

## AUTOMATIC INTERCEPT SYSTEM TRANSMISSION CONSIDERATIONS

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**1. INTRODUCTION**

**1.01** Intercept traffic consists of those calls made to exchange line numbers that are vacant, disconnected, changed, or in trouble. This traffic may be handled in the office in which the call is terminated or may be handled at a centralized point to which calls from several offices are routed.

**1.02** The Automatic Intercept System (AIS) was developed to permit automatic processing of intercept traffic. In the AIS, intercepted calls are trunked from the class 5 office, where the intercept condition exists, to a remote Automatic Intercept Center (AIC), where the intercept information is provided by means of recorded announcements.

Calls requiring operator assistance are trunked to the Central Information Bureau (CIB) where an operator will assist the customer. This is accomplished by the use of time division switching, stored program control, magnetic record storage, and voice announcement systems, which comprise a system capable of providing announcements tailored to the specific need of each call handled. In addition to providing service advantages, economic savings may be realized by reducing the operator requirements as much as 75 percent.

**1.03** With the expansion of extended area service and the increasing application of nationwide subscriber toll dialing, the number of instances in which subscribers reach the intercepting service will increase. Any misunderstanding resulting from poor transmission on intercept calls is likely to cause unfavorable customer and/or operator reaction. Thus, the importance of good intercept transmission cannot be overemphasized.

**1.04** One of the major problems in intercept service is control of a potentially wide range of transmission volumes. Calls reaching the intercept office may vary from zero length loops within the same building to the longest trunk connection, and the received volume range may be as high as 20 dB. Acceptable transmission performance requires the use of AIS trunks with lower overall net loss and higher return loss than for message network trunks. The more stringent requirements are necessary to avoid the inherent problems of low received volumes and high operator sidetone levels.

**1.05** This section describes AIS arrangements and presents the transmission considerations for trunks and circuits. In addition, system performance is assessed in terms of (1) the volume grade of service (VGS) on interoffice and toll-originated calls and (2) sidetone levels received by the operator and supervisor. A future Section 852-405-200 will provide detailed information on AIS trunk design.

## 2. SYSTEM DESCRIPTION

### A. Single-AIC System

**2.01** The simplest form of AIS is called a single-AIC system (Fig. 1). In this form, all of the class 5 offices in a city and surrounding suburbs are served by one centrally located AIC. Calls from the message network which are not completed because of number change, discontinued service, etc, are intercepted in the called class 5 (intercept) office and trunked to the the AIC for handling by recorded announcement. Path 1 in Fig. 1 indicates the connection through the switch to the announcement machine. Appropriate announcement information can be given on nearly all intercepted calls.

**2.02** At the completion of the announcement, the calling party may remain on the connection to receive operator assistance through the path 2 connection from the AIC to the CIB. The team of operators and the supervisor are located in a centralized intercept bureau (CIB), which may be at a location remote from the AIC.

**2.03** The operator has facilities for setting up other less frequent types of connections, some of which are three-way. These include the following:

- (a) The addition of the announcement machine (path 3),
- (b) The addition of the supervisor (path 4),
- (c) Emergency completion to the message network (path 5),
- (d) A direct connection from the AIC to the supervisor (path 6).

### B. Multi-AIC System

**2.04** A single AIC can serve about 50 to 100 offices, depending on the traffic rates of the individual class 5 offices. Larger metropolitan areas might be divided into a number of independent single-AIC systems; however, the use of one or more multi-AIC system (Fig. 2) may be more economical. In this system, each AIC provides announcement service for a specific group of class 5 offices, and all AICs have access to a single CIB for operator service. One of the AICs, called a home AIC, has direct access to the CIB. The

other AICs, called remote AICs, gain access through the home AIC.

**2.05** For simplification, Fig. 2 shows class 5 office connections to the remote AIC announcement machine (path 1) and to the CIB operator (path 2). Class 5 offices that are connected to the home AIC function as a single-AIC system. The CIB operator has direct trunk access to the remote and home AIC announcement machines. This trunk allows the operator to add the announcement machine onto a customer connection to observe the recording.

### C. Operator Number Identification

**2.06** In either the single-AIC or multi-AIC system, an Operator Number Identification (ONI) feature may be incorporated as an economical alternative for short life panel or step-by-step offices where the conversion cost would make their inclusion in the AIS unattractive. With this plan, the AIC routes the call directly to an ONI position where an operator requests the called intercepted number from the customer, keys the information into the AIC, and releases. From this point, the AIC handles the call on an automatic basis. The important consideration is that *every* call in ONI requires at least an initial operator connection, while only about 5 percent of calls in fully automatic operation require connection to the operator.

### D. Use of Trunk Concentrators

**2.07** Traffic to the AIC may be routed directly from the local central office to the AIC (Fig. 1) or it may be routed first to a trunk concentrator and then to the AIC (Fig. 3). As shown in Fig. 3, the 23 concentrator may be remote from or collocated with the AIC. The AIC incoming trunks from the class 5 offices are designed to junction only with reverse battery supervision. The 23 concentrator will accept loop, reverse battery, or E and M supervision and convert the reverse battery to interface with the AIC incoming trunk circuits. Only one concentrator may be used between a class 5 office and the AIC.

**2.08** With the options specified for AIS in SD-95513-01 and SD-95560-01, the 23-type concentrator is suitable for AIS application. These options make the concentrator insertion loss and return loss acceptable for AIS, although there is some transmission impairment.

**2.09** One impairment is caused by the insertion loss (IL) of the concentrator (0.6 dB with AIS options). This results in lower volume grade of service (4.02). On a two-way customer-to-operator connection, there is approximately a 1-percent change in VGS ratings from "good" to "fair" and about a 0.5-percent change from "fair" to "poor". On three-way connections, these changes are approximately doubled.

**2.10** Another effect of the concentrator is to increase operator sidetone volume by decreasing the overall return loss to the operator position. With the AIS options, the return loss of the concentrator is high enough to have only a slight effect on sidetone volume. However, the received volume relative to sidetone volume will decrease by 0.6 dB (insertion loss of the concentrator). This decrease is acceptable in two-way connections where the average received volume (without a concentrator) is 2.6 dB above average sidetone volume. In three-way connections where received and sidetone volumes are approximately equal, the decrease in received volume relative to sidetone is undesirable but probably tolerable considering the infrequent occurrence of these connections.

### **3. TRANSMISSION DESIGN REQUIREMENTS**

**3.01** The objective for the volume grade of service received by customers, operators, and supervisors should be approximately the same as on nonintercepted connections between customers in order to provide acceptable speech levels. However, a somewhat lower grade of service may be justified on three-way connections because of economic considerations and the infrequent occurrence of three-way calls.

**3.02** Another objective is that average sidetone levels received by operators and supervisors should be about 3 dB lower than average received speech levels. This level of sidetone is sufficiently high to provide a "live" connection, but not high enough to cause annoyance or excessive impairment in operator transmit volume.

**3.03** The objectives on announcement-handled calls can be met simply by setting the announcement level sufficiently high to meet the volume grade-of-service objective.

**3.04** By comparison, the problem of meeting objectives on operator-handled calls is quite

complex. Various compromises are necessary, and requirements become even more severe than in toll connecting circuits. The following factors are considered in setting the requirements:

- (a) The need for gain in limiting the overall loss of trunks and circuits between the class 5 office and the CIB;
- (b) The need for gain in operator and supervisor circuits to offset low transmitter efficiency and losses caused by the provision for three-way connections;
- (c) The need for high return losses to limit operator sidetone;
- (d) Conflicts between gain and sidetone requirements;
- (e) Loss differences in two-way and three-way connections.

**3.05** Based on these considerations, insertion loss (or gain) and echo return loss (ERL) requirements have been formulated for individual trunks and circuits to ensure acceptable overall performance. Insertion loss requirements are based on the use of 900-ohm terminations at both ends of the circuit. Return loss requirements are based on measurements with the 54C test set (0.5- to 2.5-Hz sweep) at the trunk end nearer the CIB, using 900 ohms plus 2.16  $\mu$ F for both the reference impedance and the far-end termination.

#### **A. Trunk Requirements**

**3.06** Specific insertion loss and echo return loss requirements for trunks are shown in Table A. Interbuilding trunks will usually require repeaters to meet insertion loss requirements. Impedance compensators are required at both ends of repeated and nonrepeated trunks in order to meet return loss requirements. These requirements cover the cable plus associated repeaters and compensators. Intrabuilding trunks must be equipped with pads and meet the above requirements in order to obtain proper overall performance.

#### **B. AIC Circuit Requirements**

**3.07** All connections at the AIC are made through a path consisting of an incoming trunk circuit, a time division bus, and an outgoing trunk circuit.

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The nominal 1-kHz insertion loss requirements for the complete path are 2 dB for single AICs and 0 dB for home and remote AICs or for single AICs when remote concentrators are used. The latter requirement necessitates the use of gain units which are being developed for outgoing trunk circuits and which consist of a shunt negative impedance converter of the type employed in No. 101 ESS. The echo return loss requirement for all AICs is 25-dB minimum.

**3.08** The announcement machine output should be adjusted to provide proper levels into trunks to class 5 offices. These levels are -18 VU (volume unit) for nominal 2-dB trunks and -16 VU for nominal 4-dB trunks.

### C. CIB Circuit Requirements

**3.09** A portion of the needed gain in AIS is obtained from 227-type amplifiers in the transmit and receive legs of the operator and supervisor circuits. Table B shows the approximate net power gain (or loss) provided in these circuits.

**3.10** Since the transmit and receive ports of these circuits operate at approximate impedance levels of 70 and 300 ohms, respectively, the power gains in Table B are not indicated directly on normally available transmission measuring equipment. To simplify line-up procedures, the use of 900-ohm transmission measuring equipment is specified. Line-up methods and measurement levels will be specified in Section 250-402-502.

## 4. SYSTEM PERFORMANCE

**4.01** Performance of the AIS is assessed in terms of received volume, volume grade of service, and sidetone level. These factors are discussed and compared with objectives in the following paragraphs. In addition, the effect of intercept office circuits is evaluated.

### A. Volume Grade of Service

**4.02** Volume grade of service is a performance rating combining listener opinion and received-volume distributions in a single index, which is widely used as a measure of acceptability of received-speech levels. In this section, volume grade of service is given in three categories: Good or Better (G), Fair (F), and Poor or Worse (P). Figures 4 through 8 show volume grade-of-service

data for the principal types of AIS connections on interoffice calls. Figures 9 through 13 show data for the same type of connections on toll calls.

**4.03** As an example, refer to Fig. 5, which applies to an interoffice call routed to the operator. This figure includes (1) a block diagram of transmission facilities between the calling customer and the operator, (2) customer and operator talking volumes (from surveys) and component losses and gains (from AIS requirements), and (3) received volume and grade of service at customer and operator locations.

**4.04** Note that in Fig. 5 the volume received by the customer is -29.3  $\sigma$ 4.6 VU and that the grade-of-service ratings are Good—95 percent, Fair—5 percent, and Poor—0 percent (rounded to nearest 0.5 percent). For comparison, the adjacent values in parentheses indicate the grade of service that would be expected on nonintercepted calls. These values are approximate objectives.

**4.05** The received volume shown at the input of the operator receive transformer is 5 dB higher than the actual received volume at the transformer input. This increase corrects for the higher efficiency of the operator circuit relative to the 500-type telephone set and avoids the need for corrections when using grade-of-service curves for the 500-type set.

**4.06** The following conclusions can be drawn from the data in Fig. 4 through 13:

(a) In two-way connections (Fig. 4, 5, 6, 9, 10, and 11), the grade of service received by the customer, operator, and supervisor will average slightly better (5.5 percent above to 2.5 percent below in Good category) than that received by customers on nonintercepted calls. Therefore, service should be satisfactory.

(b) In three-way connections to the operator and supervisor (Fig. 7 and 12), objectives are similarly met in eight out of twelve cases. The other cases involve end-to-end transmission between the customer and the supervisor. In the poorest of these, the ratings are Good—77 percent (91), Fair—20 percent (8), and Poor—3 percent (1). These connections are of short duration, and the operator has the ability to assist in relaying the message.

(c) In the three-way connections to the operator and message network (Fig. 8 and 13), objectives are not met in eight of twelve cases. The poorest case involves end-to-end transmission between the two customers, and the ratings are Good—55 percent (93.5), Fair—31 percent (6), and Poor—14 percent (0.5). Although the 14 percent of connections rated Poor is undesirably high, possibly not more than 4 percent or so would be considered unworkable. That performance should be regarded as tolerable.

#### B. Sidetone Level

**4.07** On two-way transmission between the customer and operator, the average operator sidetone level is  $-32.6$  VU. The average received-speech levels are  $-30.6$  VU for interoffice connections (Fig. 5) and  $-27.5$  VU for toll connections (Fig. 10). The combined average is about  $-30$  VU. The average sidetone level is, therefore, about 2.6 dB lower than the average received-speech level and is within the objective range. These same average levels of sidetone and speech are received by the supervisor on two-way connections.

**4.08** On three-way connections, operator sidetone levels are slightly higher. Supervisor average sidetone levels increase from  $-32.6$  to  $-30$  VU. The latter is slightly lower than speech levels received from the operator but higher than speech levels received from the customer. Therefore, on three-way connections, the supervisor sidetone levels will exceed the objective, but performance is considered tolerable because of the expected short duration of the connection.

#### C. Intercept Office Circuits

**4.09** In determining the grade of service and sidetone data, the assumption was made that the transmission path through the class 5 intercept office is the same as on normally completed connections to the called party. Actually, an additional office circuit is required to route the

call to the AIS, but the resulting impairments in insertion loss and return loss are insignificant.

**4.10** Calls from the message network enter the intended class 5 office of completion in an incoming trunk circuit (or similar functional circuit known by a wide variety of names in various switching systems). Normally the call is completed through the incoming trunk circuit to the called party as shown at A in Fig. 14. In the AIS, however, the call will be switched to an outgoing (intercept) trunk circuit (shown at B) and onward to the AIC and possibly to the CIB.

**4.11** Return loss and insertion loss measurements of the class 5 office circuits have been made under both normal and intercept conditions for panel, crossbar No. 1 and No. 5, and step-by-step offices. There are six types of outgoing trunk circuits used in AIS, and these are either newly developed for AIS or modified existing intercept trunk circuits. All of these were included in the measurements. From the very large number of incoming trunk circuits, nine covering the expected extreme range of characteristics were selected for measurement. The results of this investigation can be summarized as follows:

(a) As compared to the normal office connection, the intercept connection introduces insertion loss impairments at 1 kHz ranging from 0 dB to 0.3 dB.

(b) Except for panel offices, the minimum ERL of the *office* is about 22 dB for the normal path and 20 dB for the intercept path. This reduction from 22 to 20 dB should not appreciably degrade the assumed 13 dB average for the *message network plus the office*. In panel offices, the minimum ERL of the *office* is 19.5 dB for the normal path and 18.0 dB for the intercept path. This reduction will somewhat degrade the 13 dB assumed for the *message network plus office*, but is regarded as acceptable because of the expected early replacement of panel systems.

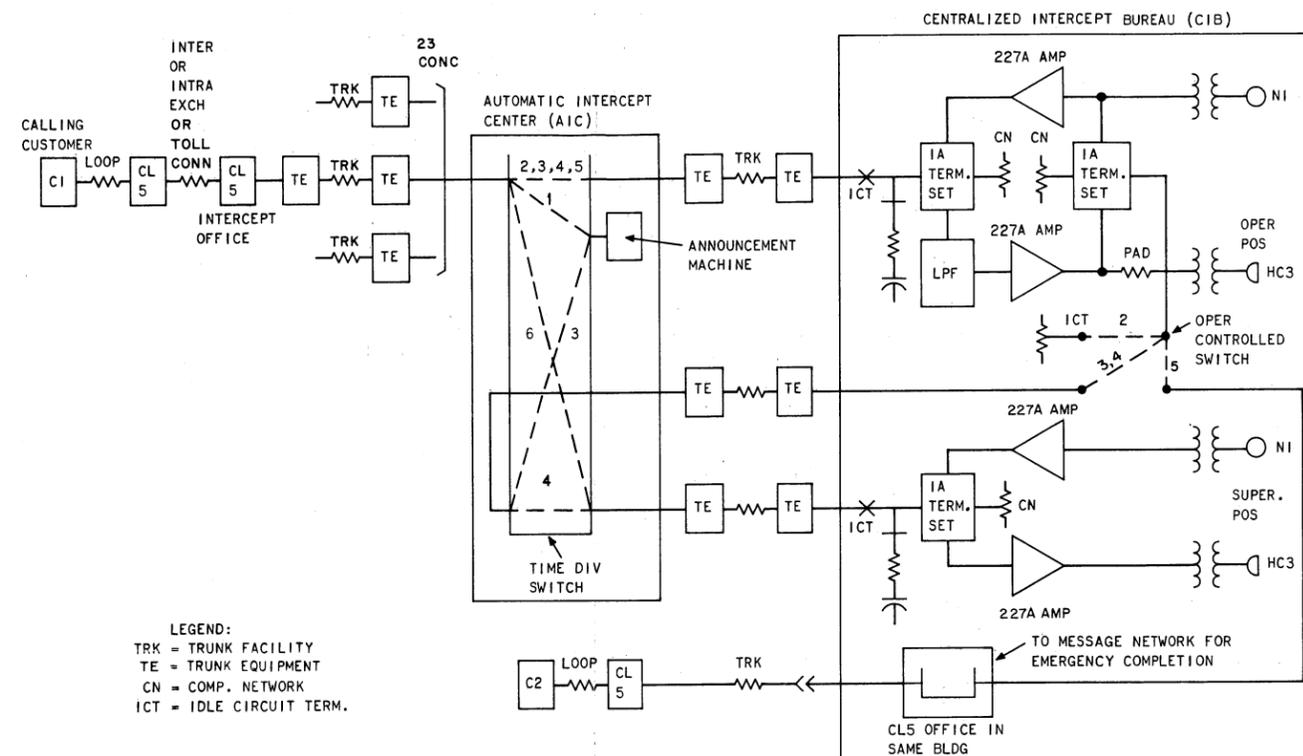
**TABLE A**  
**TRUNK REQUIREMENTS**

TRUNKS	INSERTION LOSS AT 1 KHZ	ECHO RETURN LOSS
Class 5 to Single AIC	$2 \pm 0.25$ dB	20 dB min.
Class 5 to Concentrator	$2 \pm 0.25$	20
Class 5 to Remote AIC	$2 \pm 0.25$	20
Class 5 to Home AIC	$4 \pm 0.25$	20
Concentrator to AIC*	$2 \pm 0.25$	20
Remote AIC to Home AIC	$2 \pm 0.25$	20
Single or Home AIC to CIB	$2 \pm 0.25$	23
CIB to Remote AIC	$4 \pm 0.25$	20

\*If the concentrator is collocated with the AIC, the AIC switch loss is 2 dB. If the concentrator is remote, the switch loss is 0 dB.

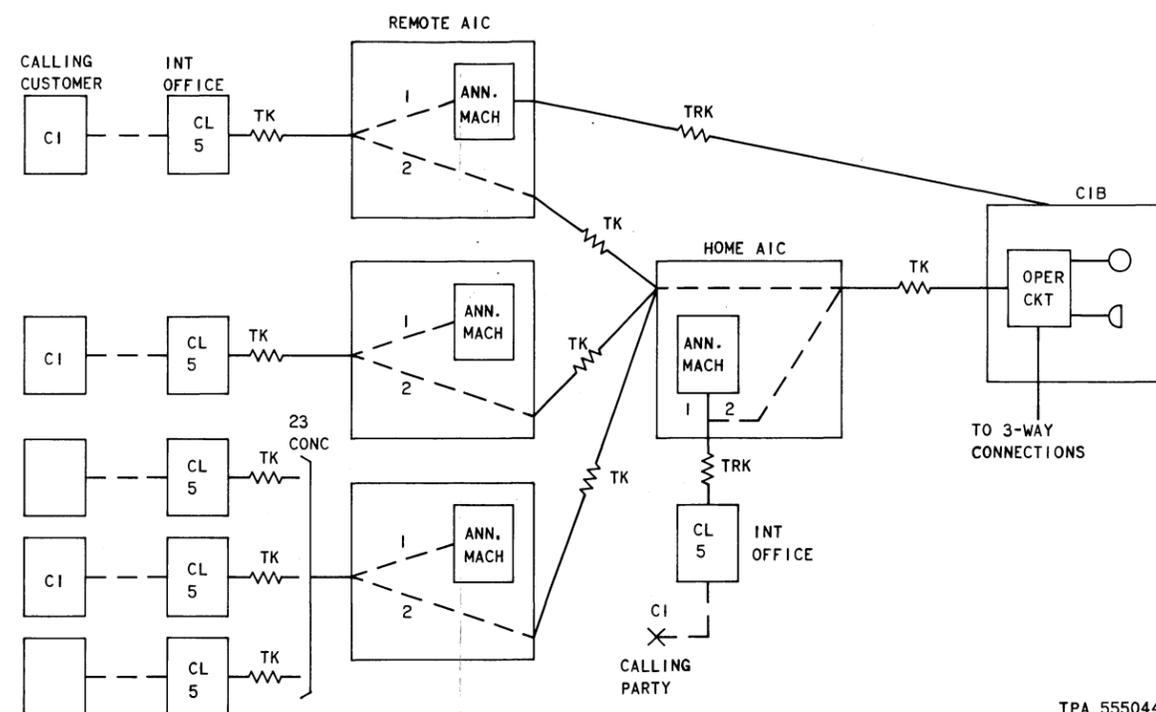
**TABLE B**  
**CIB CIRCUIT POWER GAINS**

PORTS	OPERATOR CIRCUIT	SUPERVISOR CIRCUIT
Transmitter to 2-wire incoming trunk	+4 dB	+4 dB
2-wire incoming trunk to receiver	-2 dB	-2 dB
Transmitter to 2-wire outgoing trunk	-7 dB	—
2-wire outgoing trunk to receiver	-10 dB	—



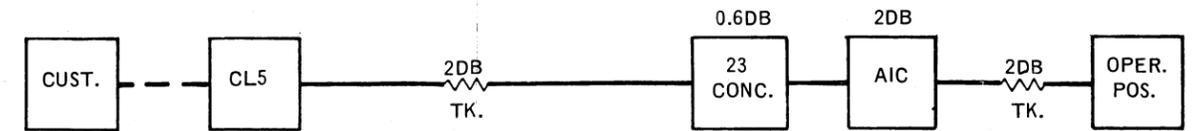
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Fig. 1—Automatic Intercept Single-AIC System

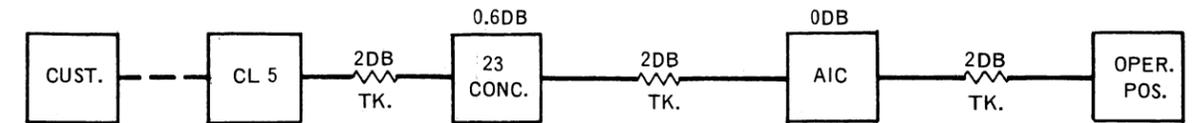


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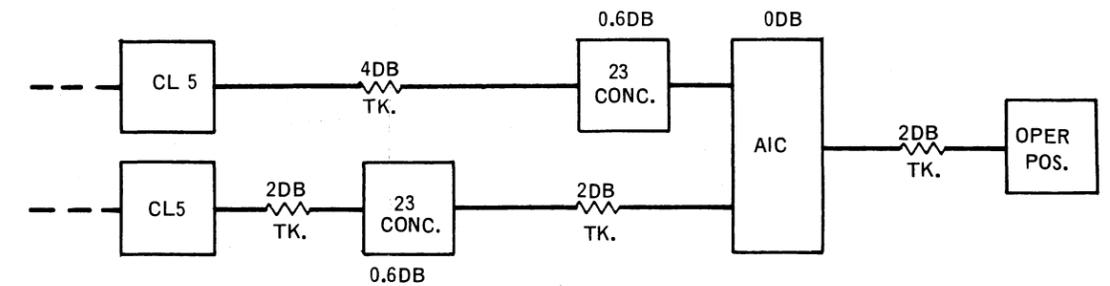
Fig. 2—Automatic Intercept Multi-AIC System



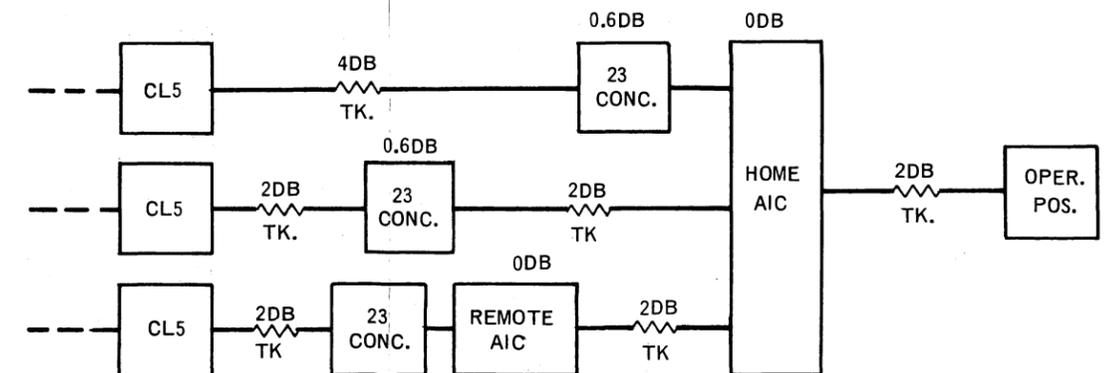
SINGLE-AIC SYSTEM  
CONCENTRATOR AT AIC  
A



SINGLE-AIC SYSTEM  
CONCENTRATOR AT INTERMEDIATE OFFICE  
B



SINGLE-AIC SYSTEM  
CONCENTRATOR AT AIC AND  
AT INTERMEDIATE OFFICE  
C



MULTI-AIC SYSTEM  
CONCENTRATOR AT SEVERAL LOCATIONS  
D

Fig. 3

EXPECTED GRADE OF SERVICE  
ON INTER-OFFICE CALLS  
CUSTOMER AND ANNOUNCEMENT

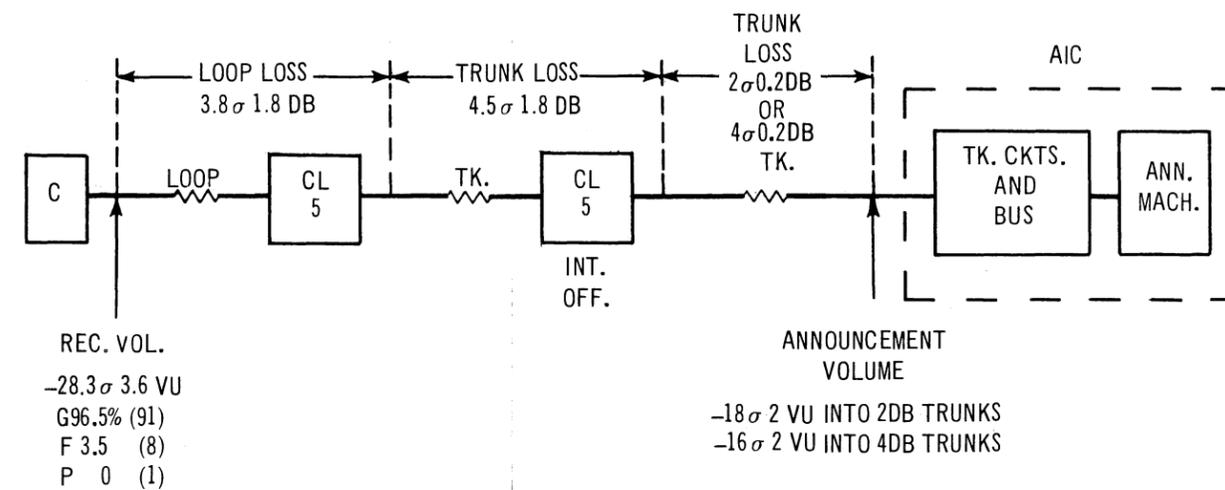


Fig. 4

EXPECTED GRADE OF SERVICE  
ON INTER-OFFICE CALLS  
CUSTOMER AND OPERATOR

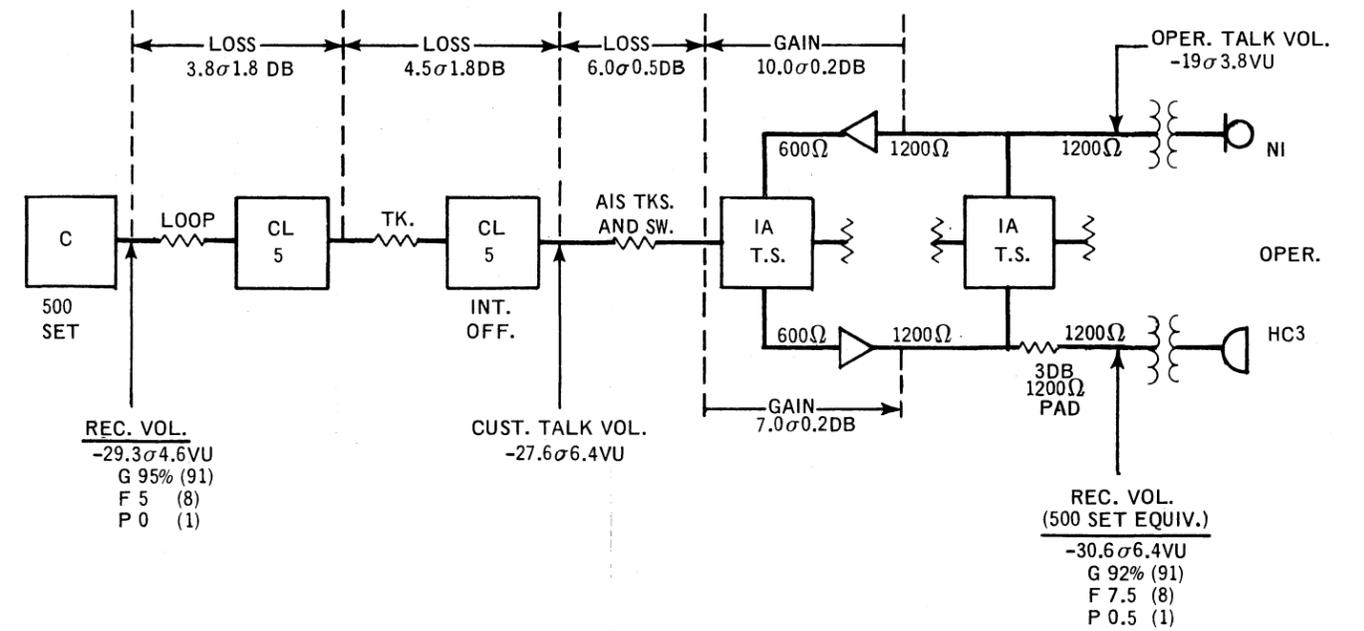


Fig. 5

EXPECTED GRADE OF SERVICE  
ON INTER-OFFICE CALLS  
CUSTOMER AND SUPERVISOR

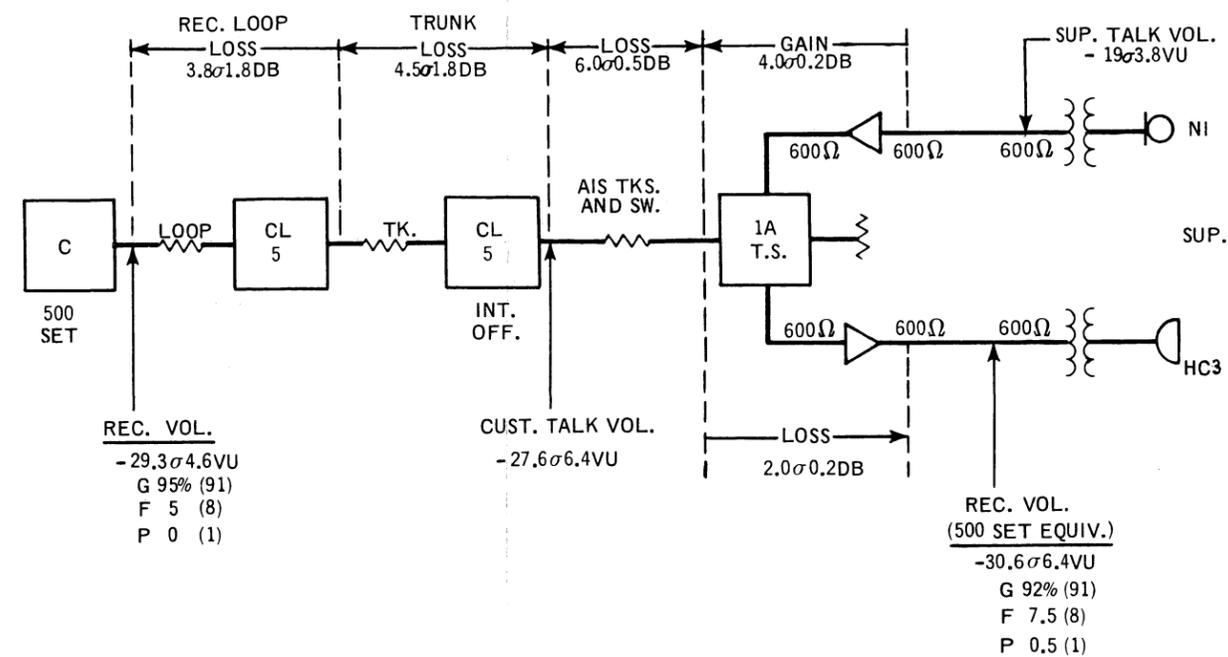


Fig. 6

EXPECTED GRADE OF SERVICE  
ON INTER-OFFICE CALLS  
CUSTOMER, OPERATOR AND SUPERVISOR

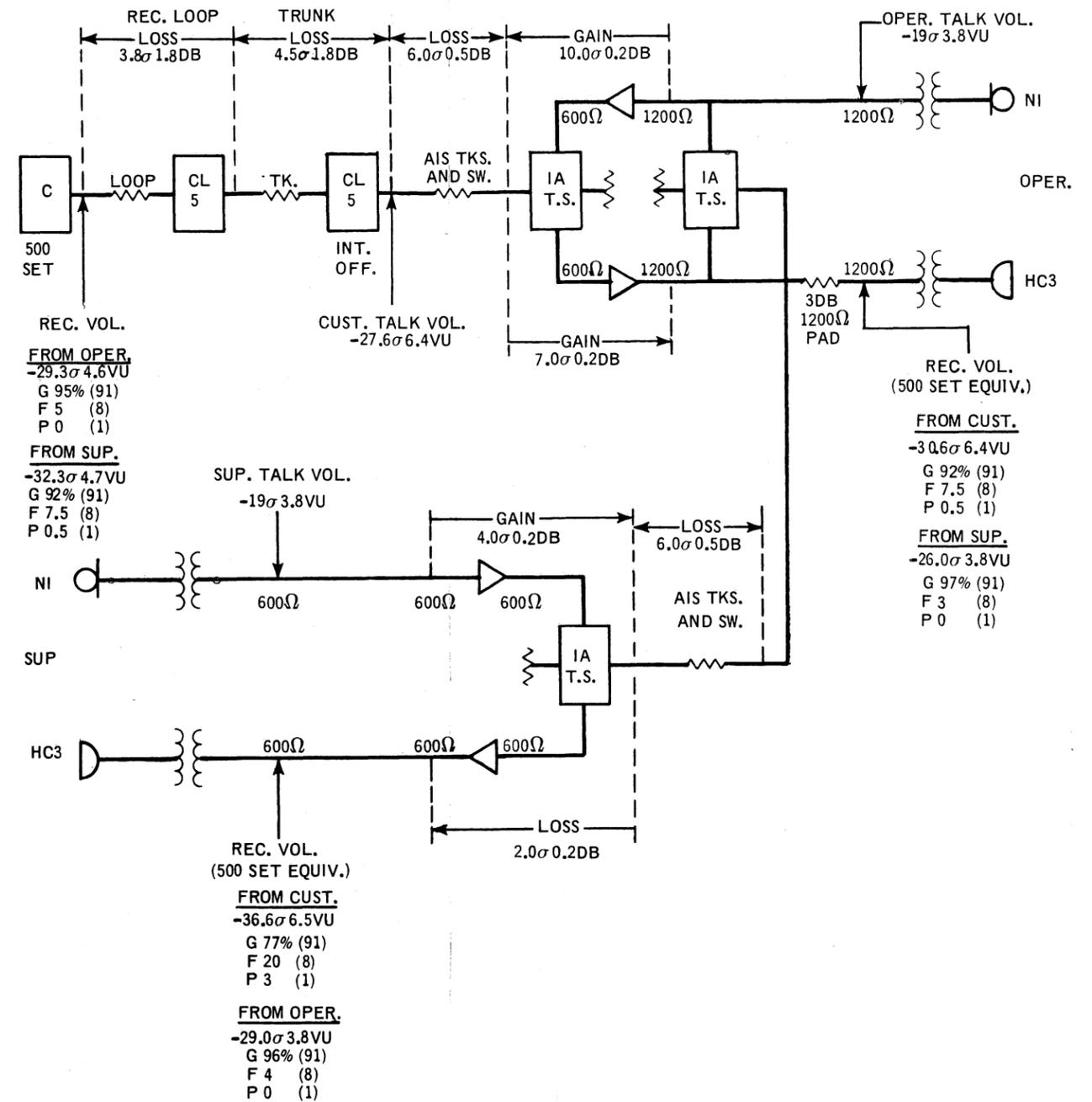


Fig. 7

EXPECTED GRADE OF SERVICE  
ON INTER-OFFICE CALLS  
CUSTOMER, OPERATOR AND MESSAGE NETWORK

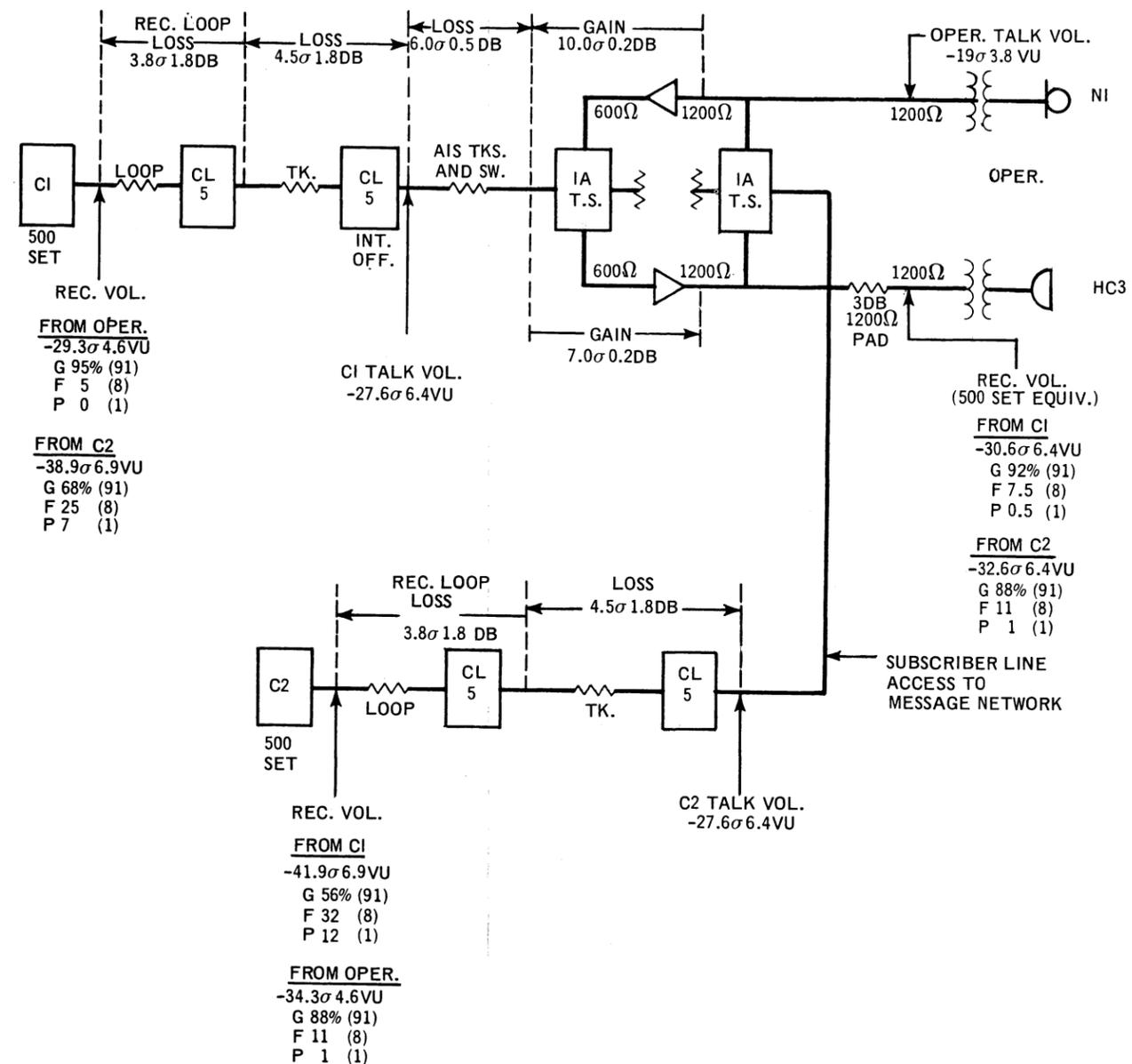


Fig. 8

EXPECTED GRADE OF SERVICE  
ON TOLL CALLS  
CUSTOMER AND ANNOUNCEMENT

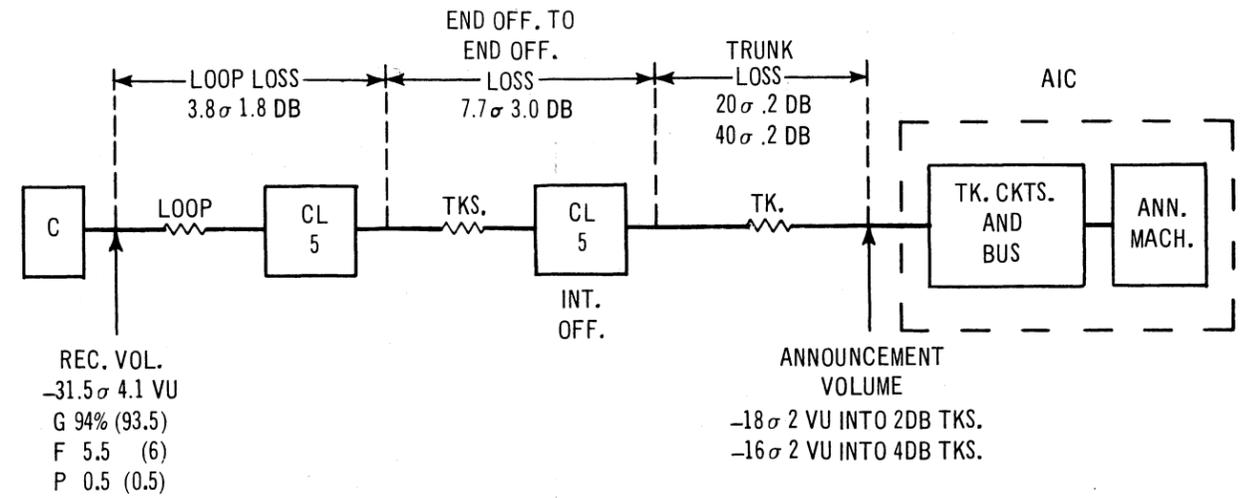


Fig. 9

EXPECTED GRADE OF SERVICE  
ON TOLL CALLS  
CUSTOMER AND OPERATOR

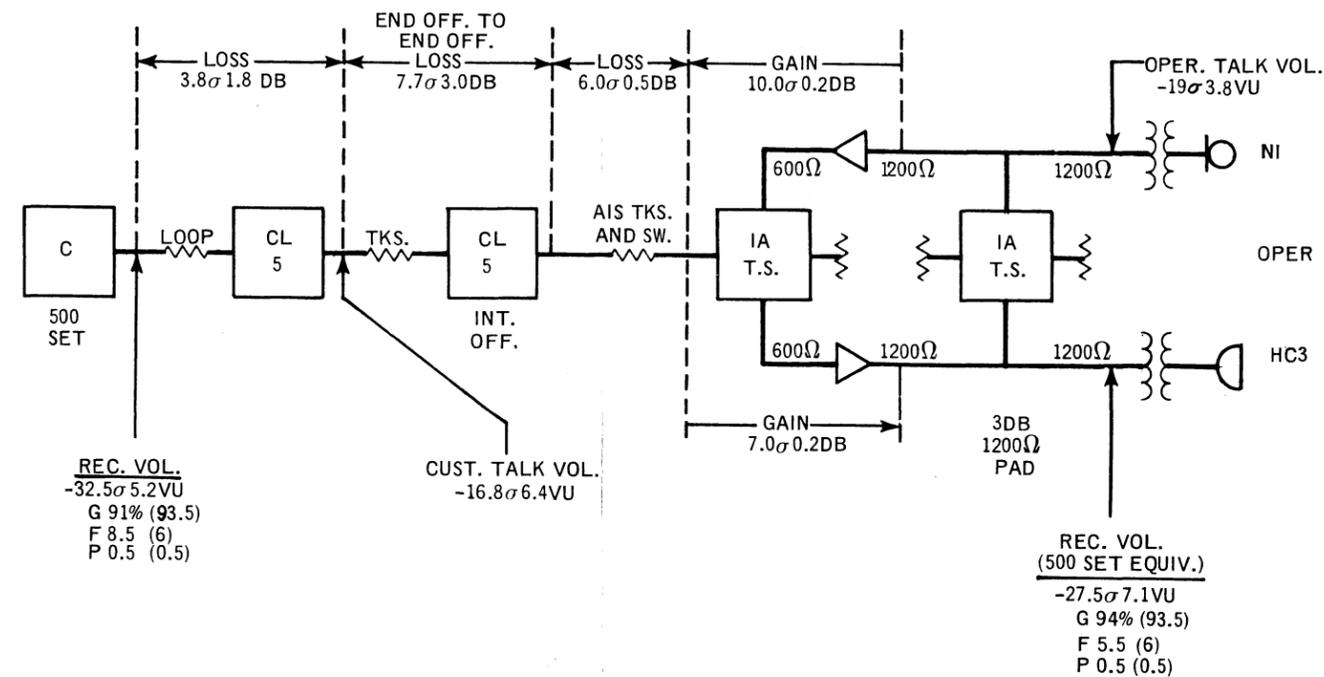


Fig. 10

EXPECTED GRADE OF SERVICE  
ON TOLL CALLS  
CUSTOMER AND SUPERVISOR

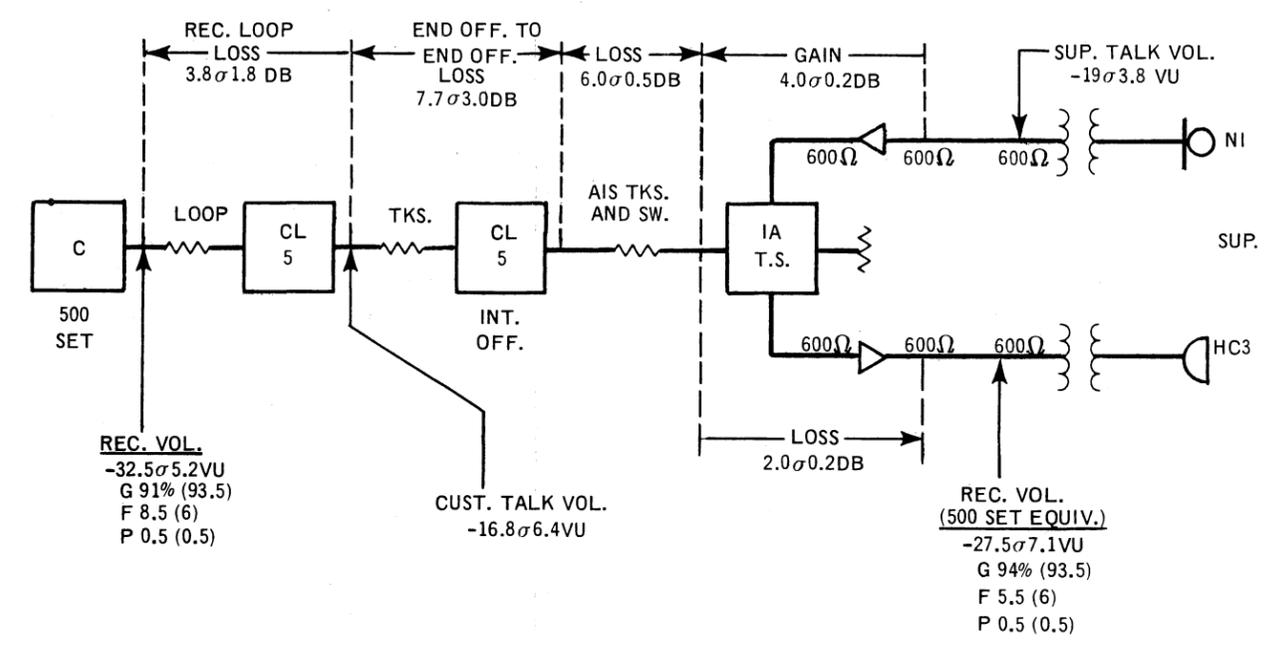


Fig. 11

EXPECTED GRADE OF SERVICE  
ON TOLL CALLS  
CUSTOMER, OPERATOR AND SUPERVISOR

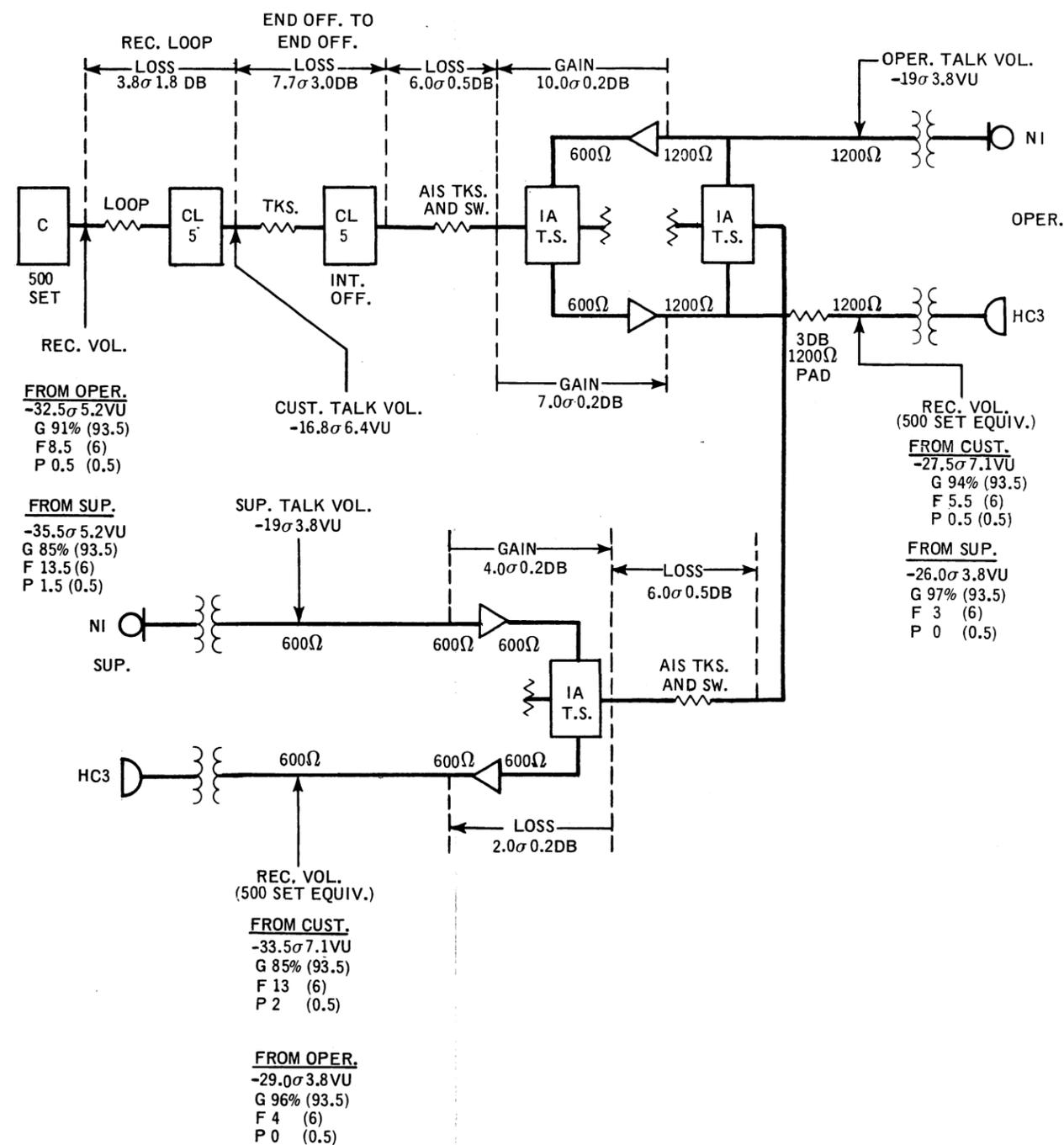


Fig. 12

EXPECTED GRADE OF SERVICE  
ON TOLL CALLS  
CUSTOMER, OPERATOR AND MESSAGE NETWORK

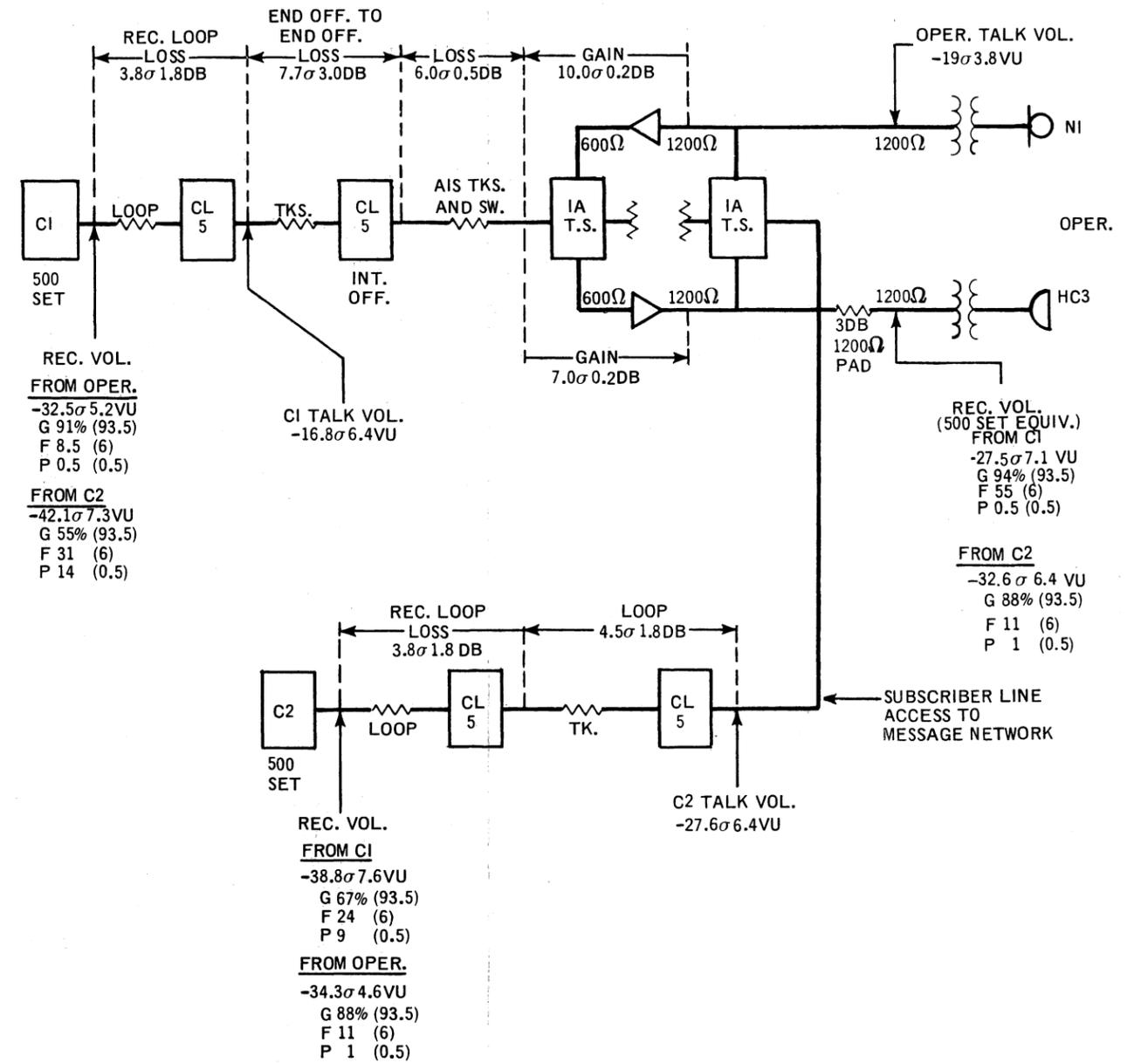


Fig. 13

TRANSMISSION PATH  
THROUGH CLASS 5 OFFICE ON  
NORMAL AND INTERCEPT CONNECTIONS

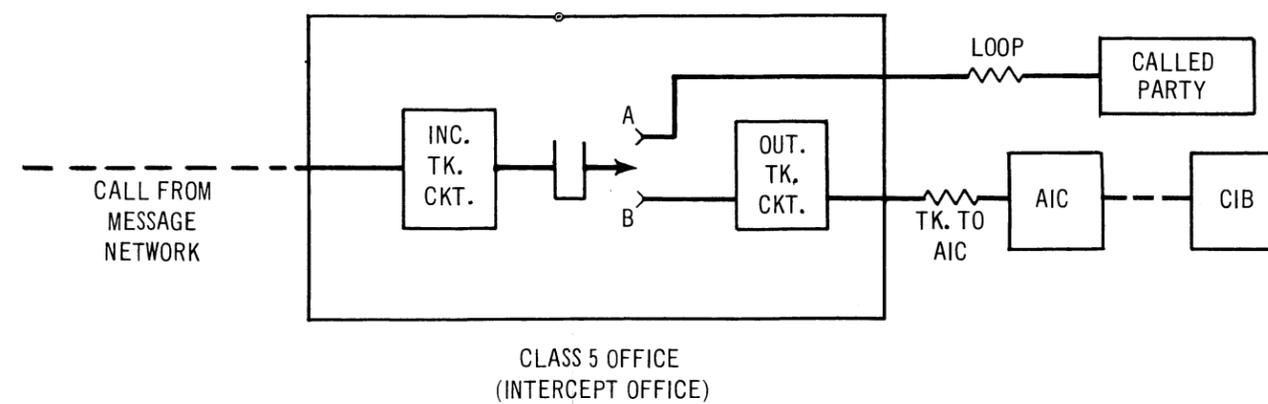


Fig. 14