 26.

4.11 Figure 2 represents the program flowchart for the CRAT program, and Fig. 3 is the listing for the program. These figures will allow the user to follow the program logic.

C. Manual Procedures

4.12 Determining cost ratios on a manual basis is also a relatively straightforward process. A basic flowchart which depicts this process is shown in Fig. 4.

4.13 A typical example of determining a cost ratio and ECCS using manual procedures is shown in Fig. 5. This example uses the same set of data as in the example in Fig. 1.

4.14 An additional calculation may be required when computing a trunk group cost with narrowband facilities. If the trunk group switch category is EM-EM, EM-AE, or AE-AE and the carrier category is narrowband, the trunk group cost should be determined for both analog narrowband and digital narrowband. The smaller of the two trunk group costs would then be used. This is done automatically in the CRAT program.

```
CRAT

TO STOP PROGRAM,ENTER STOP FOR TRUNK GROUP ID OR COMMENTS

TRUNK GROUP ID OR COMMENTS
? GR01

DISTANCES:DIRECT,AL1,AL2
? 100,100,100

CARRIER TYPES:DIRECT,AL1,AL2
? DB,DB,DB

SWITCH TYPES:A-END,TANDEM,Z-END
? AE,AE,AE

OVERRIDES TERM$,LINE HAUL $,TAND SW $: Y OR N?
? N,N,N

DIRECT ROUTE COST PER TRK= 809

AL1 COST PER TRK= 809

TANDEM SWITCH COST PER TRK= 501.8

AL2 COST PER TRUNK= 809

COST RATIO = 2.6

ECCS = 10.

TRUNK GROUP ID OR COMMENTS
? STOP
```

Fig. 1—Typical Inquiry—Response Sequence for the CRAT Program

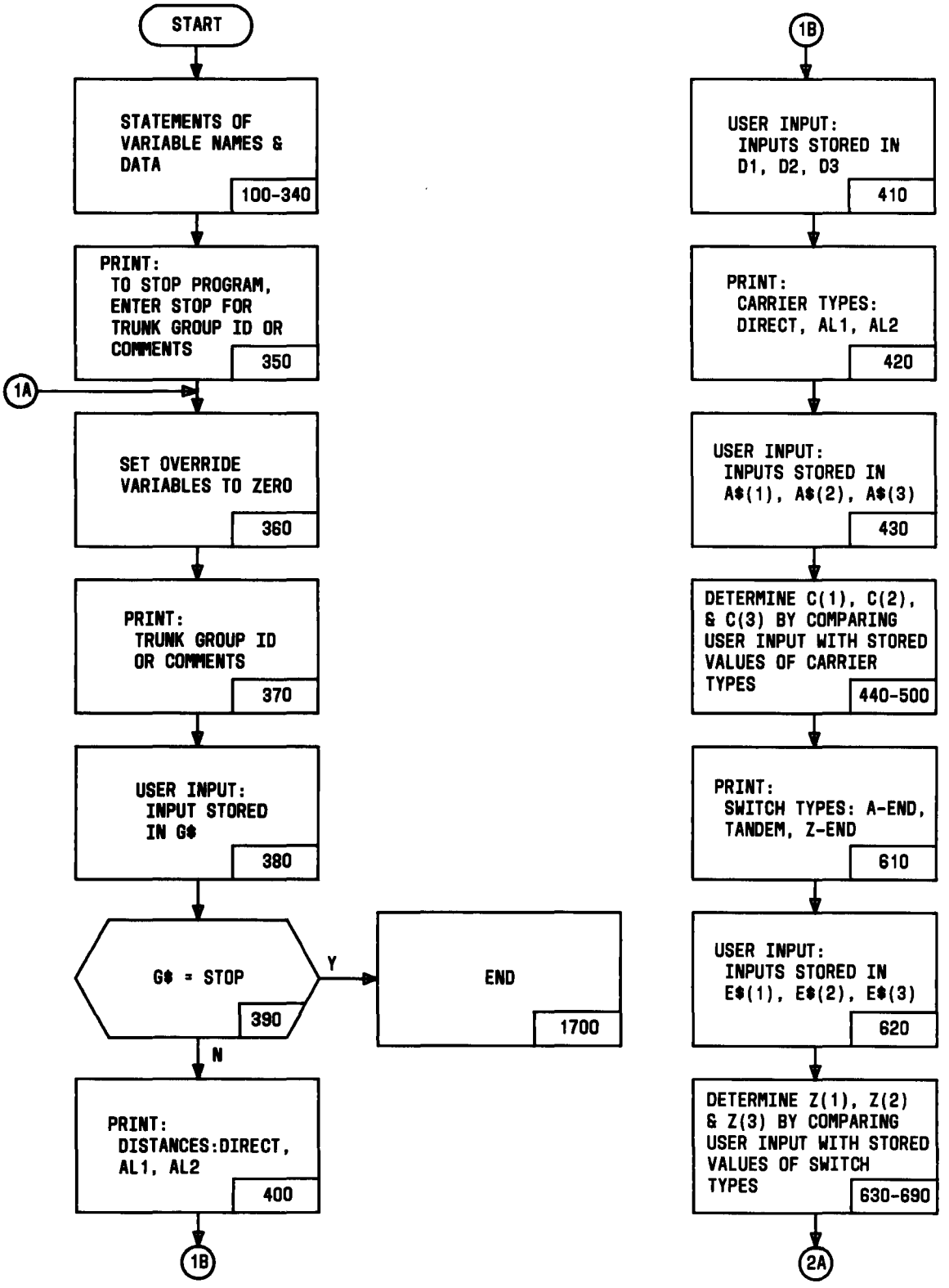


Fig. 2—CRAT Program Flowchart (Sheet 1 of 4)

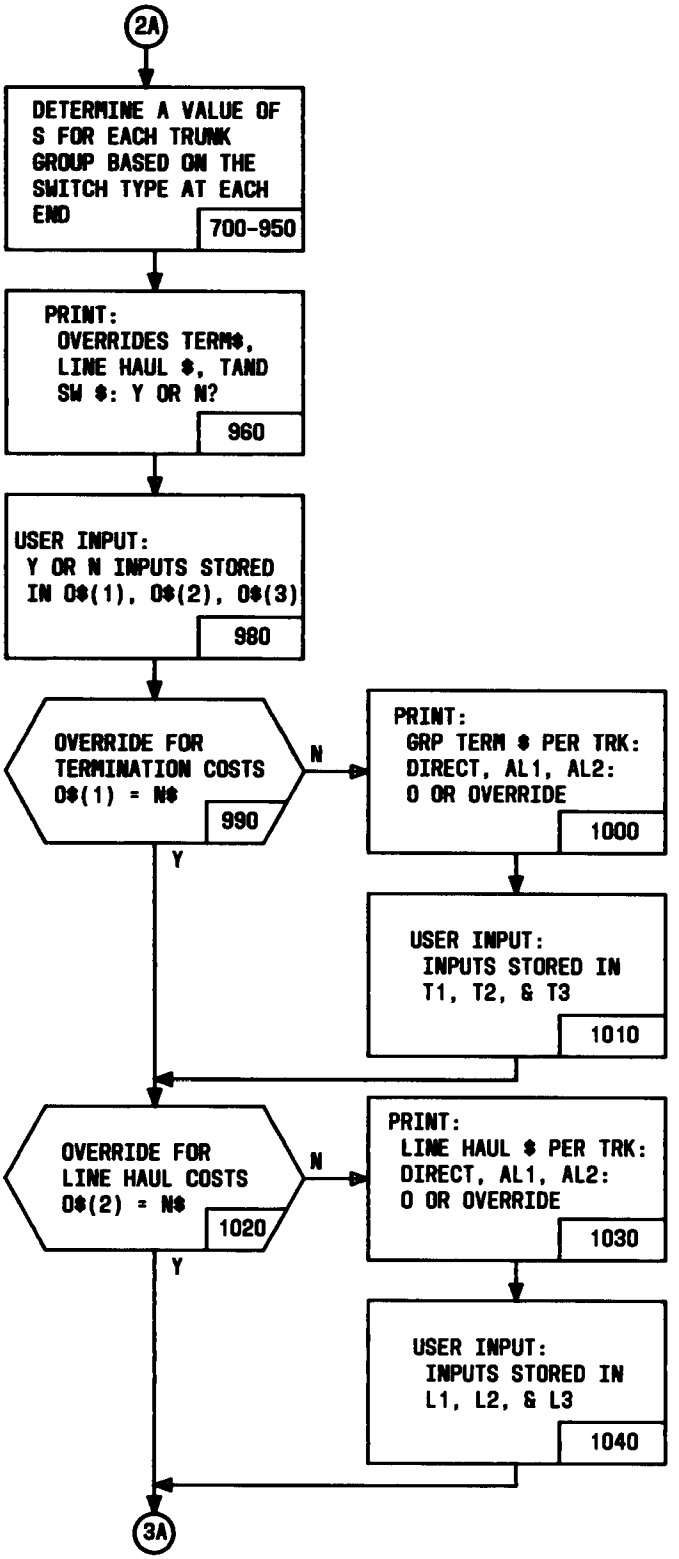


Fig. 2—CRAT Program Flowchart (Sheet 2 of 4)

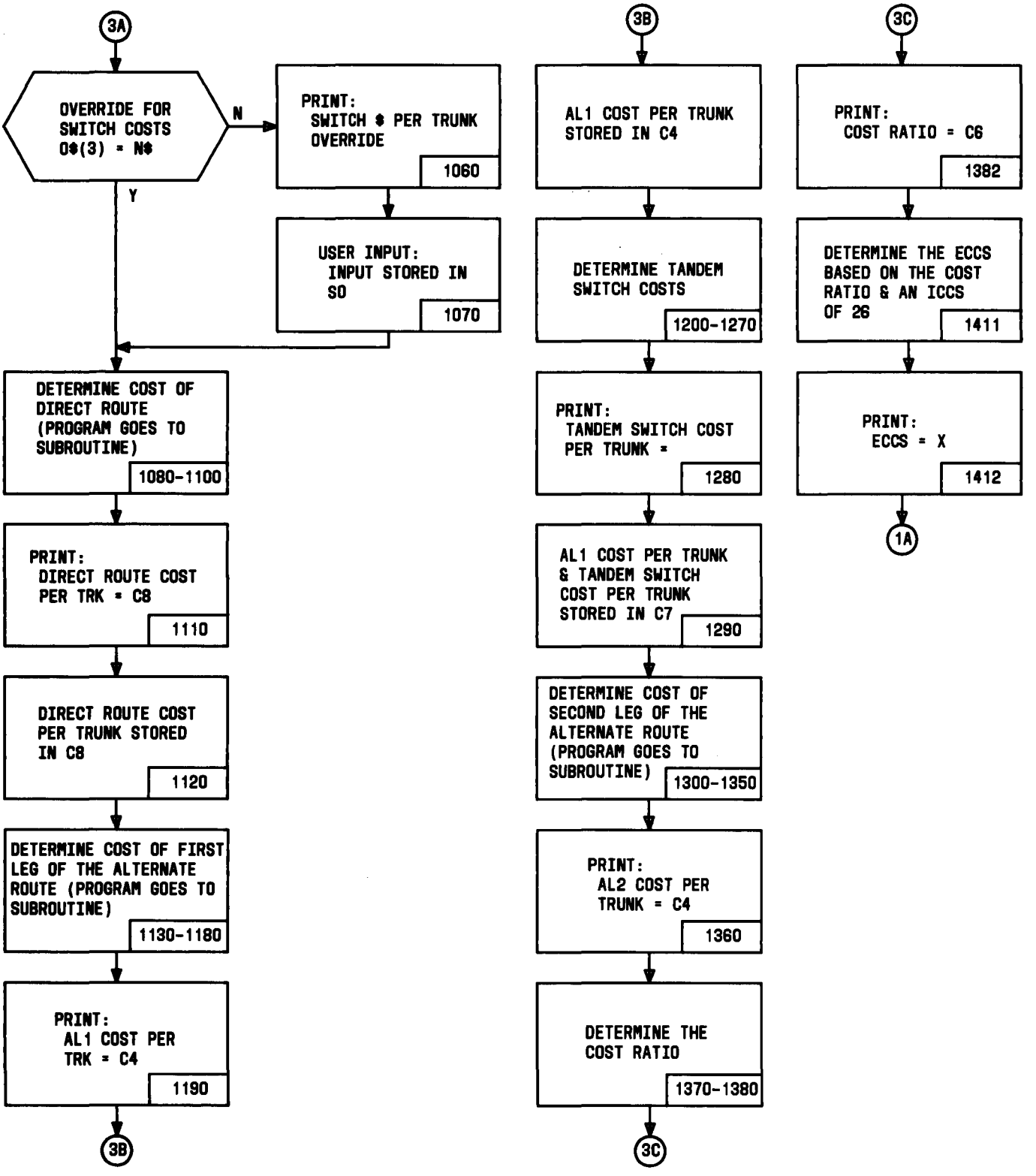


Fig. 2—CRAT Program Flowchart (Sheet 3 of 4)

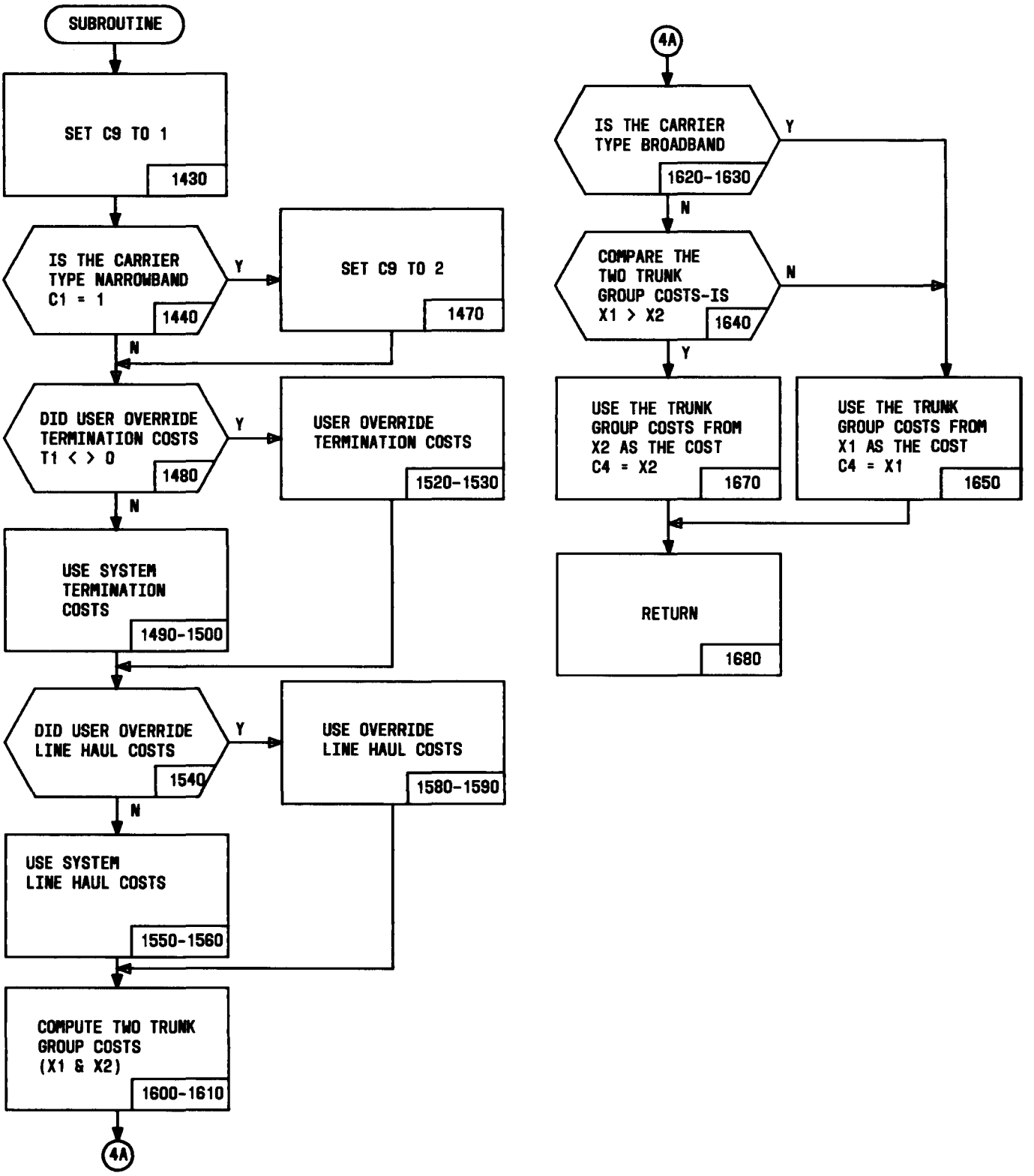


Fig. 2—CRAT Program Flowchart (Sheet 4 of 4)

```
CRAT

100 DIM L(6,4),T(6,4),C(3),S(3),R$(3),B$(3),A$(3),E$(3),Z(3)
110 MAT READ L
120 DATA 80,15,3.25,1.5
130 DATA 80,15,3.25,1.5
140 DATA 10000,15,3.25,1.5
150 DATA 80,15,3.25,1.5
160 DATA 10000,15,3.25,1.5
170 DATA 10000,15,3.25,1.5
180 MAT READ T
190 DATA 320,706,854,1189
200 DATA 286,521,669,1155
210 DATA 10000,580,728,1156
220 DATA 252,336,484,1121
230 DATA 10000,395,543,1122
240 DATA 10000,454,602,1123
250 'CARRIER TYPES ARE STORED AS ALPHANUMERICS IN R$,WHERE
260 'NB=NARROWBAND,DB=DIGITAL BROADBAND,AB=ANALOG BDBAND.
270 DATA NB,DB,AB
280 MAT READ R$
290 'SWITCH TYPES ARE STORED AS ALPHANUMERICS IN B$,WHERE
300 'EM=ELECTROMECHANICAL, AE=ANALOG ELECTRONIC, DE=DIGITAL ELECTRONIC.
310 DATA EM,AE,DE
320 MAT READ B$
330 DATA Y,N
340 READ Y$,N$
350 PRINT"TO STOP PROGRAM,ENTER STOP FOR TRUNK GROUP ID OR COMMENTS"
360 T1=T2=T3=L1=L2=L3=S0=0
361 PRINT
370 PRINT"TRUNK GROUP ID OR COMMENTS"
380 INPUT G$
390 IF G$="STOP" THEN 1700
391 PRINT
400 PRINT "DISTANCES:DIRECT,AL1,AL2"
410 INPUTD1,D2,D3
411 PRINT
420 PRINT "CARRIER TYPES:DIRECT,AL1,AL2"
430 MAT INPUT A$
440 FOR I=1 TO 3
450 FOR J=1 TO 3
460 IF A$(I)<>R$(J)THEN 490
470 C(I)=J
480 GO TO 500
490 NEXT J
500 NEXT I
510 'Z=1,2,3 IF EM,AE,DE
520 'EM-EM S=1
530 'EM-AE S=2
540 'EM-DE S=3
```

Fig. 3—CRAT Program Listing (Sheet 1 of 4)

```
550 'AE-AE S=4
560 'AE-DE S=5
570 'DE-DE S=6
580 'M INDEX DIRECT,AL1,AL2
590 'I INDEX Z VALUE OF A END OF M
600 'J INDEX Z VALUE OF Z END OF M
601 PRINT
610 PRINT "SWITCH TYPES: A-END,TANDEM,Z-END"
620 MAT INPUT E$
630 FOR I=1 TO 3
640 FOR J=1 TO 3
650 IF E$(I)<>B$(J) THEN 680
660 Z(I)=J
670 GO TO 690
680 NEXT J
690 NEXT I
700 M=1
710 I=1
720 J=3
730 IF Z(I)<>1 THEN 760
740 S(M)=Z(J)
750 GO TO 860
760 IF Z(I)=3 GO TO 820
770 IF Z(J)<>1 THEN 800
780 S(M)=2
790 GO TO 860
800 S(M)=Z(J)+2
810 GO TO 860
820 IF Z(J)<>1 THEN 850
830 S(M)=3
840 GO TO 860
850 S(M)=3+Z(J)
860 IF M=3 THEN 951
870 IF M=2 THEN 920
880 M=2
890 I=1
900 J=2
910 GO TO 730
920 M=3
930 I=2
940 J=3
950 GO TO 730
951 PRINT
960 PRINT "OVERRIDES TERM$,LINE HAUL $,TAND SW $: Y OR N?"
970 DIM O$(3)
980 MAT INPUT O$
990 IF O$(1)=N$ THEN 1020
1000 PRINT "GRP TERM $ PER TRK:DIRECT,AL1,AL2: 0 OR OVERRIDE"
1010 INPUT T1,T2,T3
1020 IF O$(2)=N$ THEN 1050
1030 PRINT "LINE HAUL $ PER TRK:DIRECT,AL1,AL2: 0 OR OVERRIDE"
1040 INPUT L1,L2,L3
1050 IF O$(3)=N$ THEN 1080
```

Fig. 3—CRAT Program Listing (Sheet 2 of 4)

```
1060 PRINT " SWITCH $ PER TRUNK OVERRIDE"
1070 INPUT S0
1080 C1=C(1)
1090 S1=S(1)
1100 GO SUB 1430
1101 PRINT
1110 PRINT "DIRECT ROUTE COST PER TRK=";C4
1120 C8=C4
1130 C1=C(2)
1140 T1=T2
1150 L1=L2
1160 S1=S(2)
1170 D1=D2
1180 GO SUB 1430
1181 PRINT
1190 PRINT "AL1 COST PER TRK=";C4
1200 IF S0<>0 THEN 1280
1210 IF Z(2)=1 THEN 1230
1220 GO TO 1250
1230 S0=1105
1240 GO TO 1271
1250 IF Z(2)=2 THEN 1270
1260 GO TO 1271
1270 S0=501.8
1271 PRINT
1280 PRINT "TANDEM SWITCH COST PER TRK=";S0
1290 C7=C4+S0
1300 C1=C(3)
1310 T1=T3
1320 L1=L3
1330 S1=S(3)
1340 D1=D3
1350 GO SUB 1430
1351 PRINT
1360 PRINT "AL2 COST PER TRUNK=";C4
1361 PRINT
1370 C7=C7+C4
1380 C6=C7/C8
1381 : #.#
1382 PRINT "COST RATIO =" ;
1383 PRINT USING 1381,C6
1384 PRINT
1410 : ##.
1411 X = 26/C6
1412 PRINT "ECCS =" ;
1413 PRINT USING 1410,X
1420 GO TO 1690
1430 C9=1
1440 IF C1=1 THEN 1470
```

Fig. 3—CRAT Program Listing (Sheet 3 of 4)

```
1450 C1=C1+1
1460 GO TO 1480
1470 C9=2
1480 IF T1 <> 0THEN 1520
1490 T4=T(S1,C1)
1500 T5=T(S1,C9)
1510 GO TO 1540
1520 T4=T1
1530 T5=T1
1540 IF L1 <> 0 THEN 1580
1550 L4=L(S1,C1)
1560 L5=L(S1,C9)
1570 GO TO 1600
1580 L4=L1
1590 L5=L1
1600 X1=T4+(L4*D1)
1610 X2=T5+(L5*D1)
1620 IF C1=3 THEN 1650
1630 IF C1=4 THEN 1650
1640 IF X1>X2 THEN 1670
1650 C4=X1
1660 GO TO 1680
1670 C4=X2
1680 RETURN
1690 GO TO 360
1700 END
```

Fig. 3—CRAT Program Listing (Sheet 4 of 4)

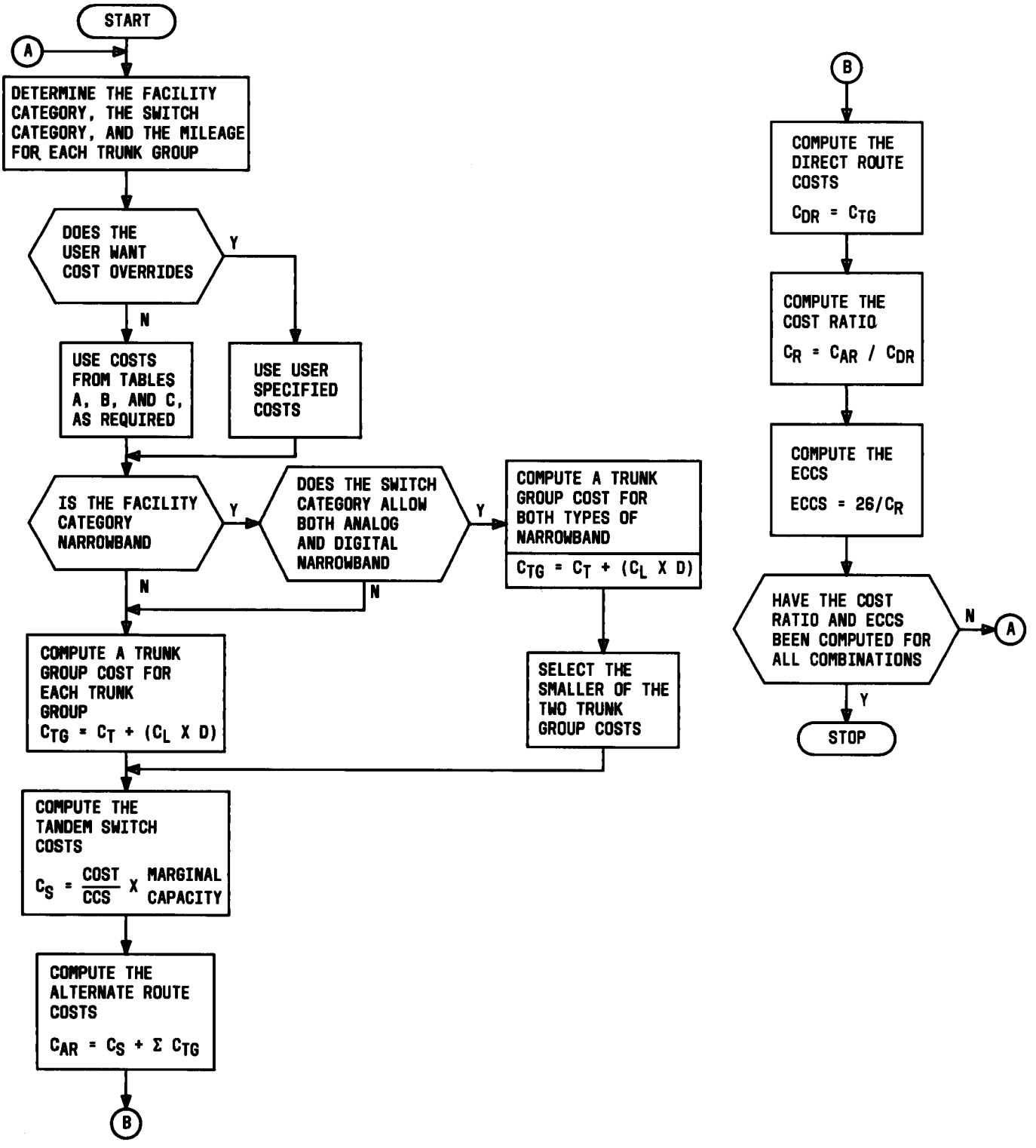
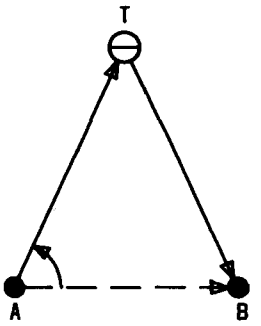


Fig. 4—Flowchart for Manual Broadguage Cost Procedures

PROBLEM:



THE TRUNK GROUP FROM A TO B IS TO BE SIZED. THE NETWORK SHOWN IS A DIGITAL BROADBAND NETWORK AND EACH TRUNK GROUP IS 100 MILES IN LENGTH. EACH OF THE SWITCHING SYSTEMS IS A NO. 1 ESS.

SOLUTION:

(1) DETERMINE THE APPROPRIATE CATEGORIES FOR EACH TRUNK GROUP. ALL TRUNK GROUPS WOULD HAVE AN AE-AE SWITCH CATEGORY, A DIGITAL BROADBAND FACILITY CATEGORY, AND A MILEAGE OF 100 MILES.

(2) COMPUTE THE TRUNK GROUP COSTS FOR EACH TRUNK GROUP.

$A \rightarrow T$	$T \rightarrow B$	$A \rightarrow B$
C_T = \$484	C_T = \$484	C_T = \$484
C_L = \$3.25/MILE	C_L = \$3.25/MILE	C_L = \$3.25/MILE
D = 100	D = 100	D = 100
$C_{A \rightarrow T}$ = \$484 + (\$3.25 X 100)	$C_{T \rightarrow B}$ = \$484 + (\$3.25 X 100)	$C_{A \rightarrow B}$ = \$484 + (\$3.25 X 100)
$C_{A \rightarrow T}$ = \$809	$C_{T \rightarrow B}$ = \$809	$C_{A \rightarrow B}$ = \$809

(3) COMPUTE THE TANDEM SWITCH COSTS (C_S).

SINCE THE TANDEM IS A NO. 1 ESS, ITS SWITCH CATEGORY IS AE. THEREFORE:

C_S = \$19.30 X MARGINAL CAPACITY
C_S = \$19.30 X 26
C_S = \$501.80

(4) COMPUTE THE ALTERNATE ROUTE COSTS (C_{AR}).

$C_{AR} = C_S + \Sigma C_{TG}$
$C_{AR} = C_S + C_{A \rightarrow T} + C_{T \rightarrow B}$
C_{AR} = \$501.80 + \$809 + \$809
C_{AR} = \$2119.80

(5) COMPUTE THE DIRECT ROUTE COSTS (C_{DR})

$C_{DR} = C_{TG}$
$C_{DR} = C_{A \rightarrow B}$
C_{DR} = \$809

(6) COMPUTE THE COST RATIO

$$C_R = C_{AR}/C_{DR} = \frac{\$2119.80}{\$809}$$

C_R = 2.62

(7) COMPUTE THE ECCS

$$ECCS = \frac{26}{CR} = \frac{26}{2.62}$$

ECCS = 9.92 = 10

Fig. 5—Example of Broadguaging Cost Using Manual Procedures

TABLE A

BROADGUAGE COSTS—TERMINATION AND LINE HAUL COSTS

SWITCH CATEGORY (NOTE 1)	CARRIER CATEGORY (NOTE 2)	TERMINATION $/TRUNK (NOTE 3)	LINE HAUL $/TRUNK-MILE
EM-EM	Analog Narrowband	320	80
EM-EM	Digital Narrowband	706	15
EM-EM	Digital Broadband	854	3.25
EM-EM	Analog Broadband	1189	1.50
EM-AE	Analog Narrowband	286	80
EM-AE	Digital Narrowband	521	15
EM-AE	Digital Broadband	669	3.25
EM-AE	Analog Broadband	1155	1.50
EM-DE	Digital Narrowband	580	15
EM-DE	Digital Broadband	728	3.25
EM-DE	Analog Broadband	1156	1.50
AE-AE	Analog Narrowband	252	80
AE-AE	Digital Narrowband	336	15
AE-AE	Digital Broadband	484	3.25
AE-AE	Analog Broadband	1121	1.50
AE-DE	Digital Narrowband	395	15
AE-DE	Digital Broadband	543	3.25
AE-DE	Analog Broadband	1122	1.50
DE-DE	Digital Narrowband	454	15
DE-DE	Digital Broadband	602	3.25
DE-DE	Analog Broadband	1123	1.50

Note 1: EM denotes any switch without electronic control. Examples are the SxS, Panel and XB systems. AE denotes switches with electronic controls which process messages in analog form. Examples are Nos. 1, 2, and 3 ESS and the RSS. DE denotes digital electronic switches such as the No. 4 ESS, 5 ESS and DMS* -10 digital switching system.

Note 2: Narrowband refers to digital carriers below the DS2 level and analog carriers below the supergroup level. VF wire, T1-T1C, N and ON are examples of Narrowband. Digital Broadband refers to digital carrier at the DS2 level and above. Analog Broadband refers to analog carrier at the supergroup level and above.

Note 3: Includes all apparatus at each end of the trunk.

* Registered trademark of Northern Telecom, Ltd.

TABLE B

BROADGUAGE COSTS—TANDEM SWITCH COSTS

SWITCH CATEGORY (NOTE)	COST ($/CCS)
Electromechanical (EM)	42.5 X Marginal Capacity
Analog Electronic (AE)	19.3 X Marginal Capacity
Digital Electronic (DE)	$0/CCS

Note: EM denotes any switch without electronic control. Examples are the SxS, Panel and XB systems. AE denotes switches with electronic controls which process messages in analog form. Examples are Nos. 1, 2, and 3 ESS and the RSS. DE denotes digital electronic switches such as the No. 4 ESS, 5 ESS and DMS-10 digital switching system.

TABLE C

BROADGUAGE COSTS—INTERFACE COSTS FOR MIXED GROWTH FACILITIES

TYPE OF INTERFACE	COST PER CIRCUIT ($)
Facility	
Analog Narrowband to/from Digital Narrowband	193
Analog Narrowband to/from Digital Broadband	267
Analog Narrowband to/from Analog Broadband	434.50
Digital Narrowband to/from Digital Broadband	74
Digital Narrowband to/from Analog Broadband	344.50
Digital Broadband to/from Analog Broadband	418.50
Switch to Carrier	
Electromechanical Switch to Analog Narrowband	160
Electromechanical Switch to Digital Narrowband	353
Electromechanical Switch to Digital Broadband	427
Electromechanical Switch to Analog Broadband	594.5
Analog Electronic Switch to Analog Narrowband	126
Analog Electronic Switch to Digital Narrowband	168
Analog Electronic Switch to Digital Broadband	242
Analog Electronic Switch to Analog Broadband	560.5
Digital Electronic Switch to Digital Narrowband	227
Digital Electronic Switch to Digital Broadband	301
Digital Electronic Switch to Analog Broadband	561.5

TABLE D

COST BROADGUAGE SOURCE INFORMATION — COMPONENT COSTS (NOTE)

COMPONENT	COST ($)	UNIT
VF Line Haul	80	/trunk-mile
T1 Line Haul		
Line Repeater and Apparatus Case	9	/trunk-mile
Cable	6	/trunk-mile
Total	15	/trunk-mile
Digital Broadband Line Haul	3.25	/trunk-mile
Analog Broadband Line Haul	1.50	/trunk-mile
Electromechanial Trunk Circuit	160	/trunk
No. 1 ESS Trunk Circuit	126	/trunk
D-Bank		
D4 Channel Bank and Bay	79	/trunk
Channel Unit	104	/trunk
Office Repeater and Bay	10	/trunk
Total	193	/trunk
DCT	158	/trunk
DIF	78	/trunk
VIF	284	/trunk
LT-1	215	/trunk
Digital Broadband Multiplexing		
M13	29	/trunk
T/R	45	/trunk
Total	74	/trunk
Analog Broadband Multiplexing		
A6B	305	/trunk
LMXG	45	/trunk
LMXS	16.5	/trunk
MMX	12	/trunk
T/R	56	/trunk
Total	434.5	/trunk
Miscellaneous Digital Electronic Switch Costs	139	/trunk
Tandem Analog Electronic Switch Costs	19.3	/CCS
Tandem Electromechanical Switch Costs	42.3	/CCS

Note:
Abbreviations used:

ab	analog broadband
A6B	multiplexor from voice to group (analog)
db	digital broadband
DBK	D-Bank (includes channel unit and repeater)
DCT	Digital Carrier Trunks
DIF	Digitial Interface Facility
ETC	trunk circuit — electronic switch
Line	carrier portion of group
LMXG	multiplexor from group to super group (analog)
LMXS	multiplexor from super group to master group (analog)
LT1	converter — analog group level to digital, DS-1, level
MMX	multiplexor to combine master groups (analog)
M13	multiplexor from DS-1 to DS-3 (digital)
S	switch
TC	trunk circuit — electromechanical switch
T/R	termination and radio equipment
VIF	Voice Interface Facility
R	Office Repeater and Bay

TABLE E

COST BROADGUAGE SOURCE INFORMATION — CONNECTION MODELS (NOTE)

TYPE OF INTERFACE	CONNECTION MODEL
SWITCH TO CARRIER	
Electromechanical Switch to	
Analog Narrowband Carrier	S-----TC------Line
Digital Narrowband Carrier	S------TC------DBK------Line
Digital Broadband Carrier	S------TC------DBK------M13------T/R------Line
Analog Broadband Carrier	S------TC------A6B------LMXG------LMXS ------MMX------T/R------Line
Analog Electronic Switch to	
Analog Narrowband Carrier	S------ETC------Line
Digital Narrowband Carrier	S------DCT------R------Line
Digital Broadband Carrier	S------DCT------R------M13------T/R------Line
Analog Broadband Carrier	S------ETC------A6B------LMXG------LMXS------ ------MMX------T/R------Line
Digital Electronic Switch to	
Digital Narrowband Carrier	S------DIF------R------Line
Digital Broadband Carrier	S------DIF------R------M13------T/R------Line
Analog Broadband Carrier	S------DIF------LT1------LMXG------LMXS ------MMX------T/R------Line
FACILITY	
Analog Narrowband Carrier to	
Digital Narrowband Carrier	vf Line------DBK------t1 Line
Digital Broadband Carrier	vf Line------DBK------M13------T/R------ ------db Line
Analog Broadband Carrier	vf Line------A6B------LMXG------LMXS------ ------MMX------T/R------ab Line
Digital Narrowband Carrier to	
Digital Broadband Carrier	t1 Line------M13------T/R------db Line
Analog Broadband Carrier	t1 Line------LT1------LMXG------LMXS------ ------MMX------T/R------ab Line
Digital Broadband Carrier to	
Analog Broadband Carrier	t1 Line------T/R------M13------LT1------ -----LMXG------LMXS------MMX------T/R------ ab Line

Note:
Abbreviations used:

ab	analog broadband
A6B	multiplexor from voice to group (analog)
db	digital broadband
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LT1	converter — analog group level to digital, DS-1, level
MMX	multiplexor to combine master groups (analog)
M13	multiplexor from DS-1 to DS-3 (digital)
S	switch
TC	trunk circuit — electromechanical switch
T/R	termination and radio equipment
VIF	Voice Interface Facility
R	Office Repeater and Bay

TABLE F

COST BROADGUAGE SOURCE INFORMATION—FACILITY DEFINITIONS

FACILITY	NUMBER OF CIRCUITS
ANALOG	
Voice	1
Group	12
Super Group	60
Master Group	600
Jumbo Group	3600
Jumbo Master Group	10800
DIGITAL	
DS-1	24
DS-1C	48
DS-2	96
DS-3	672
DS-4	2016