DATA SYSTEMS
CENTRAL OFFICE
406A TONE GENERATOR
DESCRIPTION

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1. GENERAL

1.01 This section covers the description of the 406A tone generator. The tone generator provides a continuous 2713 $\pm$0.5-Hz tone at each of six output levels. The outputs are used for providing tone-activated loop-back on 4-wire private line (PL) voiceband data channels.

1.02 A loop-back device is required at the customer location on circuits that may be accessed by a serving test center (STC) or similar organization equipped with a voiceband transmission testing capability. One type of loop-back device is the 44A1 data unit, which detects the 2713-Hz tone and provides contact closures to operate an external loop-back relay. When operated, the loop-back relay loops back the 4-wire PL voiceband data channel to provide for remote testing of the channel. Descriptive information on the 44A1 data unit is given in Section 590-100-131.

2. PHYSICAL DESCRIPTION

2.01 The printed wiring board of the 406A tone generator (shown in Fig. 1) contains capacitors, diodes, resistors, transformers, integrated circuits, a potentiometer, and a crystal. The printed wiring board is under a 50B mounting plate cover. The terminals of the printed wiring board are wire wrapped to a D3A terminal strip (TS1) and a CAL jack (J1). These assemblies are mounted on a 19-inch 224A mounting plate.

2.02 The tone generator is arranged for mounting on a 19-inch relay rack or bay in the central office (CO). Mounting on a 23-inch relay rack or bay can be made using appropriate mounting adapters. For example, two P-31A189 adapters can be used.

2.03 The 406A tone generator unit measures 2 inches high, 19 inches wide, and 4-1/2 inches deep. The tone generator weighs approximately 3 pounds.

2.04 The 406A tone generator is designed to operate within the temperature range of 40°F to 120°F.

3. FUNCTIONAL DESCRIPTION

3.01 The functional block diagram of the 406A tone generator is shown in Fig. 2 and consists of the following basic components:

- Crystal oscillator
- Binary counter ($\div$ by 64)
- Buffer amplifier

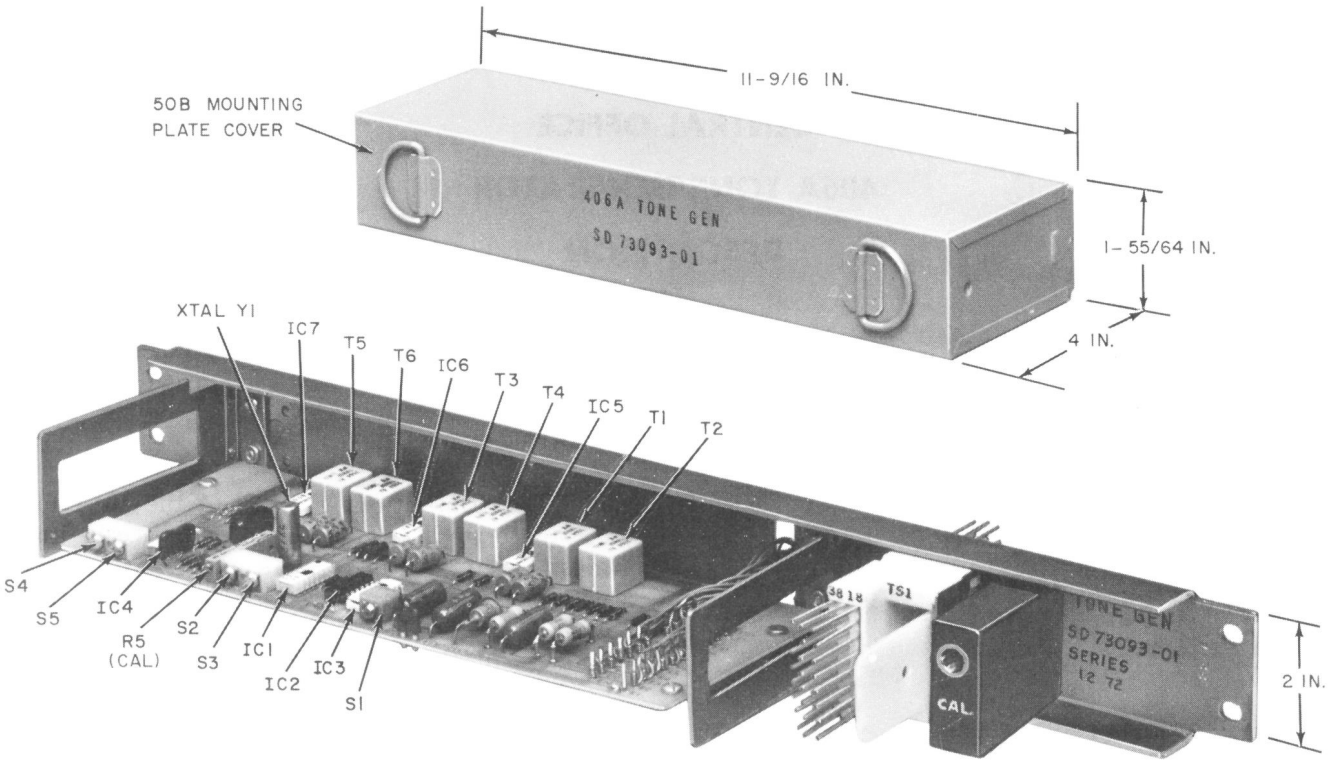

Fig. 1—Overall View of 406A Tone Generator

- Filter
- Unity gain amplifiers.

3.02 A crystal oscillator, composed of IC1 and crystal Y1, generates an approximate square wave at 173.632 kHz. Crystal Y1 primarily determines the frequency of the oscillator. A series capacitor, used when the crystal is tested and stamped with the frequency value, is not used in the oscillator circuit. Omitting the capacitor lowers the oscillator frequency and produces a square wave of slightly lower frequency than that stamped on the crystal case. A crystal stamped 173.680 kHz is used to generate 173.632 kHz.

3.03 The square wave frequency of 173.632 kHz is divided by 64 in the countdown circuit. This circuit is composed of IC2 and IC3, and consists of a 4-bit binary counter and a dual JK master-slave flip-flop. The signal output of the countdown circuit is a square wave at 2713 Hz. This output is connected to a buffer amplifier that is part of IC1.

3.04 The output of the buffer amplifier connects through potentiometer R5 to the input of the low-pass active filter. The CAL potentiometer R5 is adjusted to set the output levels of the tone generator. The filter circuit consists of passive components and operational amplifier IC4. The output of the filter is a sinewave at 2713 Hz with low distortion.

3.05 The filter furnishes the 2713-Hz tone to six unity gain amplifiers. These amplifiers provide isolation and power amplification. The output of each amplifier connects to the output terminals through an output transformer.

3.06 Five of the output amplifiers have voltage dividers at their input. These voltage dividers, which can each be removed by operating the appropriate screw switch, provide 5, 11, 17, 23, and 29 dB of loss to the amplifiers.

3.07 One of the six output amplifiers has no voltage divider at its input. This amplifier furnishes the highest output level of 0 dBm and

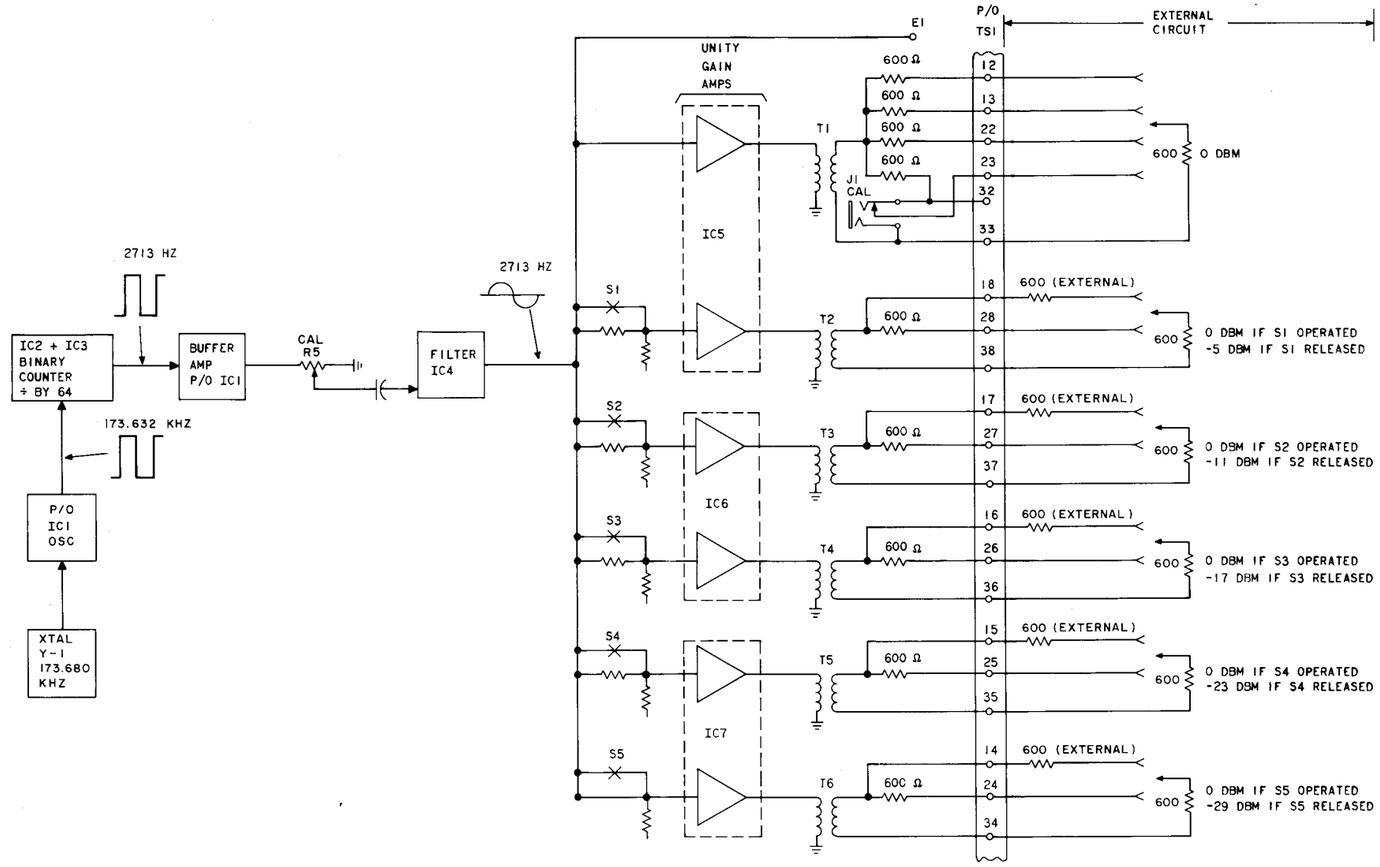

Fig. 2—Functional Diagram of 406A Tone Generator

is set by adjustment of the CAL potentiometer R5. The 406A tone generator is shipped with the CAL potentiometer properly adjusted.

4. OUTPUT CIRCUITS

4.01 Due to the variety of PL testing arrangements, the 406A tone generator provides two types of outputs. One type of output is a set of five outputs. Each of the five outputs has a screw switch that is used to set the output level to either 0 dBm or to one of the five output levels. These levels are -5, -11, -17, -23, and -29 dBm. If all five screw switches (S1 through S5) are operated, five isolated outputs at 0 dBm are provided. The output level of 0 dBm is useful if attenuators are available at the testboard. If the screw switches are released, these five outputs will provide -5, -11, -17, -23, and -29 dBm. These output levels are useful if attenuators are not available at the testboard. Each screw switch affects only one output and it may be operated or released independently of the other switches. In addition, each of these five outputs has a 600-ohm port and a low-impedance port (approximately 2 ohms). The two ports have a common terminal. The choice of output levels and impedances to be used is dependent upon the availability of attenuators in the testboard and on the number of loads that may be connected simultaneously to any one of the five outputs.

4.02 The second type of output is one 0-dBm output that has four 600-ohm ports. This output is available at only 600 ohms and 0 dBm. The output level is not affected by the operation of screw switches S1 through S5. The four 600-ohm ports are not isolated. There is a common terminal among them.

4.03 The CAL jack (J1), shown in Figures 1 and 2, is provided to facilitate measurement and adjustment of the 0-dBm output levels. A test set having a 600-ohm terminating impedance may be inserted (using a 310-type plug) into the CAL jack (J1) to measure and/or adjust the output level. The CAL potentiometer R5 is then adjusted for a 0-dBm reading on the test set meter. When the adjustment or measurement is completed, the 310-type plug should be removed from the CAL jack. Whenever a plug is inserted in the CAL jack, the generator output at TS1-23 is removed. Only the impedance of the test set is loading the 600-ohm port while this measurement is being made. This prevents an external impedance that may be connected between TS1, terminals 23 and 33, from affecting the measurement and/or the adjustment of the output levels. No external connections should be made to TS1 terminal 32 because of this possibility. The adjustment of the output level at the CAL jack will set all of the output levels to their correct values. If a 600-ohm test set is not available, a high-impedance voltmeter (greater than 75 kilohms) may be used. The output level in this case should then be 6 dB higher. The level should be adjusted to a +6 dBm meter reading using a meter calibrated for 1 milliwatt in 600 ohms.

4.04 The tone generator outputs should be wired to spare jacks throughout the testboard from which they can be patched to the PL channel for which it is desired to operate or release the facility loop-back. These jacks are hereafter referred to as 2713-Hz tone jacks. To loop back a channel, a patch cord should be connected between the 2713-Hz tone jack and the test appearance jack of the PL channel to be tested. After approximately 5 seconds, the patch cord is removed and a different frequency (usually 1000 Hz) is applied to the channel to verify that it is looped back. Loop-back occurs upon removal of the 2713-Hz tone. If the channel has failed to loop back, the patch cord connection between the 2713-Hz tone jack and the test appearance jack should be repeated to loop the channel. If the channel has looped back, loop-back tests can be performed to measure the transmission parameters. When testing is completed, the patch cord is again connected between the 2713-Hz tone jack and the test appearance jack. After approximately 2 seconds, the patch cord is removed and the 1000-Hz tone should again be applied to verify that the channel has unlooped. Release of loop-back occurs as soon as the tone has been detected. Only a short burst of 2713-Hz tone will be returned through the facility loop-back to the testboard.

4.05 The tone generator outputs are not terminated in 600 ohms at the tone jacks when the patch cord is removed. Only those jacks that are actively being used (by being connected to a PL or by being terminated in 600 ohms to measure output level) present a load to the generator. This allows an unlimited number of jacks to be connected to each output.

4.06 Certain applications of the 406A tone generator, such as 2713-Hz tone ports for the switched

access and remote testing system (SARTS), may require that each tone generator output be isolated from the other outputs. The tone generator can provide up to six isolated 600-ohm outputs. Additional 406A tone generators must be used if more than six isolated outputs are needed. However, isolated outputs will normally not be required in providing tone loop-back. Any number of 2713-Hz tone jacks may be connected to a single tone generator output. The jacks do not represent a load on the generator until a load is connected to the jack. The effect of these loads is described in Part 5C.

5. CIRCUIT APPLICATIONS

A. Power Requirements

5.01 The 406A tone generator is powered from either a −24 or −48 volt dc supply in the CO. The typical current drains are: 45 mA at −24 volts, or 55 mA at −48 volts. The 406A tone generator should be fused by equipping a 180-mA fuse at the office fuse panel. In addition to the ground connection (terminal 11 of TS1), only one voltage supply connection should be made. Connection is made to either terminal 31 (−48 V) or terminal 21 (−24 V) of TS1. The applicable power supply option is made at E25. E26, and E27 as follows:

(a) For operation from a −48 V supply, strap E26 to E27.

(b) For operation from a −24 V supply, strap E26 to E25.

5.02 The tone generator is strapped for −48 Vdc operation at the factory.

B. Selection of Output Levels

5.03 This part contains information to be used in selecting the output levels of the 406A tone generator that best suit a particular application. The selection of output levels to be used is based on attenuator availability and, if attenuators are not available, on the test appearance levels at the PL jacks. It is expected that the typical installation will have attenuators available, either portable or permanently installed in the testboard, that can be used to set the output level. If 600-ohm attenuators are available, it is advantageous to use them to set the level applied to the PL channel to −16 dBm0. In this case, only the 0-dBm output level of the 406A tone generator is needed. Screw switches S1 through S5 should all be operated. This provides six isolated 600-ohm outputs at 0 dBm as shown in Fig. 2 and in Table A. These outputs are available at the following terminal pairs of TS1: 28—38, 27—37, 26—36, 25—35, 24—34, and 12—33. There are three additional 600-ohm nonisolated outputs available at the following terminal pairs of TS1: 13—33, 22—33, and 23—33. The output port at TS1 23 should be the last one used because of the possibility that the output signal may be removed by inserting a plug in the CAL jack. The 2713-Hz tone jacks should be distributed among these outputs in order to minimize the loading on each output.

5.04 If 600-ohm attenuators are not available at the testboard, some or all of the following levels will be needed: -5, -11, -17, -23, and -29 dBm. These levels are set by releasing screw switches S1, S2, S3, S4, and S5, respectively. The outputs are shown in Fig. 2. The maximum and minimum TLPs anticipated for test appearances on PL channels are +13 TLP and −16 TLP. The highest test level permitted is −13 dBm0. The lowest test level that will provide an adequate level at the station, for the 44A1 data unit and the new detector to be used in DAS 829-type, is −18 dBm0. Therefore, each 406A tone generator output level can be used to cover a 5-dB range of TLPs. This will result in a 5-dB range of test levels between −13 dBm0 and −18 dBm0. Table B shows the tone generator output level to be used for each test appearance level between +13 TLP and −16 TLP, as well as the resulting test levels. If any of the −5 through −29 dBm output levels are not needed, the corresponding outputs may be set to 0 dBm by operation of the proper screw switches. This will provide additional 0-dBm outputs for other applications as required. A 2713-Hz tone jack at a particular output level is required at or near each test position that has test appearances in the TLP range covered by that output level. For example, a test position has test appearances at +13, +9, +7, and −16 TLPs. It can be determined from Table B that testboards without available attenuators will require having three 2713-Hz tone jacks at or near this test position. The three jacks are connected to the −5, −11, and −29 dBm outputs of the tone generator with S1, S2, and S5 released. There are generally several test appearances on each channel at a given test position. Only those test appearances at which it is desirable to insert the 2713-Hz tone need to be considered to determine the 406A tone generator

TABLE A

OUTPUT LEVELS AVAILABLE FROM 406A TONE GENERATOR

OUTPUT (DBM)	AT TS1 TERMINALS	OUTPUT IMPEDANCE (OHMS)	SCREW SWITCH OPERATION	OUTPUT POWER INTO 600-OHM LOAD (DBM)
0	12-33, 13-33, 22-33, 23-33	600	NONE	0
0 or −5	18-38	2	S1 RELEASED	−5*
0 or −5	28-38	600	S1 RELEASED	−5
0 or −5	18-38	2	S1 OPERATED	0*
0 or −5	28-38	600	S1 OPERATED	0
0 or −11	17-37	2	S2 RELEASED	−11*
0 or −11	27-37	600	S2 RELEASED	−11
0 or −11	17-37	2	S2 OPERATED	0*
0 or −11	27-37	600	S2 OPERATED	0
0 or −17	16-36	2	S3 RELEASED	−17*
0 or −17	26-36	600	S3 RELEASED	−17
0 or −17	16-36	2	S3 OPERATED	0*
0 or −17	26-36	600	S3 OPERATED	0
0 or −23	15-35	2	S4 RELEASED	−23*
0 or −23	25-35	600	S4 RELEASED	−23
0 or −23	15-35	2	S4 OPERATED	0*
0 or −23	25-35	600	S4 OPERATED	0
0 or −29	14-34	2	S5 RELEASED	−29*
0 or −29	24-34	600	S5 RELEASED	−29
0 or −29	14-34	2	S5 OPERATED	0*
0 or −29	24-34	600	S5 OPERATED	0

* These load powers assume an external 600Ω source resistor connected in series with the generator output.

output levels needed at the test position. The most desirable test appearance for insertion of the 2713-Hz tone would be the one nearest the station in each direction.

5.05 There are five groups of TLPs and each group is covered by one of the 406A tone generator output levels, as shown in Table B. If at a test position there are no test appearances in some of these groups, the tone generator output levels that cover the groups need not be connected at that test position. The outputs of the tone generator that are needed should be connected to spare jacks at or near each test position of the testboard. Testboards without available attenuators will require having from one to five jacks at or near each test position. Testboards with available attenuators will require having only one jack at or near each test position.

C. Selection of Output Impedances

5.06 If only the 0-dBm output level is needed (S1 through S5 operated to set all outputs to 0 dBm) and more 2713-Hz tone jacks are needed than can be provided by connecting one jack to each 406A tone generator output, the jacks should be distributed among the outputs equally so that each tone generator output has a minimum number of jacks connected to it. If the −5 through −29

TABLE B

RESULTING TEST LEVELS AT VARIOUS TEST LEVEL POINTS

TEST APPEARANCE LEVEL (TLP)	TONE GENERATOR OUTPUT LEVEL USED (DBM)	RESULTING TEST LEVELS (DBM0)
+13	−5	−18
+12	−5	−17
+11	−5	−16
+10	−5	−15
+9	−5	−14
+8	−5	−13
+7	−11	−18
+6	−11	−17
+5	−11	−16
+4	−11	−15
+3	−11	−14
+2	−11	−13
+1	−17	−18
0	−17	−17
−1	−17	−16
−2	−17	−15
−3	−17	−14
−4	−17	−13
−5	−23	−18
−6	−23	−17
−7	−23	−16
−8	−23	−15
−9	−23	−14
−10	−23	−13
−11	−29	−18
−12	−29	−17
−13	−29	−16
−14	−29	−15
−15	−29	−14
−16	−29	−13

dBm output levels are needed, each of the five similar outputs must drive all of the jacks requiring that output level. After determining the number of jacks to be connected to each output, the selection of the output impedance port to be used for each of the five similar outputs should be made. The impedance port at each output is chosen independently of the other outputs.

5.07 The selection of output impedances to be used at the five similar outputs is based on the number of 2713-Hz tone jacks to be connected to each output and on the probability that more than one jack connected to the same output will be loaded simultaneously. If several 2713-Hz tone jacks are connected to one 600-ohm output (the jacks connected in parallel) and the output is loaded

simultaneously at more than one jack, the output level will be reduced excessively. This may prevent satisfactory operation of the tone detector at the station end. The probability of this multiple simultaneous loading of an output will depend on the number of 2713-Hz tone jacks connected to the output. If the probability of this multiple loading is small, this will only require that the loop-back attempt be repeated occasionally. However, a high probability of multiple loading suggests that the low-impedance output (approximately 2 ohms) should be used. The disadvantage of using the low-impedance outputs is that the required 600-ohm source impedance must be obtained by using an externally provided 600-ohm resistor wired in series with each jack. The jacks are connected in parallel by connecting the generator side of the externally provided resistors together. A convenient location for mounting the resistor is on the jack. The output power at each terminal pair, the output impedance, and screw switch operation is summarized in Table A. The choice of using the 600-ohm of low-impedance outputs should be made by estimating the probability of multiple simultaneous loading at each of the five similar outputs.

5.08 If the low-impedance outputs are chosen, many loads can be driven simultaneously at each 406A tone generator output with a negligible decrease in the output level. Tone detector operation should not be affected by this decrease. If a channel fails to loop-back when using a low-impedance output and an externally provided 600-ohm source resistor (only one tone jack should be connected to each external resistor), the channel may be assumed to be faulty. The externally provided resistor should be 600 ohms $\pm 1\%$, 1/8-watt or higher power rating. The low-impedance outputs are capable of driving ten 600-ohm loads (each having a 600-ohm source resistor wired in series) with a decrease in output voltage of approximately 0.2 dB from the open circuit voltage.

D. Output Circuit Limitations

5.09 The output levels at the 2713-Hz tone jacks will vary with distance of the jacks from the 406A tone generator. This is due to the loss of the cable connecting the jacks to the 406A tone generator. Figure 3 shows an example of several 2713-Hz tone jacks being connected to each output. This figure does not necessarily represent a typical installation. It is used only to illustrate the connection of more than one jack to each type of output (both the low-impedance and the 600-ohm outputs). Although any number of jacks may be connected to each output, there is a limitation on the distance of the tone jacks from the tone generator. The maximum allowable cable length separating the 406A tone generator from any jack is a function of the cable gauge and, for the low-impedance outputs, on the number of PL channels patched into a particular output simultaneously. Table C shows the maximum allowed cable length between the tone generator outputs and any jack appearance as a function of wire gauge and the number of test positions using the same output simultaneously. The cable lengths shown will provide a maximum cable loss of approximately 0.5 dB. The maximum length of cable connected to the 600-ohm outputs should be chosen by assuming one load. The maximum length of cable connected to the low-impedance outputs should be chosen by estimating the maximum number of simultaneous loads that are likely to be connected to each output.

5.10 An example of the selection of cable length is as follows:

In this example, it is expected that the maximum number of PL channels to be connected to an output is three and that 24-gauge wire is used. From Table C it is shown that for the low-impedance outputs, the maximum cable length allowed between any 2713-Hz test jack and the 406A tone generator ouput is 333 feet. If the 600-ohm output is used, the allowable cable length can be 1000 ft.

5.11 The cable lengths given in Table C assume the 406A tone generator outputs will be connected using BU or BY switchboard cable (twisted pair).

6. REFERENCES

6.01 The schematic drawing and circuit description covering the 406A tone generator are SD- and CD-73093-01.

6.02 More descriptive information on equipment associated with the 406A tone generator is covered in the Bell System Practice entitled 44A1 Data Unit—Tone Detector—Description (590-100-131).

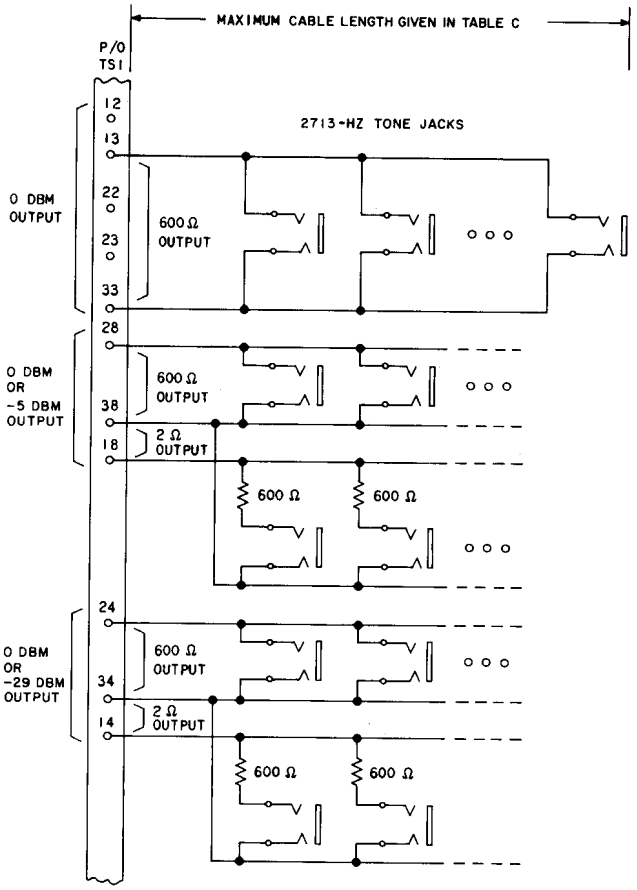

Fig. 3—Example of Multiple Jack Connections to 406A Tone Generator Outputs

TABLE C

MAXIMUM CABLE LENGTH ALLOWED BETWEEN TONE GENERATOR AND TEST JACKS

NUMBER OF SIMULTANEOUS LOADS DRIVEN	LENGTH OF CABLE ALLOWED FOR EACH OUTPUT (FEET)		
	22 GAUGE	24 GAUGE	26 GAUGE
1	1000	1000	716
2	865	500	358
3	576	333	238
4	432	250	179
5	346	200	143
6	288	167	119
7	247	143	102
8	216	125	89
9	192	111	79
10	173	100	71

Note: Although Table C allows for ten simultaneous loads, it is expected that, for a typical case, the maximum number of loads will be considerably fewer.