DATA SET 202D-TYPE TRANSMITTER-RECEIVER THEORY OF OPERATION AND SUPPLEMENTARY INFORMATION

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1. GENERAL

1.01 Data Set 202D-type is a frequency-modulated (FM), transmitter-receiver data terminal modem. It is designed to operate on either 2-wire or 4-wire facilities to provide voiceband transmission and reception of serial digital information. The data set is separate from the telephone subscriber set, but provides an optional arrangement to work with Data Auxiliary Set (DAS) 804A-type when a telephone is required.

1.02 Data Set 202D-type provides a medium speed, serial data transmission system for use on DDD, TWX, or private line facilities. The data set will accept and deliver dc data pulses at rates up to 1200 bits per second over switched network facilities, and at rates up to 1800 bits per second over appropriately conditioned private line facilities. The applied data input signals are converted by a transmitting data set into FM signals suitable for transmission over voiceband telephone facilities. The receiving data set restores the FM signal to

the original dc form for delivery to the business machine.

1.03 To give Data Set 202D-type the flexibility required for operation with a variety of business machines and a wide range of transmission speeds (up to 1800 bits per second), synchronized recovery is not provided. There is no restriction as to the code used or the number of consecutive marks and spaces. Provision is available for optional reverse-channel operation and echo suppressor disabling on 2-wire connections. Provision is also made for automatic calling and automatic answering capabilities when required.

1.04 Data and control signals are interchanged through a 25-pin interface connector. The signal levels are in bipolar voltage form. Pin selection is in accordance with Electronic Industries Association (EIA) Standard RS-232-A, where applicable. Connector pin numbers and circuit functions are defined in Part 7.

1.05 Some Data Sets 202D1- and 202D2-type units are powered by a self-contained J87235A1 L1 power supply. Other Data Sets 202D1- , 202D2- , 202D3- , and 202D4-type are powered by a self-contained 17A Power Unit. Both power supplies provide semiregulated +18.0 vdc and -18.0 vdc sources from a commercial ac source. Both power supplies employ a ferroresonant circuit which requires a 117 volt (±10 percent) 60 (±0.6) Hz input. Neither power supply will operate on 50-Hz power. The design differences between the power supplies are that the 17A Power Unit provides both greater attenuation to conductive power line noises, and an increased current capacity when compared with the J87235Al L1. Data sets using the 17A Power Unit are provided with shunt resistors for draining the excess current. Data Set 202D-type consumes approximately 7 watts of ac power.

1.06 The commercial power source must not be under the control of a switch. It is highly recommended that the source be on the same ac circuit as that which serves the associated business machine, in order to minimize noise-causing impulse potentials by using the same ground bus for both machines.

1.07 The Data Set 202D-type is designed to operate in an ambient room temperature of +50° to +120°F and a relative humidity range of 20 to 95 percent.

1.08 Data Set 202D should be situated so that the interface cord supplied by the customer will not extend more than 50 feet in length from the business machine. On all installations, the housing must be retained on the data set.

1.09 In most installations, the data set is located separately from the associated business machine on a desk, table, stand, etc. Customers desiring to minimize the visible space occupied by the data set may have it mounted on a closet wall or similarly inconspicuous place (within the 50-foot interface cable limitations), and may place a Data Auxiliary Set 804A (when used) on a nearby desk or table where it can be operated. The overall data set dimensions are approximately 11 inches wide by 5-1/2 inches high, and 10-1/4 inches deep. The data set weighs approximately 14 pounds.

2. SUMMARY OF CONNECTORS AND OPTION STRAPPING

2.01 The following summary describes both internal and external connections required for data set operation. Option strapping is included for reference convenience. Detailed strapping requirements are included in later descriptions.

2.02 ***Interface Connectors of Data Set 202D-Type are as follows:***

(a) ***Data and Control Interface (Customer Connector):*** A 25-pin connector allows the interchange of data and control signals between the data set and the customer business machine (Part 7).

(b) ***Power Supply Connector:*** The data set power unit accepts a commercial ac power source through a 10-foot KS-14532 L16 3-conductor cord. (See 1.05 and 1.06.)

(c) ***Telephone Line Connection:*** Connection between the data set and the provided telephone facility is made through either the D6AA-61 or the D34B-61 mounting cord and appropriate connecting block.

2.03 ***Data Set Internal Connections and Strappings:***

(a) ***Printed Wiring Board Options:*** A carrier soft turnoff *Option ZY* is provided by means of terminals on printed wiring board AS 39 in Data Sets 202D3 and 202D4. The board is delivered from the manufacturer with *Option ZY* in service (terminal 1 strapped to terminal 2). The option can be strapped out of service by removing the strap from terminals 1 and 2 and by placing a strap between terminals 3 and 4.

(b) ***Terminal Board Options:*** Available options for various modes of operation are defined and listed in Table A.

3. DATA SET TRANSMITTER

3.01 The data set transmitter circuits convert the applied data signals from the business machine into an FM signal which is suitable for transmission over the voice network. Frequency modulation is used because it allows signals to be correctly recovered despite sudden amplitude changes of the carrier during transmission.

> ***Note:*** In the following descriptions, interface functions are used to establish the sequence of operational events. The functions are designated by both their mnemonic abbreviations and their EIA symbols, respectively, separated by a slant line.

3.02 Transmitter circuits consist of a modulator which provides the voltage control over a multivibrator frequency generator. A block diagram of the data set transmitter and receiver circuits is shown in Fig. 1. This diagram illustrates the data set connected for a 2-wire operation. A 4-wire operation is permitted by rearranging certain control circuit connections and splitting the line connections between transmitter and receiver in order to allow independent transmit and receive paths.

3.03 The data set transmitter circuits respond to Request to Send (RS/CA) and Send Data (SD/BA) signals from the business machine. In return, the data set provides a Clear to Send (CS/CB) signal to the business machine. The CS/CB signal is returned 200 (±20) milliseconds after RS/CA is received. This delay is required for operation on all 2-wire facilities including operation without the reverse channel option. With this delay, echo suppressors are set by the initially transmitted carrier (a 2025-Hz tone from a DAS 804A-type unit), prior to data transmission.

3.04 The delayed CS/CB signal is also necessary after each reversal of direction during the course of data transmission. The delay permits restraining of SD/BA for the duration of echo suppressing and a blanking interval at the receiver. The receiver blanking interval may consist of one or both squelch time of 150 (±25) milliseconds and a clamp time of 40 (±10) milliseconds. The squelch is used on all 2-wire facilities and the clamp is used on 4-wire facilities, if desired. Except for the receiver interval, this delay is not necessary on 4-wire facilities.

3.05 The transmitted frequencies are generated by a free-running multivibrator with an output frequency proportional to a reference voltage. To shift the frequency of the multivibrator precisely between mark (1200-Hz) and space (2200-Hz) frequencies, a mark-to-space control is used between the SD/BA input and the controlled voltage input to the multivibrator. The control establishes a precise voltage change at the multivibrator input.

3.06 A pulse-shaping network is used between the mark-to-space control and the multivibrator to attenuate the higher speed data pulse frequency components. These frequency components may cause disturbing effects on sideband frequency components appearing in the carrier band. The resulting effects are symmetrical mark-to-space and space-to-mark transitions which produce a dependable 1200 (±12) Hz mark frequency when SD/BA is negative, and a 2200 (±22) Hz space frequency.

TABLE A — OPTIONS AND CONNECTIONS

NUMBER OF OPTIONS REQUIRED PER CIRCUIT	FEATURE OR OPTION DESCRIPTION		APP OR WIRING DESIG	TB1 CONNECT AS SHOWN	TB2 CONNECT AS SHOWN	TB3 CONNECT AS SHOWN	TB4 CONNECT AS SHOWN	1A1 DATA UNIT WHEN PROVIDED (REVERSE CHAN)
1	2-WIRE OPERATION		Z		61—62; 64—65			
	4-WIRE OPERATION		Y*		62—63—64			
1	600-OHM TERMINATION		X*		32—33; 37—38			
	900-OHM TERMINATION		W		33—34; 38—39			
1	CLAMP ON DEMOD OUTPUT WHEN NOISE PROTECTION IS REQUIRED		V*		20—21			
	CLAMP OFF DEMOD OUTPUT WHEN NOISE PROTECTION IS NOT REQUIRED		U		21—22			
1	REVERSE CHANNEL IN		T*			1—2; 6—7		
	REVERSE CHANNEL OUT		S			2—3; 7—8		
1	SQUELCH IN		R		35—36 (REMOVE ZL WIRING)			
	SQUELCH OUT		ZL*§		25—35			
1	AUTOMATIC ANSWERING		Q*		59—60			
	NO AUTOMATIC ANSWERING		—		REMOVE Q WIRING			
1	EIA VOLTAGE INTERFACE		N*		1—2; 4—5; 6—7; 8—9			
	CONTACT INTERFACE		M		2—3; 5—6; 9—10; 12—13			
1	DATA TRANSMIT POWER LEVELS	0 DBM	K		11—12			
		−3 DBM	J		24—25			
		−6 DBM	H*		22—23			
		−9 DBM	G		23—24			
1	EQUALIZERS FOR SWITCHED NETWORK OPERATION	AMPLITUDE EQUALIZER IN	F*		18—19			
		AMPLITUDE EQUALIZER OUT	E		17—18			
1		DELAY EQUALIZER IN	B*		27—28; 30—31			
		DELAY EQUALIZER OUT	A		28—29—30			
1	BIT RATE	900 BITS PER SECOND OR LESS	ZA		14—15			
		OVER 900 BITS PER SECOND	ZB*		15—16			
1	ENABLES DATA SET TEST KEY		ZE*		44—45; 47—48; 50—51			
	DISABLES DATA SET TEST KEY (REQUIRES TEST KEY IN DATA AUXILIARY SET 804A)		ZF		45—46; 48—49; 51—52			
1‡	2-WIRE OPERATION		ZG		53—54			
	4-WIRE OPERATION WITHOUT BACKUP OR 2 DDD BACK UP		ZH*		54—55			
	4-WIRE OPERATION WITH 1 DDD BACKUP		—		REMOVE ZH WIRING			
1	WHEN DATA SET IS NOT USED WITH DATA AUXILIARY SET 804A OR A 6017AP KEY		ZJ*	19—23	57—58; 40—41			
	WHEN DATA SET IS USED WITH DATA AUXILIARY SET 804A OR A 6017AP KEY		—	19—25	56—57; 42—43			
1	REVERSE CHANNEL TRANSMIT POWER LEVELS	−3 DBM	ZK				1—(W)	
		−6 DBM	ZM†				2—(W)	
		−9 DBM	ZN				3—(W)	

* WIRING FURNISHED BY MANUFACTURER.

† WIRING FURNISHED BY MANUFACTURER WHEN REVERSE CHANNEL IS SPECIFIED.

‡ WHEN DATA AUXILIARY SET 804A IS USED TO SWITCH FROM 2- TO 4-WIRE OR 4- TO 2-WIRE OPERATION, REMOVE BOTH ZG AND ZH OPTION WIRING.

§ A P-43N572 CONNECTOR LEAD ASSEMBLY, OR EQUIVALENT IS REQUIRED TO CONNECT TERMINALS 25 AND 35.

+ OPTION IS PERMANENTLY WIRED IN ON TRASMITTER CIRCUIT PACK AS22.

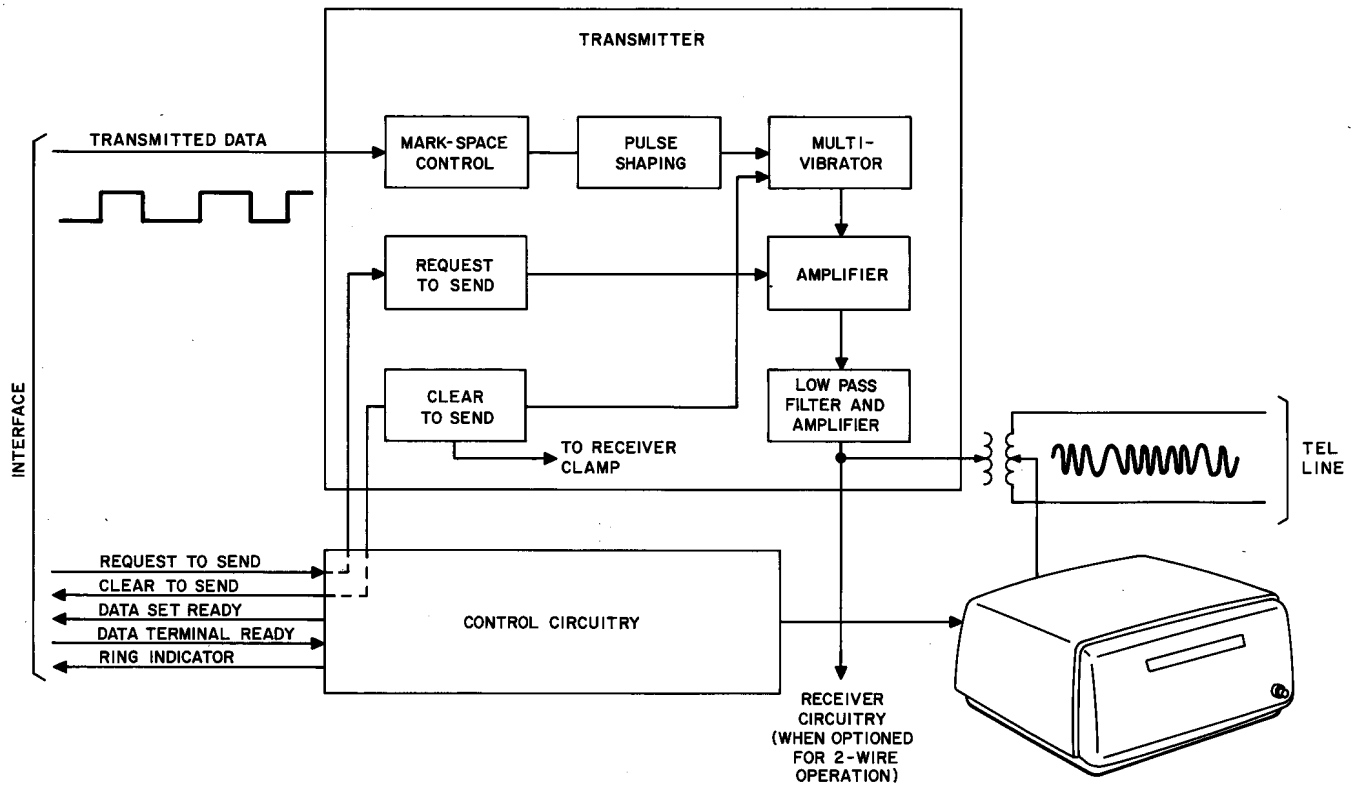


Fig. 1—Data Set 202D-Type Transmitter Circuits, Block Diagram

3.07 The multivibrator output is isolated from the transmission facilites by two amplifiers and a low-pass filter. The first amplifier output is applied to the low-pass filter. The filter provides sufficient attenuation to suppress carrier harmonics to an acceptable level for voiceband telephone line transmission. The second amplifier permits selection of one of the four possible line level outputs listed in Table B.

TABLE B

TRANSMISSION LEVELS

POWER LEVEL (DBM)	STRAP BETWEEN TB2 TERMINALS	OPTION IDENTIFICATION
0	11 to 12	K
−3	24 to 25	J
−6	22 to 23	H
−9	23 to 24	G

3.08 ***Soft Turnoff:*** At the end of transmission, the business machine RS/CA signal is switched off synchronously with the SD/BA lead in mark condition. The change in status of the RS/CA lead causes the transmitted line signal of Data Sets 202D1 and 202D2 to shift from 1200 Hz to 900 Hz. This allows the distant receiver to turn off in the presence of line signal. The 900-Hz signal is attenuated slowly through gating in the output amplifier and delaying the complete removal of line signal until the distant receiver is inhibited. The soft turnoff minimizes transients that might give false data output in any associated Data Set 202A, 202B, 202C, or 202D receivers. The soft turnoff feature is optional in Data Sets 202D3 and 202D4. If it is not provided, the transmitted line signal ends abruptly with an ON to OFF change in the RS/CA lead status. Removal of carrier, coincident with RS/CA removal, is desirable in some multiparty private line systems.

4. DATA SET RECEIVER

4.01 A block diagram of the data set receiver circuits is shown in Fig. 2. The FM signal

from the telephone line is coupled to the receiver circuits through a repeating coil, and an input matching amplifier is coupled to a bandpass filter. The filter (666A) passes signals in the 1000-to-2800-Hz spectrum, which is adequate for mark and space frequencies.

4.02 Signals from the bandpass filter are applied to a 376A delay equalizer. This equalizer is required for switched network facilities in order to provide delay equalization *(Option B)*. On private line facilities where equalization is provided in the telephone plant equipment, this equalization may not be required and can be strapped out *(Option A)*. Signals passed, or bypassed, at this stage are applied to an amplitude slope equalizer and limiter circuit input. The slope equalizer provides amplitude equalization *(Option F)* to correct for line amplitude character. Amplitude equalization is removed by installing *Option E*.

4.03 The limiter converts the applied sinusoidal input into a corresponding square-wave output. With no input signal present, the stage is a square-wave oscillating amplifier having a free-running mode at approximately 500 to 800 Hz. This

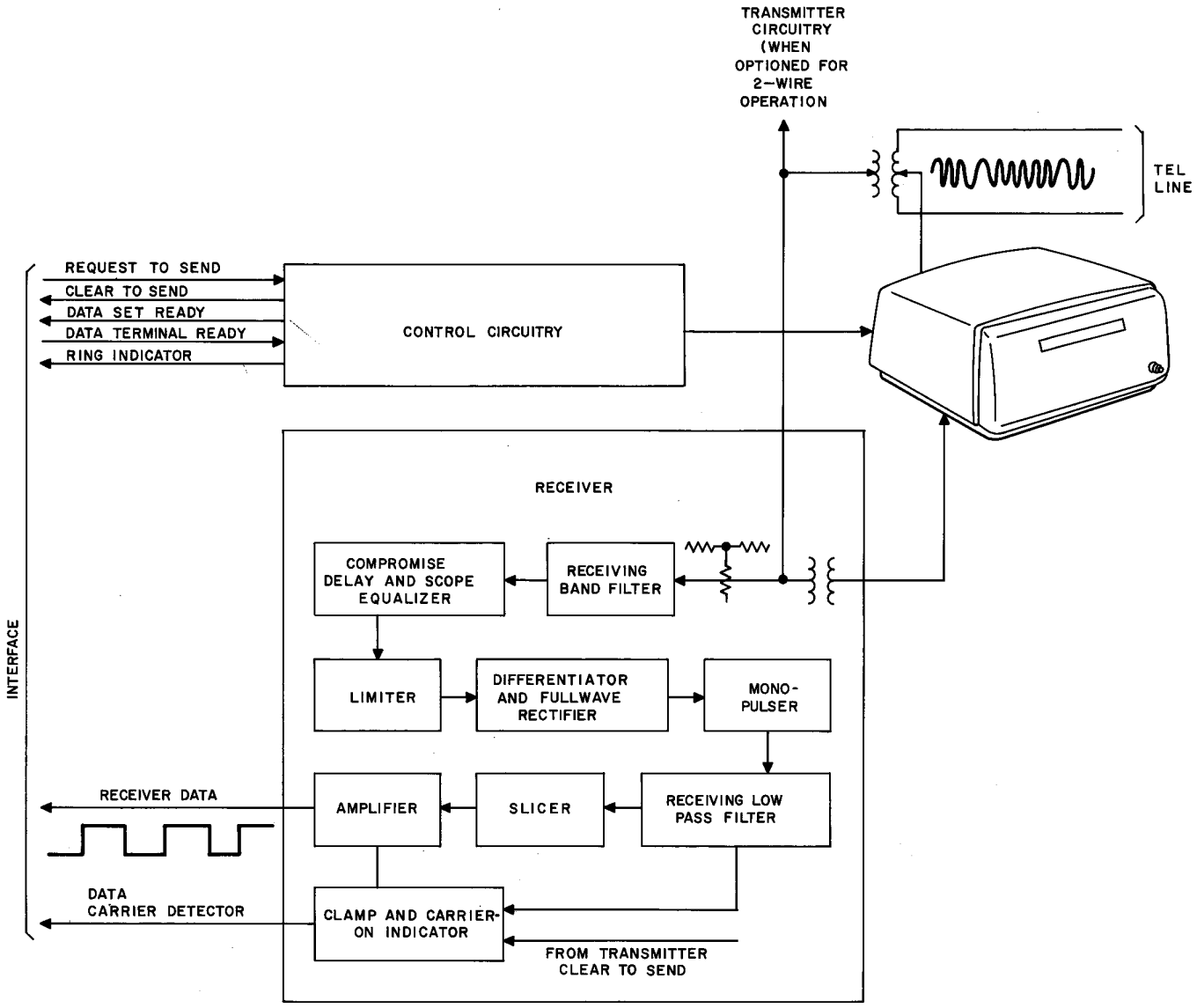


Fig. 2—Data Set 202D-Type Receiver Circuits, Block Diagram

frequency range is acceptable because it is below the data band and will ensure a mark hold condition when no carrier is received. The circuit will accept and lock onto an incoming in-band frequency which has amplitude of not less than –50 dBm at the input. Output signals are symmetrical square waves.

4.04 Limiter output signals are applied to a differentiator and to a full-wave rectifier stage which provides output pulses only at the zero crossings of the square-wave input. These pulses mark the zero crossings of the limited signal. The generated pulses are applied to a full-wave rectifier which provides a train of positive going pulses which trigger a monopulser.

4.05 The monopulser is a one-shot multivibrator which provides an accurately timed pulse output for each trigger pulse applied to the input. The timing accuracy is ensured by the use of precision components. Circuit design has provided a monopulser output of very low impedance which is compatible with the low-pass filter stage discussed in the following paragraphs.

4.06 Signals from the monopulser are applied to the 662A low-pass filter. The density of the output pulses of the monopulser yields an average dc which is proportional to frequency. The filter integrates the pulses and provides an output voltage that has a greater positive voltage for a mark than for a space. The receiver line signal input has been transformed through a series of individual stages from a frequency to a proportional voltage level. This action has eliminated undesired components while providing an average voltage which varies in proportion to the original baseband input signal. A strapping option at the low-pass filter provides a 1000-Hz cutoff when the data set is operated at 900 bits per second or higher *(Option ZB)*. Operation at transmission speeds below 900 bits per second requires additional circuitry which is available through *Option ZA*.

4.07 Output signals from the low-pass filter are applied to both a slicer, and the clamp and carrier detector circuit. The slicer has a threshold level set by precision components to distinguish between the mark and space voltages. The potential of a mark frequency is approximately 5.0 volts more positive at the slicer input than is that of a space frequency. The slicer makes the decision between mark and space voltages. The decision is biased through a precision threshold reference that is approximately half the potential between the marking voltage and the spacing voltage.

4.08 Output signals from the slicer are applied to an amplifier. The signals are amplified to a level conforming to EIA Standard RS-232-A before they are delivered to the receiving business machine. A marking frequency causes –8.0 to –5.0 vdc to be applied on the Receive Data (RD/BB) lead. A spacing frequency causes +8.0 to +5.0 vdc to appear on the RD/BB lead.

4.09 The clamp and carrier detector circuit is energized by the signal output of the low-pass filter. The circuit operates on the presence of frequencies within the data band that are constantly present for 40 (±10) milliseconds.

4.10 After the delay of approximately 40 milliseconds, the Data Carrier Detector [Carrier ON-OFF (COO/CF)] interface lead is placed ON. If the receiver clamp option *(Option V)* is used, the RD/BB lead is clamped OFF until COO/CF is ON. This detection circuit is provided with a protection feature which prevents false operation from noise impulses. The mark and space voltage levels at the low-pass filter output are precise. The COO/CF control circuitry is designed to allow for excess peak frequency excursions caused by delay distortion, and still delineate acceptable data. Input signals creating voltage ranges greater than the acceptable thresholds are suppressed. Such signals prevail with a data input having excessive delay distortion or with noise on the input.

4.11 The clamp circuit provides a hold-over time of 15 (±5) milliseconds so that short carrier dropouts will not clamp the receiver and require the 40-millisecond delay on the RD/BB interface lead. This hold-over prevents a small error from destroying potentially good data immediately following a dropout.

4.12 At the end of transmission and when the received frequency drops to approximately 900 Hz (if this option is provided), the noise guard feature in the COO/CF circuit forces the clamp to be ON after the appropriate hold-over time.

4.13 When using 2-wire facilities, a squelch feature is provided to disable the receiving of a previously transmitted signal which has returned to the data set as an echo. The squelch feature

operates the receiver clamp when the RS/CA lead of the associated transmitter is switched from ON to OFF. The clamp remains in force for 150 (±25) milliseconds and then goes OFF. If a signal is present during this squelch period, the last 40 (±10) milliseconds will be applied toward release of the clamp. With the clamp OFF, the receiver can receive data again. This feature should be strapped out through *Option R* for operation over 4-wire facilities.

5. REMOTE TEST AND REVERSE CHANNEL

Remote Test

5.01 Data Set 202D-type is provided with a remote test feature which permits testing from a distant centralized Data Test Center. When the data set is in the remote test condition, the Data Test Center sends and receives signals which test the following functions:

(a) Transmitter marking frequency

(b) Transmitter spacing frequency

(c) Receiver output and slicing level

(d) Operation of the Data Carrier Detector (COO/CF) circuit

(e) Operation of the RS/CA circuit

(f) Operation of the CS/CB circuit

(g) Operation of the RD/BB circuit

(h) Operation of the SD/BA circuit

(i) The transmit level and receiver sensitivity (in some installations)

(j) Parts of the line control (when DAS 804A-type is used)

(k) Reverse-channel operation (if provided)

5.02 The data set is conditioned for remote testing over 4-wire facilities when the local attendant on request from the Data Test Center presses the TEST button. In this condition, the customer interface leads are disconnected from the business machine and transmitter-receiver functions are interconnected. Through this interconnection, the Data Test Center can measure data set performance with transmitted and receiver signals. During this test over 2-wire facilities using a DAS 804A-type unit, the remote test circuitry within the data set switches the data set-originated tones ON and OFF to prevent the data set from locking in one state during testing. This allows control of the data set by the Data Test Center.

5.03 The remote test capability does not replace an end-to-end test, by using the required 900-type Data Test Sets, to provide a performance indication of the whole system as provided by the telephone companies. In some cases when a Data Test Center is not available, the remote test may be accomplished from the telephone company central office by using the proper connections, together with the procedures, levels, and tolerances provided in Section 668-102-512 entitled Data Test Center—904A/B and 904C/D, Test Procedure—Data Sets 202C- and 202D-Type, Loop-Back and Dynamic Tests. Some of the procedures may require modification in order to be adaptable to central office equipment.

Reverse Channel

5.04 The reverse channel feature is provided by a 1A1 Data Unit and is incorporated into the data set on an optional basis. On 2-wire facilities, it provides a means by which the receiving station can communicate with the transmitting station during data transmission. This feature is generally used for circuit assurance to signal a break in the circuit. It can be used to facilitate certain forms of error control.

5.05 The reverse channel feature has a recommended maximum signaling rate of 5 bauds which is a relatively slow transmission speed. The associated business machine must be equipped to use this option. Whether used for communication or not, the reverse-channel feature provides a means of surveillance over the quality of data transmission as well as a means of holding echo suppressors disabled when no data carrier is on-line. In calls where line distortions result in marginal conditions, keying the reverse channel may cause interference in the normal data channel. In all cases there will be some degradation of the forward channel. However, only in some cases will the degradation cause errors.

5.06 The reverse channel transmit and receive power levels may be strap-adjusted within the data set. The available options and levels are listed in Table C.

TABLE C

REVERSE CHANNEL POWER LEVELS

OPTION	POWER LEVEL
ZK	−3.0 dBm
ZM	−6.0 dBm
ZN	−9.0 dBm

6. CONTROL CIRCUITRY

6.01 Control signals may be presented to the data set from one of the following sources:

(a) ***Manual Operation:*** When the data set is used in conjunction with a compatible auxiliary unit, such as Data Auxiliary Set 804A, manual actions are necessary to establish the line facilities between two customers. Such installations can be provided on 2-wire or 4-wire facilities and with DDD backup, when necessary. Manual actions are limited to functions such as DATA, TALK, AUTO ANSWER (when provided), and TEST through pushbuttons on the associated data auxiliary set. Lamps under the pushbuttons are illuminated individually to provide visual indication of equipment status. Dialing and normal telephone usage are in this category of manual operation.

(b) ***Customer Business Machine:*** The following signals are provided by the customer in conformance with EIA RS-232: RS/CA, Remote Release (RR), and customer Ready (RDY), and Data Terminal Ready (DTR/CD) in conformance with EIA RS-232-A.

(c) ***Within the Data Set 202D-Type:*** The following signals are initiated in the data set and conform to EIA RS-232-A requirements: Data Set Ready (DSR/CC), Clear to Send (CS/CB), Data Carrier Detector (COO/CF), and Ring Indicator (RI1/CE and/or RI2/CE).

(d) ***EIA RS-232-A Interface:*** A closed relay contact from the ring detector in the line control unit of an associated data auxiliary set signals the business machine by a voltage level in accordance with EIA RS-232-A for approximately 150 milliseconds on interface lead Ring Indicator 1 (RI1). This condition is provided through installer *Option N.* In older installations, such as those where a Data Set 202D-type replaces a 202B-type and the contact closure is provided directly to the connected business machine, installer *Option M* is incorporated in the data set to meet the interface requirement. Contact closure is provided to the business machine for approximately 150 milliseconds through both interface leads RI1 and RI2.

6.02 Manual operations involve only the actions of personnel at the customer location. The personnel involved may be responsible for numerous operations related to the customer business machine in addition to the following functions.

6.03 At a data station, the responsible attendant operates the telephone set in a normal manner to establish a data call. If the telephone is part of an associated data auxiliary set, the TALK button must be pressed.

6.04 When two data stations are connected by a 2-wire facility and both stations are attended, a verbal agreement must be established as to the nature of the data, which station transmits, etc. This defines the ***calling*** and the ***called*** arrangement. Upon suitable agreement, both attendants press their respective DATA buttons. It is necessary for the ***calling*** station to have the DTR/CD interface lead operated prior to going into the data mode. If the ***called*** station is equipped with either Data Set 202A or 202B, both ***calling*** and ***called*** stations may go into the data mode simultaneously. If the ***called*** station is equipped with Data Set 202D, the ***called*** station must go into the data mode first. Data Set 202D-type is conditioned by ringing to establish a predata mode with a 2025-Hz answer-back tone for approximately 3.5 (±1.5) seconds. The attendant at the ***calling*** station must wait until the tone ceases, or changes pitch before pressing the DATA button to prevent false data transmission or reception.

6.05 When the nonlocking DATA button is pressed, the DATA lamp is illuminated. When the DATA button is released, the TALK button is

released also. If data transmission is between two Data Sets 202D, the TALK lamp in the data auxiliary set of the ***calling*** station is never illuminated. The TALK lamp in the data auxiliary set of the ***called*** station is illuminated in the talk mode, and remains illuminated in the data mode. For the duration of transmission, this feature indicates to the attendant whether his equipment is the ***called,*** or ***calling*** station. This information is required to re-establish the data link if for some reason data transmission must be interrupted for telephone communication. When transferring between the talk and data modes after an interrupted transmission, the ***calling*** station must again wait for the end of the answer-back tone from the ***called*** station before pressing the DATA button.

6.06 Manual calls on 2-wire facilities where the ***called*** station data set is equipped with the 1A1 Data Unit (reverse channel) option, the ***calling*** station attendant may hear the 2025-Hz answer-back tone, followed by the 387-Hz reverse channel transmitted carrier. This sequence is used to disable echo suppressors on the line and to hold them disabled until data transmission begins.

6.07 A control signal from an idle business machine will hold the DTR/CD interface lead ON. If a data station has an associated data auxiliary set equipped with the AUTO ANSWER option, the auxiliary set circuits together with the control signal permit a ***called*** data station to go on-line automatically. This can be accomplished if the AUTO ANSWER button is pressed or through the data auxiliary set *Option Q* which can provide automatic answer capability without depressing the DATA key.

6.08 The specific options which are required in the data set and associated DAS unit for AUTO ANSWER service are listed below:

For EIA RS-232-A *(Option N)*

(a) ***Key Control:***

(1) Install *Options B* and *G* in DAS 804A-type.

(2) Remove or do not install *Option Q* in Data Set 202D.

(OR)

(1) Install *Option E* in DAS 804A-type

(2) Install *Option Q* in Data Set 202D.

(b) ***Permanent AUTO ANSWER:***

(1) Install *Option B* in DAS 804A-type

(2) Install *Option Q* in Data Set 202D.

For EIA RS-232 (Contact or *Option M)*

(a) ***Key Control:*** (Customer controls Remote Release)

(1) Install *Option E* in DAS 804A-type.

(2) Install *Option Q* in Data Set 202D.

(b) ***Permanent AUTO ANSWER:*** (Customer controls Remote Release)

(1) Install *Option B* in DAS 804A-type.

(2) Remove or do not install *Option Q* in Data Set 202D.

6.09 Four-wire operation is provided if the Data Set 202D is equipped with installer *Option Y*. The data set may require additional option strapping, depending upon station arrangement. Two-wire operation without 4-wire backup requires installation of *Option ZG*. Four-wire operation without 2-wire backup requires installation of *Option ZH*. Operation of Data Set 202D without Data Auxiliary Set 804A (or a 6017AP key) requires installation of *Option ZJ*.

Control Signals Between Equipment

6.10 When the telephone facilities are used for voice communication, the data set holds the DSR/CC interface lead in the OFF condition. If the ***called*** station is switched (by the operator pressing the DATA key) to the data mode, the DTR/CC lead is ON, and the DSR/CC lead is switched to present an ON indication to the business machine. After a nominal 1.1 second delay, the ***called*** station generates a 2025-Hz signal on-line in order to disable echo suppressors. When this tone ceases or is replaced, the ***calling*** station data set is switched to the data mode and the DSR/CC interface lead is switched to indicate an ON condition to the connected ***calling*** business machine. The transmitting business machine may apply an RS/CA

signal at any time after an ON indication is provided through the DSR/CC lead.

6.11 Data set carrier will start immediately, but will not reach the telephone lines until the 2025-Hz tone has ceased. The transmitting station returns a CS/CB signal after a delay of approximately 200 (±20) milliseconds. Within the transmitting data set, if it is a ***called*** station, the CS/CB signal is inhibited during answer-back tone transmission, and switches ON approximately 150 milliseconds after the tone ceases. On 4-wire facilities where echo suppressors are not used in the customer lines and the data mode has been established for both ***called*** and ***calling*** stations, transmission time may be saved by transmitting after applying RS/CA and ignoring the CS/CB signal. This condition may not exist in turning around a DATA-PHONE® call. The turn-around feature cannot be satisfactorily used on 2-wire facilities because the wide variances in system propagation times are not coincident with the receiver squelch time and the RS/CA-to-CS/CB delay must be adhered to.

6.12 When a customer desires to save transmission time as described previously for 4-wire facilities, *Option U* may be installed in the data set. This option removes the receiver clamp which would cause data to be lost for 40 (±10) milliseconds or for the time required for the clamp to release the receiver. If the customer delays transmission for 60 milliseconds or more, *Option V* (clamp-in) may be used, depending the condition of telephone facilities.

6.13 While *Option U* offers certain advantages to the customer, it also creates disadvantages to the system as a whole. Removal of the clamp circuit allows the demodulator to operate at maximum sensitivity while in the idle condition. Impulse noise on the facility, which is well within the system objectives, can be detected as intelligible information and passed to the customer business machine. If the Start-of-Message (SOM) code used by the business machine is not sufficiently complex, the impulse noise signal can be interpreted as legitimate data, and on failure of parity check, can be labeled as an error or errors. It is possible to minimize this effect on private line applications using the clamp by limiting the data transmit level to 0 dBm and the data receive level to -16 dBm. These levels and the clamp circuit provide adequate protection during idle (no signal) conditions. No other arrangement will provide the same amount of protection against spurious interference signals occurring during the idle condition. However, if it is absolutely necessary that the clamp circuit be disabled, a method of protection should be devised whereby the input signal to the data set demodulator is padded to provide a minimum signal level of -32 dBm. The business machine should use a multibit SOM with some eight (or greater) bit characters. A preferred method would be to have a 15-to-20-bit character having as many transitions as possible, and a leader of at least 10 milliseconds should be transmitted before the SOM character.

6.14 A Data Set 202D-type may be switched into the data mode either by an attendant or by the automatic answering feature, when available. In the data mode, the DSR/CC lead gives an ON indication to the business machine. If the RS/CA CS/CB delay is used in the transmitter, receiver clamp-in *(Option V)* should be used at the receiver. When the RS/CA lead to the transmitter is ON, the carrier appears on the line. At the far end, the received carrier, after a delay of 40 (±10) milliseconds, plus the system propagation time, removes the clamp on the receiver. With the clamp removed, the far-end COO/CF circuit delivers an ON indication to the business machine and data is received on the RD/BB lead.

6.15 If *Option U* (receiver clamp removed) is used, data may be received immediately, but the COO/CF circuit still requires a delay of approximately 50 milliseconds before providing the ON indication to the business machine. When the transmission is completed, and data is lost for more than (beyond) the 10-to-20-millisecond interval after completion of transmission, the COO/CF circuit is switched, thereby providing an OFF indication to the business machine.

6.16 The DTR/CD lead, when operating to EIA RS-232-A through *Option N*, terminates a data call by switching from ON to OFF. If the interface requirement of older installations relies on a contact closure of DTR/CD, operation using *Option M* will provide a contact opening between interface pins 20 (DTR) and 21 (RDY) to terminate a data call.

7. DATA SET INTERFACE

A. Customer Connector

7.01 The customer connector is a 25-pin receptacle. The mating plug (Cinch or Cannon DB-19604-432), locking hood (Cinch or Cannon DB-51226-1), and

the connecting cable which should not exceed 50 feet are to be supplied by the customer. The customer connector is wired as shown in Table D.

Electrical Characteristics of Drivers and Terminators

7.02 With one exception, the electrical characteristics of the interface circuits which are available on the customer connector meet EIA RS-232-A specifications. The exception is the COO/CF circuit which is a line energy detector operating on received power regardless of its nature, and not on the data carrier exclusively.

Control Drivers

7.03 When the data set is the signal source, the interface circuit is a driver. Control drivers will deliver a +8.0 to +5.0 volt ON signal, or a -8.0 to -5.0 volt OFF signal to a 3000-ohm (or higher) resistive load. A driver is used for each of the following circuits:

Receive Data (RD/BB)

Clear to Send (CS/CB)

Data Set Ready (DSR/CC)

Carrier ON-OFF (COO/CF)

Reverse Channel-Receive (RCR/SB)

Control Terminators

7.04 When the data set is the signal acceptor, the interface circuit is the terminator. Control terminators recognize +3 to +25 volts as an ON

TABLE D

FUNCTIONS THROUGH CUSTOMER CONNECTOR

PIN NO.	CIRCUIT FUNCTION	MNEMONIC SYMBOL	EIA RS-232-A DEFINITION	EIA SYMBOL
1	Frame Ground	FG	Protective Ground	AA
2	Send Data	SD	Transmitted Data	BA
3	Receive Data	RD	Received Data	BB
4	Request to Send	RS	Request to Send	CA
5	Clear to Send	CS	Clear to Send	CB
6	Data Set Ready	DSR	Data Set Ready	CC
7	Signal Ground	SG	Signal Ground	AB
8	Carrier ON-OFF	COO	Data Carrier Detector	CF
9	Positive Test Voltage	+18V	—	—
10	Negative Test Voltage	−18V	—	—
11	Reverse Channel-Transmit	RCT	Supervisory Transmitted Data	SA
12	Reverse Channel-Receive	RCR	Supervisory Received Data	SB
19	Remote Release	RR	—	—
20	Data Terminal Ready	DTR	Data Terminal Ready	CD
21	Ready	RDY	—	—
22	Ring Indicator 1	RI1	Ring Indicator	CE
23	Ring Indicator 2	RI2	—	—

Note: Unlisted pin numbers are not used.

signal and -3 to -25 volts as an OFF signal without regard to rise and fall time of transitions.

7.05 Shunt capacity to signal ground on all control terminators, measured at the interface and including up to 50 feet of cable, shall not exceed 2500 pf. Input resistance to all control terminators is greater than 3000 ohms. A terminator is used for each of the following circuits:

Send Data (SD/BA)

Request to Send (RS/CA)

Reverse Channel-Transmit (RCT/SA)

Data Terminal Ready (DTR/CD)

EIA Standards

7.06 In this practice, all references to the ONE, MARK, or OFF state will be in accordance with the EIA definition as listed in Table E.

TABLE E

DEFINITION OF CONDITION

Binary State	ONE	ZERO
Signal Condition	MARK	SPACE
Control Function	OFF	ON
Voltage Level	NEGATIVE	POSITIVE
Paper Tape	HOLE	NO HOLE

7.07 ***Description of Signals on Customer Connection:***

(a) ***Send Data (SD/BA)—Terminator:*** Serial data generated by the transmitting business machine is presented to the transmitting data set on the SD/BA circuit. The transmitting business machine must hold SD/BA in the OFF condition when signals are not to be transmitted. Business machines designed for Receive Only service must hold this circuit OFF at all times. The SD/BA circuit requires that both OFF and ON signal conditions be held for the total duration of each signal element.

(b) ***Receive Data (RD/BB)—Driver:*** Serial data obtained from demodulating the received line signal is delivered to the interface on the RD/BB lead. In half-duplex service, the receiving data set holds RD/BB OFF when both terminal data sets hold RS/CA in the OFF condition. When the data set is transmitting in half-duplex service, the RD/BB circuit follows the local SD/BA circuit and can be used to provide local copy if the connected business machine is equipped to monitor. The RD/BB circuit requires that both OFF and ON signal conditions be held for the total duration of the signal element.

(c) ***Request to Send (RS/CA)—Terminator:*** In half-duplex service, conditioning RS/CA to ON connects the data set transmitter to the line, turns on carrier, and initiates the RS/CA-CS/CB period which is required to condition the line and far-end equipment. The data set receiver is connected to provide local copy on the RD/BB circuit if the business machine is so equipped. RS/CA must be held ON for the full duration of the message and for the entire interval of the last bit to be transmitted. When the data set is conditioned to provide full-duplex service over 4-wire facilities, RS/CA must not be switched OFF for at least 1.0 millisecond after the end of the last information bit is applied to the SD/BA lead. This time interval ensures that the last bit is clear of the transmitter before carrier is turned OFF. If the data set is providing half-duplex service over 2-wire facilities, the RS/CA OFF time interval is increased to approximately 4.0 milliseconds. The extra time is required for the last bit of local copy to clear the receiver circuits before the squelch circuit clamps the receiver output. When using half-duplex service and RS/CA is OFF, the data set is conditioned to receive only; or if RS/CA is ON, the data set is conditioned to transmit only. These conditions are established without regard to signals on SD/BA or RD/BB leads. When RS/CA is switched OFF, the data set turns OFF the carrier, disconnects the transmitter, and connects the receiver to the line. Business machines designed for receive-only service must hold RS/CA in OFF conditions at all times. Business machines designed for either transmit-only or full-duplex service may hold the RS/CA condition ON at all times. On a multipoint communication channel that may successively carry data signals transmitted by several data

stations, RS/CA must be used by each data terminal to condition the local data set to transmit.

(d) ***Clear to Send (CS/CB)—Driver:*** Clear to Send is an indication to the customer's business machine that the data system is prepared to transmit data on the SD/BA lead. CS/CB is OFF if RS/CA is OFF. CS/CB is switched ON 200 (±20) milliseconds after RS/CA comes ON, in order to permit the data system to establish a channel to the far-end business machine. In receive-only service, the data set holds RS/CA in the OFF condition at all times, which holds CS/CB OFF.

(e) ***Data Set Ready (DSR/CC)—Driver:*** An ON indication is provided if the data set is not in the test mode and operating power is supplied. An OFF indication is given if the data set is in the test or talk mode. The DSR/CC driver is at 0 volts if power is not applied.

(f) ***Signal Ground (SG/AB) and Frame Ground (FG/AA):*** The Signal Ground establishes the common ground reference potential for all interchange circuits, except Frame Ground, and data set operating voltages. SG/AB is connected to FG/AA within the data set to minimize the introduction of noise into the electronic circuitry.

(g) ***Data Carrier Detector (COO/CF)—Driver:*** An ON indication of COO/CF indicates that carrier is being detected in the data set receiver. Certain line noises and speech patterns, as well as carrier, can operate this circuit if the level is received for at least 40 (±10) milliseconds. When the end of message or a dropout on the line causes a loss of carrier, the COO/CF will not switch RD/BB to OFF until a 15 (±5) millisecond guard time delay has elapsed. In half-duplex service, COO/CF responds to either local or far-end carrier signals. Sensitivity of the COO/CF circuit is the same as the receiver sensitivity (–42 to –48 dBm with a random signal input). Signals below –42 dBm will be grossly distorted.

(h) ***+18V, -18V:*** The power supply voltages are available through individual 1800-ohm resistors on the customer connector. These voltages are used to supply ON and OFF signals to other interface leads; however, they should not be used to supply power to any customer equipment.

(i) ***Reverse Channel-Transmit (RCT/SA)—Terminator:*** This lead, together with RCR/SB, is provided only at the interface on data sets equipped with the optional reverse channel 1A1 Data Unit. Signals on RCT/SA are used for communication from a receiving data set to the transmitting data set. The business machine should interrogate the reverse-channel response for at least 50 milliseconds to be sure that valid signal indications are received. This circuit can be used only when RS/CA is OFF. The reverse channel transmit level can be adjusted to –3, –6, or –9 dBm with appropriate strapping to the 1A1 Data Unit.

(j) ***Reverse Channel-Receive (RCR/SB)—Driver:*** Signals on this circuit primarily provide information to the transmitting data set regarding line conditions through the telephone facility to the far-end data set receiver. When connected through the interface connector to a business machine capable of utilizing RCR/SB, a slow-speed communication link (5-baud maximum) can be established through this circuit with the far-end business machine.

(k) ***Data Terminal Ready (DTR/CD)—Driver:***

Note: The following description is for data set use on 2-wire facilities and with DAS 804A-type. If the data set is used on a 4-wire private line having no voice or no DAS requirements, the condition of the DTR/CD lead is immaterial. If the DTR/CD lead is ON, the data set may be switched into the connecting telephone facility. However, if the call has been established automatically or manually, the ON condition maintains only the connection established by the alternate means. When the data set is provided with the automatic answering option for receiving calls, connection to the line is arranged to occur in response to the ringing signal. The OFF condition does not disable the operation of either Ring Indicator circuit.

(l) ***Ready (RDY):*** The RDY interface lead is provided to accommodate installations not meeting EIA RS-232-A interface specifications. The RDY feature is used in conjunction with automatic answer and presents a contact closure

under control of the business machine. If the data set contact is closed and the DTR lead is connected to the control common, the data set will answer a call when conditioned for automatic answer. When the contact is open, indicating that the business machine is not ready to operate, a call cannot be answered automatically. The RDY closure can be opened by the business machine for at least 50 milliseconds to automatically terminate an unattended call and perform a remote release function. Data set operation using the RDY feature may use the RDY lead separately or combined with the DTR lead to provide a remote release function.

(m) ***Ring Indicators (RI1/CE and RI2/CE):*** The function of interface leads RI1 and RI2/CE is to signal the business machine when an incoming call is received. When the data set interface is conditioned for EIA RS-232-A operation, the incoming ringing current will cause a positive voltage indication to be delivered to the business machine for approximately 150 milliseconds. If the interface requirement is designed for contact closure on the RI leads, this is provided through installer *Option M.* Indications are delivered directly to the business machine by normally open contacts which close for the nominal 150 milliseconds when ringing current is received.

B. Mounting Cord and Connector

7.08 Data Sets 202D-type are delivered with a D6AA-61 mounting cord. If the data set is to operate with a Data Auxiliary Set 804A-type unit, the D6AA-61 mounting cord must be replaced with a D34B-61 mounting cord which can be ordered locally. The D6AA-61 mounting cord is equipped with a connector which mates with the receptacle on a 44A Connecting Block. The D34B-61 mounting cord is equipped with a connector which mates with the receptacle on a 66E3 Connecting Block.

7.09 Connection diagrams for interconnecting the data set to various transmission facilities, together with specific required DAS 804A-type options, are given in Section 592-016-400 entitled Data Set 202D-Type, Transmitter-Receiver, Connections. If a DAS 804A-type is used in the station arrangement refer to Section 598-030-100, entitled Data Auxiliary Set 804A-Type, Identification and Connections, for the available option wiring.

7.10 Both mounting cords provide connections between the data set circuitry and the telephone facility and associated equipments. The mounting cord is terminated at terminal board TB1 within the data set. Various functions serviced by the mounting cord connections are listed in Table F using the numeric sequence of terminals on data set terminal board TB1.

7.11 Do not confuse abbreviations used in Table F with abbreviations used for the business machine interface connector. Functions and pin numbers at the interface are established by convention and the EIA RS-232-A specifications which do not apply to interconnecting facilities established by the telephone company.

8. CONNECTIONS

8.01 Data Set 202D-type can be connected to operate over a wide variety of telephone facilities. Each installation uses a multitude of connections and in some stations, the data set connections can be adapted to fulfill individual needs not covered in this publication. Because of the wide latitude of available connections, the descriptions are general and the illustrations are simplified sketches.

8.02 Each sketch illustrates a connection to a different type of telephone facility. Only the most common arrangements are presented by a brief operational description. The circuits are used, for the most part, with equipment housed in key telephone cabinets. Additional details, beyond the scope of this section, may be found in equivalent station system schematics. Only the operation pertaining to control of the line is provided in the descriptions.

8.03 A Data Auxiliary Set 804A-type, which is a telephone and control unit in a data set housing, is required when telephone or line control features [such as AUTO ANSWER and Automatic Calling Unit (ACU) compatibility] are requested. This unit provides the necessary controls for talk and data service in conjunction with the signaling controls necessary for switched network or private line systems. The 4-wire system terminals provide data switching on the receive pair because DAS 804A-type provides data switching only for the transmit pair. Two-wire data switching is complete in the DAS 804A-type. DAS 804A1 is used in all 2-wire and 4-wire applications. The DAS 804A2 is

TABLE F

CIRCUIT FUNCTIONS THROUGH THE MOUNTING CORD

TB1 TERMINAL NUMBER	COMMON ABBREVIATION	DESCRIPTIVE FUNCTION
1	DR	Data Ring for 2-wire facilities
2	RO	Remote Operate
3	DT	Data Tip for 2-wire facilities
4	DTR	Data Transmit Ring
5	L1	Reverse Channel tip — line input
6	DTT	Data Transmit Tip
7	TEL	Test Lamp
9	DTRY	Data Terminal Ready
10	RR	Remote Release
11	RM3	Ring Memory Control
12	RIC	Ring Indicator Common
13	RM2	Ring Memory Hold
14	TEKA	Test Key — positive battery
15	TEKB	Test Key — negative battery
16	C3	Reverse Channel Inhibit
17	D4W	Data 4-Wire control
18	TRO	Test Remote Operate
19	DSR	Data Set Ready
20	RI	Ring Indicator
21	+V	Positive battery
22	TKL	Talk Lamp
23	DSRC	Data Set Ready Common
24	GRD	Ground
26	RM4	Ring Memory Set
27	D2	Reverse channel ring — output
28	D1	Reverse channel tip — output
29	L2	Reverse channel ring — line input
30	−V	Negative battery

used to meet the requirement of switching between 2- or 4-wire switched network lines and 4-wire private lines.

8.04 Physical and functional descriptions of the DAS 804-type are beyond the scope of this publication. This information is available in Section 598-030-100 entitled Data Auxiliary Set 804A-Type, Identification and Connections. The latest option connections required for Data Set 202D-type operation are also described in that publication.

A. 2-Wire Switched Network

8.05 Figure 3 illustrates the telephone and control unit for Data Set 202D-type when it is used on a 2-wire switched network line. This installation requires *Options W, H, Q,* and *J* in DAS 804A1. *Option T* is required for operation with an 801A Automatic Calling Unit (ACU). The specific options which are required in the data set and associated DAS unit for AUTO ANSWER service are listed below:

For EIA RS-232-A *Option N*

(a) ***Key Control:***

(1) Install *Options B* and *G* in DAS 804A-type.

(2) Remove or do not install *Option Q* in Data Set 202D.

(OR)

(1) Install *Option E* in DAS 804A-type

(2) Install *Option Q* in Data Set 202D.

(b) ***Permanent AUTO ANSWER:***

(1) Install *Option B* in DAS 804A-type.

(2) Install *Option Q* in Data Set 202D.

For EIA RS-232 (Contact or *Option M*)

(a) ***Key Control:*** (Customer controls Remote Release)

(1) Install *Option E* in DAS 804A-type.

(2) Install *Option Q* in Data Set 202D.

(b) ***Permanent AUTO ANSWER:*** (Customer controls Remote Release)

(1) Install *Option B* in DAS 804A-type.

(2) Remove or do not install *Option Q* in Data Set 202D.

8.06 Normal operation of DAS 804A1 used with Data Set 202D-type is described in the following paragraphs. These paragraphs are referenced in the description of other line facilities because they apply generally to all similar connections. In describing other line facilities, only the peculiar operation arrangement required for the application will be used. Abbreviations are defined in Table F.

8.07 When a ringing signal appears on the Tip (T) and Ring (R) leads, the audible ringer and the ring detector respond. The ring detector relay R operates, and the following conditions are enabled:

(a) Contact closure between ring indicator leads RI and RIC

(b) Setting of both the oscillator and timer

(c) Setting of the data set ring memory on lead RM4

(d) C relay operate control extended to the RO lead. With *Option G* and the AUTO ANS key, the control extends through the C relay driver to the DTRY lead. The C relay is operated if either the RO lead *(Option B)* or RR lead *(Option G)* is grounded, or if the DTRY lead has a positive EIA signal. Installations using an interface contact closure will operate the C relay through *Option E* and a ground on TRO, or through the operated AUTO ANS key with RO grounded.

8.08 Contacts on the C relay perform the following functions:

(a) Closure of the circuit to operate the H relay. (Contacts on the H relay hold the C relay operated.)

(b) Disconnection of the ring detector

(c) Closure of the Data Mode Interconnection (DMI) lead to ground

(d) Removal of the DT key from ground through *Option T* (when used)

(e) Illumination of the DATA lamp

(f) Lock-up of the ring memory by closure of the negative supply to both the RM2 lead and the oscillator and timing circuit

8.09 Other contacts on the C relay connect the telephone line to leads L1 and L2 which provide the line input to the reverse channel unit. The reverse channel data input returns on leads D1 and D2. The oscillator signal is applied through the repeat coil and the reverse channel unit, and back to the line (T and R). After the answer signal, the LS relay operates and connects the data set to the telephone line on leads DR and DT. The ring memory illuminates the TALK lamp through the TLK lead.

8.10 Operation with manual answer requires that the RO lead be open and the AUTO ANS key released whether using *Option G* for EIA RS-232-A interface or *Option E* for contact closure interface. When the call is answered, the handset is removed from the cradle and the TALK key is depressed. Contacts associated with the TALK key operate the T relay. Closed T relay contacts provide the following functions:

(a) Locking of the ring memory

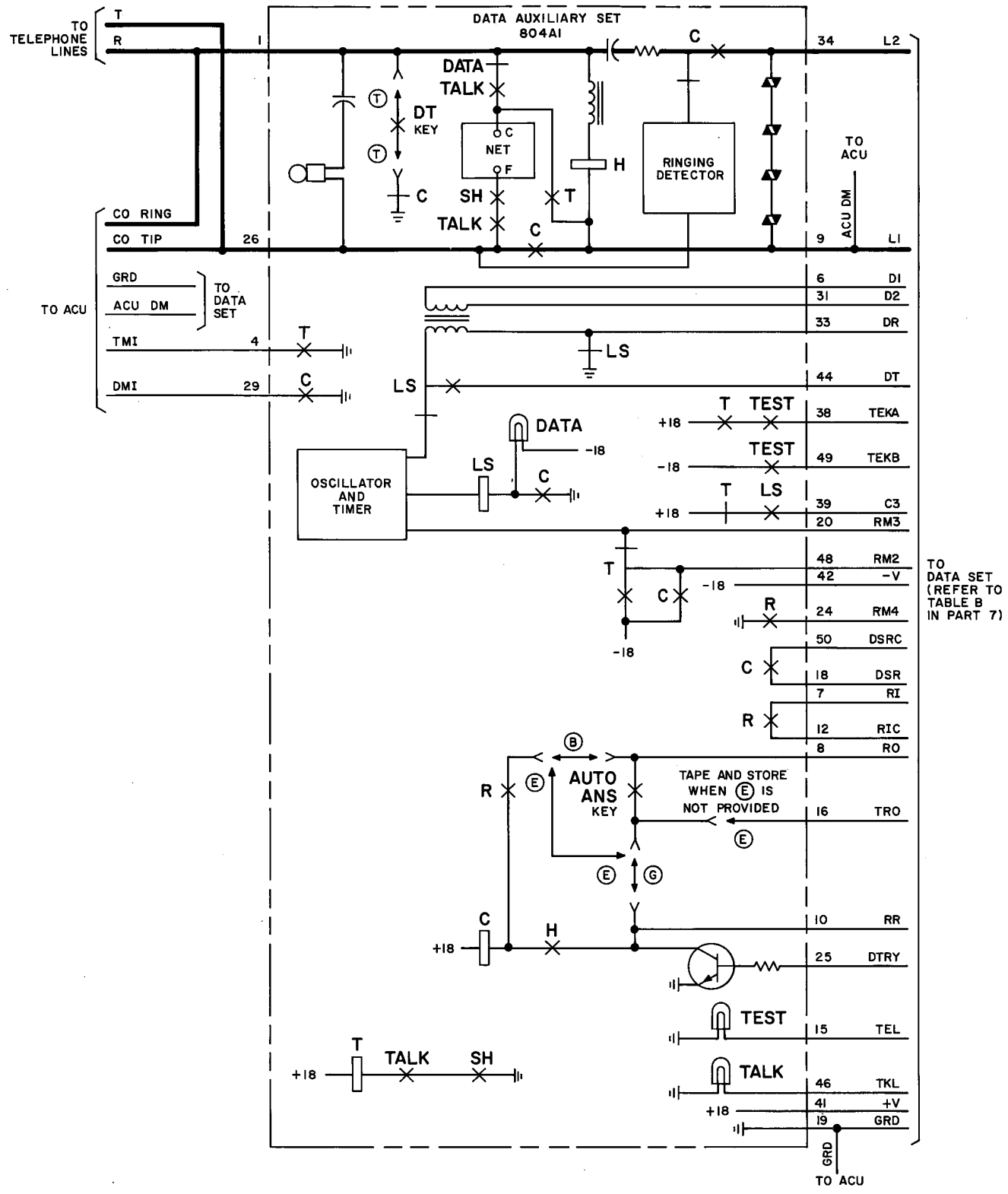


Fig. 3—The 2-Wire Switched Network

(b) Closure of the Talk Mode Interconnection (TMI)

(c) Extension of the positive supply to the TEST key

(d) Opening of the C3 lead

8.11 Pressing the DATA key opens the R side of the telephone network and the H relay is operated through contacts of the TALK key, switchhook (SH), the network, and the T relay contacts. The H relay operates the C relay. By depressing and releasing the DATA key, the TALK key is released, which opens the contacts and removes the network from the line. Ringing opens the RM3 lead in the ring memory, and when the T relay is de-energized, the timing and oscillator circuit starts.

8.12 In addition to connecting the data set to the telephone lines, an LS relay contact connects the C3 lead to the positive supply. Depressing the TEST key during the talk mode operates the data set test relay with the positive voltage from the TEKA lead. Data set test relay contacts illuminate the TEST lamp through the TEL lead. Releasing the T relay allows the data set test relay to be de-energized by the negative voltage on the TEKB lead through contacts on the operated TEST key.

8.13 Sequences for originating a call are identical to those for answering a call except that the ring memory is not operated. An ACU may be used in this installation. When the ACU completes a connection, contact closure on the ACU DM lead to the T lead will operate the H relay.

B. 2-Wire Private Line

8.14 Figure 4 illustrates the arrangement of a 2-wire private line with 20-Hz locked-in signaling for Data Set 202D-type with DAS 804A1. Interrupted ringing or any standard signaling arrangement may be provided as required by the customer. The DAS 804A1 must be strapped with *Options V, N, J, and H.*

8.15 Momentary 20-Hz ringing operates the ring-up (RU) relay. Closed RU relay contacts perform the following functions:

(a) Connection of the heater winding of the time out (TO) relay to ground

(b) Operation of the R1 relay

(c) Completion of a holding circuit through the SW back contact and the thermal delay contact of relay TO.

If the answer does not occur within the 30-second time-out period, the thermal contact de-energizes the RU relay.

8.16 Relay R1 connects the 20-Hz local ringing supply to the station ringer and detector. *Option N* separates the ring detector and audible ringer from the transmission pair. When the station answers automatically, a contact on relay R operates the C relay as described in 8.07 through 8.09.

8.17 The C relay contact on DAS 804A1 lead 29 operates the TC relay. Closed TC relay contacts perform the following two functions:

(a) Connection of line battery to the station side of the repeating coil R1

(b) Operation of the SW relay

The SW relay contacts operate the T0 relay. Relay T0 contacts disconnect the thermal winding which de-energizes the RU relay. The back contact to the TC relay drops the R1 relay which trips the ring signal from the station.

8.18 When the answer is manual, the T contact through lead 4 of DAS 804A1 operates the TC relay. The remaining sequence is identical to automatic answer.

8.19 To initiate a call, the handset is lifted from the cradle and the TALK key is depressed. The T contact operates the TC relay. Momentarily depressing the RING key operates the R relay which transfers the line to the 20-Hz generator. Both TC and SW relays prevent the operation of relay RU when the station is busy.

C. 2-Wire Private Line With a DDD Backup Line

8.20 Figure 5 illustrates a 2-wire private line with 20-Hz locked-in signaling and an alternate switched network. The DAS 804A1 is used for line control and should be strapped with *Options W, N, J,* and *H.* Interrupted ringing on any other standard 20-Hz signaling arrangement may be installer-provided. Selective 2-wire arrangements may be provided by using the 6A Intercommunicating Circuit with the data set as the station.

8.21 Line signaling on the private line is identical to Fig. 4 as described in 8.15 through 8.18, except that both received and transmitted signals operate the K relay for the duration of the call. The K relay contacts provide the following functions:

(a) Prevent the RU1 relay from operating the R1 relay

(b) Prevent the auxiliary switched network line lamp from being illuminated

(c) Prevent the D1 Relay from being accidentally operated

(d) Prevent the D1 relay from operating the D1 relay on automatic line answering

8.22 Ringing on the auxiliary line is detected by relay RU1. Contacts on the RU1 relay provide the following functions:

(a) Illuminate the DD1 lamp during the ring cycle

(b) Operate the R1 relay to transfer ringing to the set

(c) Cause the D1 relay to operate with the automatic answer option

8.23 When using manual answer, the handset is removed from the cradle and the DD1 key is depressed momentarily. The DD1 key contacts operate the D1 relay. Closed contacts of the D1 relay provide the following conditions:

(a) Completion of a holding circuit

(b) Locking off of relay K

(c) Illumination of the DD1 lamp

(d) Transferal of the data set to the switched network

(e) Trip ringing

Transfer to the data mode is accomplished as described in 8.07 through 8.13. When the station terminates the call, the data set automatically reconnects to the private line.

8.24 When a call is originated, the handset is lifted from the cradle, the TALK key is operated, and the DD1 key is momentarily depressed. Relay D1 operates as described, and dialing is accomplished in the usual manner. When the station is busy on either line, the remaining line is idle to an incoming call.

D. 4-Wire Common Battery

8.25 Figure 6 illustrates a 4-wire common battery arrangement using a DAS 804A1 for line control. The DAS 804A1 should be strapped for *Options V, N, M,* and *H. Option N* separates the ring detecting circuits from the transmission pair and *Option M* is required for 4-wire operation.

8.26 A call is answered after ringing appears on the line receive pair T and R. Ringing is transferred to the data audible ringer and ring detector through the C relay contacts. When answering is manual, establishing the talk mode operates the A(PU) relay by a ground through the C1 relay contact. Closed contacts of the operated A(PU) relay provide the following conditions:

(a) Closure of the line side of repeating coil R

(b) Connection of the telephone receiver leads to the station side of the repeating coil R

(c) Connection of the sidetone network components (resistors and capacitors ST and SR) between the transmitting pair and the receiving pair

(d) Extension of the ON relay through lead 3 circuit to the DAS 804A1 ON relay contact.

Central office battery is held on the transmit pair through contacts on the DATA and TALK keys, a telephone network, and a switchhook contact.

8.27 When a transfer to data mode is performed, the C1 relay is operated by a ground supplied

through relay C contacts. The C1 relay holds the A(PU) relay when the ground through T relay contacts is removed. Contacts of relay C1 also transfer the T and R receive pair to the data set through repeat coil R1. The transmit pair, T1 and R1, are connected to the data set through a repeat coil in DAS 804A1. Relay C1 contacts disconnect the telephone receiver from the transmit pair by opening the sidetone circuit network paths.

8.28 When a call is answered automatically, relay C1 is operated by a ground from the DAS. The C1 relay operates the A(PU) relay to transfer the receive pair to repeat coil R1. The A(PU) relay completes the connection as described above.

8.29 When a call is originated, the A(PU) relay is operated by a ground from the DAS. The ON relay disconnects the sidetone network and opens the shunt paths on the transmitting pair when the dial is pulled off-normal. Dialing is accomplished over the transmit pair. Relay sequences are identical to those for answering a call manually.

E. 4-Wire E and M Lead Signaling Central Office Circuit

8.30 Figure 7 illustrates the 4-wire E and M signaling central office circuit using DAS 804A1 for line control. The DAS should be strapped to provide *Options V, N, M,* and *H. Option N* separates the ring detecting circuits from the transmit pair and *Option M* is required for 4-wire operation.

8.31 Incoming signaling is initiated by a ground on the E lead which operates the signal relay R. Closed R relay contacts connect the 20-Hz ringing generator to the DAS audible ringer and ring detector circuits. Manual answering in the talk mode operates the DAS T relay which completes the circuit to operate the TB relay in KTU4 and relay A(PU) in KTU3. Relay A(PU) contacts perform the following functions:

(a) Connection of the station side of repeat coil R to the DAS telephone receiver

(b) Connection of the sidetone network between the transmit and receive line pairs

(c) Completion of the circuit to operate the ON relay

(d) Completion of the circuit to operate the A relay

The TB relay signals the central office that the station has gone off-hook by connecting battery voltage on the M lead.

8.32 Closed contacts of the A relay provide the following functions:

(a) Disconnection of the terminations on the line side of the transmit and receive pairs

(b) Connection of the line side of the transmit pair to the DAS

(c) Connection of the line side of repeat coil R to the receive pair

(d) Completion of the circuit to operate the lock-out (LO) relay

The operated LO relay disconnects the R relay to stop ringing and transfers the E lead to LO relay contacts. The LO relay remains operated until the E lead ground is removed and the A relay is released.

8.33 When a transfer to the data mode is made, relay C1 is operated by a ground from the C relay contact in the DAS. The C1 relay holds relay A(PU) operated and transfers the receive line pair to the data set through repeat coil R1. The transmit pair is connected to the data set through the DAS which also provides a holding path for relay TB. Relay C1 disconnects the telephone receiver by opening the sidetone network connection.

8.34 When a call is answered automatically, relay C1 is operated by a ground from the C relay contact in the DAS. The DAS also completes the circuit to operate relay TB. Contacts on relay TB connect battery to the M lead to signal the central office. Relay C1 transfers the line side of the receive pair to repeat coil R1 and operates relay A(PU). The A(PU) relay completes the connections as described previously.

8.35 When a call is originated, the A(PU) relay is operated by a ground from the DAS T relay contact. Relay TB is operated through the DAS transmit circuitry. The ON relay disconnects the sidetone network when the dial is pulled off-normal. Dialing is transferred to the M lead

by the TB relay following the dial pulses. All relay sequences are identical to those for answering a call manually.

F. 4-Wire Private Line

8.36 Figure 8 illustrates the 4-wire private line arrangement using a DAS 804A1 for line control. The DAS 804A1 should be strapped for *Options V, N, M,* and *H. Option N* separates the ring detecting circuits from the transmission pairs and *Option M* is required for 4-wire operation.

8.37 Incoming signaling will operate relay R through one of the appropriate selected options. When using *Option Q,* relay R is operated through the RU contact in the private line circuit. When using *Option R,* relay R is operated through the DB contact in the selective signaling system. In the private line circuit, a time-out relay may be provided for an *Option Y,* and interrupters (INT) for ringing may be provided as required for the individual system. Relay R remains energized through a circuit completed by a back contact on the cut-through relay CT. Closed contacts on the R relay will close the 20-Hz supply to the station and lock out the TO relay (when provided).

8.38 For manual answering, the DAS responds to ringing voltage at the ringing detector circuit. Lifting the handset from the cradle and depressing the TALK key completes the station circuitry to operate the talk battery relay TB and relay A(PU). The A(PU) relay contacts provide the following functions:

(a) Termination of the station side of the repeat coil R to the telephone receiver

(b) Connection of the sidetone networks

(c) Extension of the ON relay control to the DAS

(d) Extension of the outgoing signaling circuit to the station

(e) Operation of the CT relay

The CT relay contacts provide the following functions:

(a) Disconnection of the receiving termination

(b) Connection of the repeating coil R to the line

(c) Opening of the circuit to relay R

(d) Cancellation of the time-out feature by grounding the CO lead to the visual and audible signaling circuit to end the incoming signal

The station is now prepared for talking.

8.39 When the DATA key is pressed to transfer the data set into the data mode, operated C relay contacts provide the ground to operate relay C1. Closed C1 relay contacts hold the A(PU) relay operated, transfer the receiver pair on the line side of repeat coil R to the data set receiver, and disconnect the DAS telephone receiver by opening the sidetone network paths. The transmit pair is transferred to the data set through the DAS circuits.

8.40 When ringing is detected by the DAS set for automatic answer, the C relay in the DAS operates the C1 relay, which operates the A(PU) relay. The remaining sequence is as given previously.

8.41 When originating a call, the relays follow the same sequence. The DAS SPARE 1 key can be used to initiate ringing through the ring-out RO relay in some signaling systems. Relay TB transfers dial pulses to the selective signaling system through the P relay. Pulling the rotary dial off-normal operates the ON relay, which disconnects the sidetone network and extends a ground to the signaling circuit.

G. 4-Wire Private Line With Alternate Switched Network 2-Wire Line

8.42 Figure 9 illustrates an arrangement for using Data Set 202D-type with DAS 804A2 over an alternate 2-wire switched network or a 4-wire private line network. The DAS 804A2 should be strapped with *Options V, U, N,* and *H. Option N* separates the ring detectors. *Option U* inserts the 4W relay to enable the telephone unit to be switched between the 2-wire circuit and the 4-wire circuit.

8.43 In addition to the above options in DAS 804A2 for 4-wire operation, an additional

Option ZF, should be provided to ensure proper data-to-talk transfer when operating over the DDD line. This option is detailed in Issue 4 of Section 592-016-400 entitled Data Set 202D-Type, Transmitter-Receiver, Connections.

8.44 The 4-wire private line operates in essentially the same sequence described in 8.36 through 8.41. The T1 relay is added to provide more talk mode control contacts. When the switchhook contacts are closed, relay T1 operates. This operation prepares the key telephone unit for its individual functions. With the DD1 relay in the nonoperated condition, the circuit is essentially the same as described in Part F. In the idle condition, relay DD1 is always in the nonoperated condition. Therefore, the data station is always connected to the 4-wire private line unless it is purposely switched to the alternate DDD network line.

8.45 Ringing on the switched network line is detected by relay RD1 which then operates the auxiliary ring relay R1 through a back contact of relay A(PU). The A(PU) relay contact prevents the detection of ringing when the station is busy on the private line. The station appears idle to an incoming switched network call when it is busy on the private line. The R1 relay contacts provide the following functions:

(a) Illumination of the DD1 lamp

(b) Connection of the local ring supply to the station detectors

(c) Operation of relay DD1 when automatic answer *Option Z* is provided

8.46 When the answer is manual, the handset is lifted from the cradle and the nonlocking DD1 key on the DAS must be pressed. Momentary closure of the DD1 key contacts operates the DD1 relay. The station must remain off-hook or in the data mode in order to hold the DD1 relay operated. Releasing the DD1 relay terminates the call.

8.47 Functions provided through DD1 relay contacts are as follows:

(a) Disconnection of relay A(PU) to make the private line idle

(b) Illumination of the DD1 lamp for the duration of the call

(c) Transferring of the switched network to the station

(d) De-energizing of relay 4W to provide the 2-wire telephone circuit

(e) Provision of a ground on lead D4W to condition the data set for 2-wire operation

(f) Transferring of the station side of the DAS from 4-wire transmit and receive pairs to the 2-wire transmit/receive pair on DT and DR.

The transfer of the switched network to the station trips central office ringing.

8.48 To originate a call on the switched network line, the handset is lifted from the cradle and the DD1 key is pressed to operate the DD1 relay. The relay sequences are as described above and dialing is accomplished in the usual manner.

8.49 When a call is terminated, the station reverts to the private line mode by de-energizing the DD1 relay.

H. 4-Wire Private Line With Two Alternate Switched Network 2-Wire Lines

8.50 Figure 10 illustrates an arrangement for using two switched network lines as a 4-wire alternate to a 4-wire private line network. This arrangement uses a Data Set 202D-type with a DAS 804A2 which has been strapped to provide *Options V, U, N,* and *H*. *Option N* separates the ring detectors and *Option U* inserts relay 4W to enable the DAS telephone unit to be switched between the 2-wire circuit and the 4-wire circuit.

8.51 In addition to the above options in DAS 804A2 for 4-wire operation, an additional *Option ZE* should be provided to ensure proper data-to-talk transfer when operating over the DDD line. This option is detailed in Issue 4 of Data Set 202D-Type, Transmitter-Receiver, Connections (Section 592-016-400).

8.52 The 4-wire private line is operated essentially the same as described in Part G. The 20-Hz signal key shown in Fig. 9 is replaced by an off-normal contact for point-to-point signaling. Replacement of the key by a dial contact is necessary because all the keys are used for line control. The signal key circuit is completed by dialing any digit.

When the selective signaling system is used, the off-normal contact will provide an off-normal indication to the signaling system. When dialing a switch network line, break contacts on relays DD1 and DD2 are in series with the off-normal contact to prevent ringing from being applied to the private line. When the station is off-hook, relay CT prevents ringing signals on the private line from operating relay R. This open connection prevents the ringing signal from being applied to the station.

8.53 Operation of both switched network lines are identical, except for component nomenclature. Only the operation of the DD1 line is given below. When ringing appears on the DD1 line, relay RD1 operates, thereby causing the illumination of the DD1 lamp and connecting the local ring supply to the station detectors. The call must be answered manually by depressing the TALK key, lifting the handset from the cradle, and momentarily depressing the DD1 key.

8.54 Closed contacts of the operated DD1 relay perform the following functions:

(a) Completion of a holding circuit through a back contact on the AUX relay

(b) Disabling of relay 4W to make the telephone circuit a 2-wire operation

(c) Extension of the operate path to the AUX key and relay C1

(d) Illumination of the DD1 lamp for the duration of the call

(e) Transferal of the DD1 line to the T and R lines of DAS 804A2

(f) Opening the auxiliary relay path in series with relay D2 contact

(g) Opening of the lead in series with the off-normal contact

Ringing is tripped, and the 2-wire circuit is completed to the distant station.

8.55 When the circuit to the far-end station is confirmed, the AUX key is depressed to place the DD1 line on hold. The AUX key contacts operate relay D1. Contacts of relay D1 provide the following functions:

(a) Completion of a circuit to hold itself operated

(b) Transfers of the DD1 line to the T repeat coil

(c) Transfers of the T repeat coil to the transmit pair and disconnects the private line transmit pair on the line side

(d) Operation of the AUX relay

Operating the AUX relay releases the DD1 relay. Release of the AUX key releases the AUX relay. The station is held off-hook, and waits for ring signals on the DD2 line.

8.56 Ringing on the DD2 line operates relay RD2 which illuminates the DD2 lamp and connects the local ring supply to the station detectors. Pressing the DD2 key operates relay DD2 and the closed contacts provide the following functions:

(a) Completion of a circuit to hold itself operated

(b) Extension of the operate path of relay D2 to the AUX key and relay C1

(c) Disabling of relay 4W

(d) Illumination of the DD2 lamp for the duration of the call

(e) Transfer of the DD2 line to the T and R leads of DAS 804A2

(f) Opening of the auxiliary relay lead connected in series with the D1 relay contact

(g) Opening of the lead in series with the off-normal contact

Ringing is tripped, and the 2-wire connection to the distant station is completed.

8.57 After the connection is confirmed, the station may be transferred to the data mode. Closed contacts of the DAS C relay operate the C1 relay.

Contacts of the operated C1 relay provide the following functions:

(a) Transfer of the receive pair to the data set receiver

(b) Holding of relay A(PU) operated

(c) Operation of relay D2

The closed contacts of relay D2 perform the following:

(a) Completion of a holding circuit

(b) Operate the AUX relay which de-energizes relay DD2

(c) Transfer the line side of repeat coil R to the DD2 line

(d) Transfer the station side of repeat coil R to the receive side of the 4-wire switched network line

(e) Disconnect the receive side of the 4-wire private line

Relays D1 and D2 both prevent ringing signals from being applied to the station and hold lamps DD1 and DD2 illuminated while the call is active.

8.58 Relays D1 and D2 remain operated until the call is terminated; then the station is automatically returned to the 4-wire private line. When the station is transferred to the talk mode with the alternate lines, the talk path is completed over the 4-wire service with DD1 serving as the transmit pair and DD2 serving as the receive pair.

8.59 Establishing the call requires that the originating station dial from the DD2 line to an answering DD1 line to keep the data and telephone transmitters connected to the distant data and telephone receivers. The originating station DD1 line should also be connected to the called station DD2 line. When a call is originated over the auxiliary lines, the sequences are the same as those for answering a call.

I. 4-Wire Private Line with Reverse Channel

8.60 Figure 11 illustrates the 4-wire private line with reverse channel using Data Set 202D-type and DAS 804A1. The operation of this circuit is essentially the same as described in Part 8F. The DAS 804A1 must be strapped to provide *Options V, N, M,* and *H. Option N* separates the ring detecting circuits from the transmit pairs. *Option M* is required for 4-wire operation.

8.61 Relays RCR (reverse channel receive) and RCT (reverse channel transmit) are provided for selective reverse channel reception or transmission over one pair of private line facilities. The DAS 804A1 should be equipped with a key and lamp designated RCR, and another key and lamp designated RCT in order to provide the customer with a control and indication of reverse channel reception and transmission.

8.62 When the nonlocking RCR key is pressed, closed key contacts operate the RCR relay. Closed contacts of the RCR relay complete the following:

(a) A self-locking circuit through its own closed contacts and a back contact of relay RCT

(b) Transferal of the reverse channel unit from the 2-wire transmit pair to the 2-wire receive pair shown as DT and DR

(c) Placing of the lightning protective circuit across the line

(d) Illumination of the RCR lamp during the time the reverse channel is to be received.

When this mode of operation of used, the business machine must maintain the Reverse Channel-Transmit interface lead (pin 11) in an OFF condition (or less than –5.0 vdc).

8.63 Pressing the nonlocking RCT key operates the RCT relay and deenergizes relay RCR, and open relay contacts transfer the reverse channel to the transmit pair DTT and DTR. The RCT lamp is illuminated through a back contact of relay RCR. In this condition, the reverse channel receiver monitors the transmitter.

8.64 The reverse channel signal and the data signal appear on the transmission facility together. Consideration must be given to the overall signal level applied to the Zero Transmission Level Point (0 TLP) to prevent possible overloading of the transmission facility. Table G shows nominal

combined output levels for various options in the reverse channel and data set. In some installations it may be necessary to add a compensating pad on the 2-wire transmit pair.

TABLE G

DATA SET COMBINED OUTPUT LEVELS

DATA SET OPTION (DBM)	COMBINED OUTPUT LEVEL WITH REVERSE CHANNEL OPTION *		
	-3 DBM	-6 DBM	-9 DBM
0	+4.65	+3.55	+2.65
−3	+3.00	+1.65	+0.55
−6	+1.65	0.00	−1.35
−9	+0.55	−1.35	−3.00

* The levels provided will be changed in the near future to agree with new FCC regulations.

8.65 Figure 12 illustrates a block diagram for connecting a reverse channel "Data Only" (no voice) over 4-wire facilities. In the reverse-channel transmit terminal, data is received over the receive pair while reverse-channel is transmitted over the transmit pair. The complement of this operation holds for the reverse-channel receive terminal. At the reverse-channel transmit terminal, data transmission cannot occur simultaneously with reverse-channel transmission.

J. 2-Wire Switched Networks

8.66 Figure 13 illustrates an arrangement for using two switched network lines as a 4-wire circuit with Data Set 202D-type and a DAS 804A2 with *Options W, U, N,* and *H. Option N* separates the ring detectors. *Option U* inserts relay 4W to enable the telephone unit to be switched between the 2-wire circuit and the 4-wire circuit.

8.67 In addition to the above options in DAS 804A2 for 4-wire operation, an additional option, *ZF,* should be provided to ensure proper data-to-talk transfer when operating over the DDD line. This option is detailed in Issue 4 of Data Set 202D-Type, Transmitter-Receiver, Connections (Section 592-016-400).

8.68 Operation of the two switched network lines is approximately the same as for the alternate switched network operation described in Part 8H. This configuration repeats the 2-wire operation but reflects a reduction in station hardware because there is no provision for an alternate 4-wire private line.

8.69 When ringing appears on the DD1 line and operates relay RD1, closed contacts illuminate the DD1 lamp and connect the local ring supply to the station detectors. The call must be answered manually with the TALK key depressed by lifting the handset from the cradle and momentarily depressing the DD1 key. Closed contacts on the DD1 key operate relay DD1, and closed relay DD1 contacts provide the following functions:

(a) Completion of a holding circuit through a back AUX relay contact

(b) Disabling of relay 4W to make the telephone circuit 2-wire operation

(c) Extension of the operate path for relay D1 to contacts on the AUX key and relay C1

(d) Illumination of the DD1 lamp for the duration of the call

(e) Transferal of the DD1 line to the T and R leads of DAS 804A2

(f) Opening of the operate path for relay AUX through relay D2 contact

Ringing is tripped and the 2-wire talking path is completed to the distant station.

8.70 When the path is confirmed, the AUX key is pressed to place the DD1 line on hold. The AUX key operates relay D1 and closed relay contacts provide the following functions:

(a) Completion of a holding circuit

(b) Transferal of the DD1 line to the transmit pair through the T repeat coil

(c) Causation of the AUX relay to operate

The AUX relay releases the DD1 relay. Releasing the AUX key will de-energize the AUX relay. The

station is held off-hook and waits for ring signals on the DD2 line.

8.71 Ringing on the DD2 line operates the RD2 relay. Closed contacts illuminate the DD2 lamp and connect the local ring supply to the station detectors. Pressing the DD2 key operates the DD2 relay and closed relay contacts provide the following functions:

(a) Completion of the circuit to hold itself operated

(b) Extension of the operate path of relay D2 to contacts on the AUX key and the C1 relay

(c) Disconnection of the 4W relay

(d) Illumination of the DD2 lamp for the duration of the call

(e) Transferal of the DD2 line to the T and R leads of DAS 804A2

(f) Opening of the operate path for the AUX relay through the relay D1 contacts

Ringing is tripped and the 2-wire talking path is completed to the distant station.

8.72 When the call is confirmed, the station may be transferred to the data mode. The DAS C relay contacts operate the C1 relay, which transfers the receive pair to the data set receiver, locks relay CT operated, and operates the D2 relay. Closed D2 relay contacts perform the following functions:

(a) Completion of a holding circuit

(b) Operation of relay AUX which de-energizes relay DD2

(c) Transferal of the line side of repeat coil R to the DD2 line

Relays D1 and D2 illuminate lamps DD1 and DD2 while the call is active. When the call is terminated, relays D1 and D2 de-energize and automatically return the station to the idle condition. If the station is transferred to the talk mode by using both the DD1 and DD2 lines, the transmit pair uses the DD1 line and the receive pair uses the DD2 line.

8.73 Setting up the call requires the originating station to dial from the DD2 line to the answering DD1 line. This procedure keeps the local data and telephone transmitters connected to the distant data and telephone receivers. The originating station should also connect the local DD1 line to the distant DD2 line. When a call is originated over the DDD lines, the sequences are the same as those used in answering a call.

K. 2-Wire Private Line (Using Only 200-Type Key Telephone Units)

8.74 Figure 14 illustrates an arrangement for a 2-wire private line with 20-Hz locked-in signaling using Data Set 202D-type with a DAS 804A1 and 200-type key telephone units (KTUs). The DAS 804A1 should be strapped to provide *Options V, N, J,* and *H.* The exclusive use of the 200-type KTUs demonstrates a cost and hardware saving over the arrangement illustrated in Part 8B, although both arrangements provide the same operation. Interrupted ringing, or any other standard signaling arrangement may be provided as the customer requires.

8.75 Momentary 20-Hz ringing operates relay RU, and closed relay RU contacts connect the heater winding of relay TO to ground. The TO relay is held operated through a back TC contact and the thermal delay contact of relay TO. If the station does not answer within the 30-second time-out period, the thermal contact opens and de-energizes the RU relay.

8.76 The operated RU relay connects the 20-Hz ringing supply to the station ringer and detector circuit. *Option N* in the DAS 804A1 separates the ring detector and audible ringer from the transmit pair. If the station answers automatically, the R contact operates relay C as described in 8.07 through 8.09. The C contact on lead 29 operates relay TC which trips the ring signal from the station and operates relay TO. Operated relay TO disconnects the thermal winding and de-energizes the RU relay. The line holding relay H in DAS 804A1 is operated through a BF relay contact. When the station answer is manual, a T (TALK key) contact operates relay TC through lead 4. The remainder of the sequence is identical to that used for automatic answer.

8.77 To initiate a call, the handset is removed from the cradle and the TALK key is depressed. A T contact operates relay TC as described above. Momentarily pressing the RING key operates relay R and transfers the line to the 20-Hz generator. Relay TC prevents relay RU from operating when the station is busy.

L. 2-Wire Private Line With a DDD Backup Line (Using Only 200-Type Key Telephone Units)

8.78 Figure 15 illustrates an arrangement of a 2-wire private line with 20-Hz locked-in signaling and an alternate switched network line using Data Set 202D-type, a DAS 804A1, and 200-type KTUs. The DAS 804A1 should be strapped to provide *Options W, N, J,* and *H.* The exclusive use of 200-type KTUs demonstrates a cost and hardware saving over the arrangement illustrated in Part 8C. Both arrangements provide the same operation.

8.79 Interrupted ringing, or any standard 20-Hz signaling arrangement may be installer-provided as required by the customer. Selective 2-wire arrangements may be provided using a 6A Intercommunicating Circuit with the data set as the station.

8.80 Line signaling on the private line is accomplished as outlined in Part 8K. except that both received and transmitted signals operate relay K for the duration of the call. Closed K relay contacts provide the following functions:

(a) Prevention of accidental operation of relay D1 during ringing on the private line

(b) Prevention of the illumination of the auxiliary switched network lamp

(c) Prevention of relay RU1 from operating relay D1 on automatic auxiliary line answering

8.81 Ringing is detected on the auxiliary line by the RU1 relay. Closed relay contacts provide the following functions:

(a) Illumination of the DD1 lamp during the ring cycle

(b) Supply of ringing to the DAS 804A1 through a TC relay contact

(c) Causation of relay D1 to operate when using automatic answer *Option X*

When answering manually, the handset is lifted from the cradle and the DD1 key is momentarily depressed. Closed contacts of the DD1 key operate the D1 relay. Closed relay D1 contacts provide the following functions:

(a) Completion of the circuit to hold itself operated

(b) Prevention of relay K from operating

(c) Illumination of the DD1 lamp

(d) Transferal of the data set to the switched network line
network line

(e) Tripping of the ringing signal

Transfer to the data mode is the same as described in Part 8D. When the call is terminated, the data set is automatically reverted to the private line.

8.82 When originating a call, the TALK key is depressed, the handset is lifted from the cradle, and the DD1 key is depressed momentarily. Relay D1 is operated as previously described and dialing is accomplished in the usual manner.

8.83 When the station is busy on either line, the remaining line appears idle to an incoming call.

9. TRANSMISSION REQUIREMENTS

9.01 Data Set 202D-type is designed to operate through telephone facilities meeting either the 2000 series or the Type 3002 data channel requirements which are conditioned according to the service desired. Four-wire terminations are preferred over 2-wire terminations for maintenance and return loss considerations. Operation may be one-way reversible (half-duplex), or 2-way simultaneous (duplex). Facilities where 2-way simultaneous operation occupies different and noninterfering portions of the bandwidth are considered to be reversible (half-duplex).

9.02 When the data set operates over conditioned facilities, the compromise equalizer should be disconnected except as in Table H.

9.03 If the 900-series data test sets are available, measurements of the peak-to-peak distortion on the data set, both with and without the equalizer, can be used to determine which configuration provides the best distortion results. A brief comparison of the various grades of conditioning applicable to the 2000 series and Type 3002 channels are shown in Table I.

TABLE H

LINE CONDITIONING FOR DATA SET 202D

BIT RATE	RECOMMENDED CONDITIONING*	USE EQUALIZER
1000 bps	None	On multipoint circuits
1400 bps	C1	When envelope delay distortion on the channel exceeds 1200-2200 Hz — 400 μsec 1000-2400 Hz — 500 μsec 800-2600 Hz — 1000 μsec Attenuation Frequency Distortion 1000-2400 Hz — 3 dB
1800 bps	C2	When envelope delay distortion on the channel exceeds 1100-2400 Hz — 300 μsec 900-2600 Hz — 400 μsec Attenuation Frequency Distortion 500-2800 Hz — 3 dB

* Recommended conditioning varies with transmission speed.

TABLE I

CONDITIONING GRADES APPLICABLE TO 2000 SERIES AND TYPE 3002 CHANNELS

GRADE	ATTENUATION DISTORTION		ENVELOPE DELAY DISTORTION		APPLICABLE BELL SYSTEM PUBLICATION REFERENCE
	(HZ)	(DB)*	(HZ)	(μSEC)	
Unconditioned C-Grade	300-3000 500-2500	−3 to +12 −2 to +8	800-2600	1750	AB27.350.01
C1 Conditioned	300-2700 1000-2400	−2 to +6 −1 to +3	1000-2400 800-2600	1000 1750	AB27.350.02
C2 Conditioned	300-3000 500-2800	−2 to +6 −1 to +3	1000-2600 600-2600 500-2800	500 1500 3000	AB27.350.03
C4 Conditioned	300-3000 500-3000	−2 to +6 −2 to +3	1000-2600 800-2800 600-3000 500-3000	300 500 1500 3000	AB27.350.04

* Minus (−) signifies less loss.

9.04 ***Attenuation Distortion:*** The Attenuation Distortion column of Table I specifies the attenuation characteristic over the given frequency range. There is no provision for the transmission of dc signals. The allowable deviations and frequency ranges vary with the grade of conditioning. The allowable deviation is specified as the difference in gain or loss from the measured loss (L) of 1000 Hz with proper terminations.

9.05 ***Envelope Delay Distortion:*** Envelope delay distortion must be controlled to provide satisfactory data transmission. Table I illustrates that the allowable deviation becomes smaller and the frequency range wider for progressively better grades of conditioning. The absolute delay for all arrangements is not specified. The absolute delay may prevent some systems which use a retransmission arrangement from transmitting information at the maximum data transfer rate.

9.06 ***Impulse Noise:*** The susceptibility of the data set to impulse noise varies with the transmission rate. However, the facility should never exceed a count of 15 noise peaks in 15 minutes at 72 dBrn OVB. Impulse noise can be monitored at the data set interface using a 6A Impulse Counter, but a similar measurement at the zero transmission level point (0 TLP) would reflect the immediate condition of the facility. If the 15 counts in 15 minutes are measured at the TLP, and the rms data signal measures +4.0 dB or more above the TLP, an expected error rate of 1 in 10 bits per second should result if remaining parameters are within their limiting values.

9.07 ***Impairment Tolerances:*** The transmission facility should meet the following limits if the error rate stated in 9.06 is not to be exceeded:

(a) Sudden Net Loss Variation: ±4.0 dB

(b) Frequency Translation Error

(1) 10 Hz causes 1.0 dB SNR impairment

(2) 25 Hz causes 3.0 dB SNR impairment

(c) Signal-to-Noise Ratio: 20 dB minimum

(d) Near-end Crosstalk: 30 dB below received signal

9.08 ***Phase Jitter:*** Data transmission should not be applied to a facility where phase jitter exceeds 15 degrees peak-to-peak between data sets. A standard test set for this measurement is not presently available, but the following method provides a usable rough estimate of the amount of phase jitter present on a circuit.

(a) Connect a 1000-Hz signal at –10 dBm-0 to the far end of the circuit (preferably using a 71-type generator or a 21A Transmission Measuring Set)

(b) Connect the incoming signal to an oscilloscope to create a normal sine wave presentation of one complete cycle. Phase jitter will cause a smearing of the zero crossings on the horizontal axis.

(c) Measure the length of smearing and the length of the sine wave. The ratio multiplied by 360 (as shown in the example below) will provide an approximation of peak-to-peak phase jitter. For small amounts of jitter, expand the scale so that only a fraction of the total wave is displayed.

$$\textit{Example:}\ \frac{\text{Total cycle length}}{\text{Smearing length}} \times 360 \text{ degrees}$$

9.09 ***Harmonic Distortion:*** A test of harmonic distortion can be accomplished by transmitting a 700-Hz signal at –10 dBm-0 from the far end and measuring the second harmonic (1400 Hz) at the receiving end with a frequency selective meter. The measured reading should never exceed –40 dBm-0.

9.10 All transmission facilities serving Data Sets 202D-type should meet the requirements established in Issue 3 of Private Line Data Circuits, Voice Bandwidth Circuits For Miscellaneous Data, Over-All Tests and Requirements (Section 314-410-500) and Issue 4 of Voice Bandwidth Circuits For Private Line Data Use, 2000 And 3000 Series Channels, General Information (Section AB27.350).

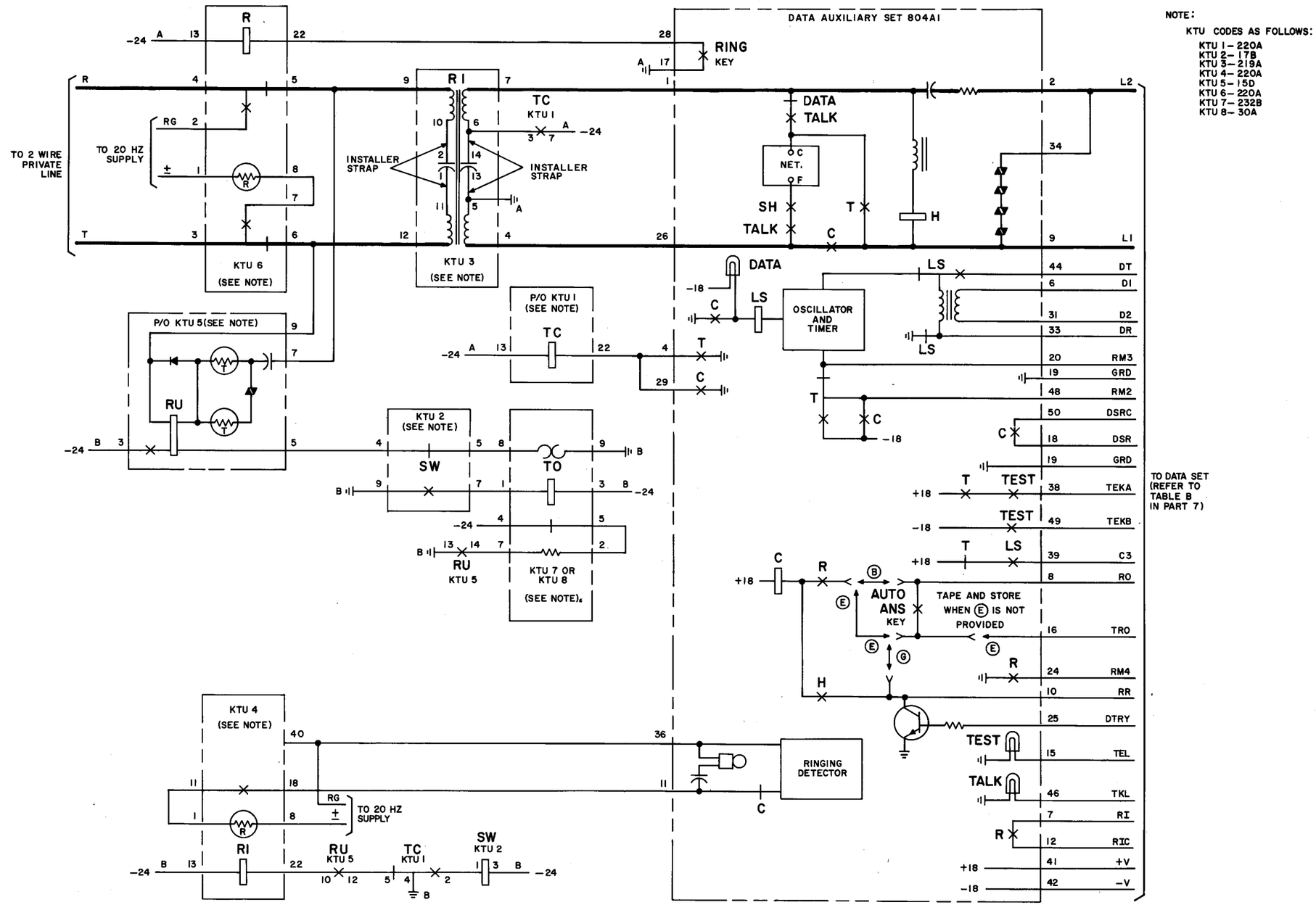


Fig. 4—The 2-Wire Private Line

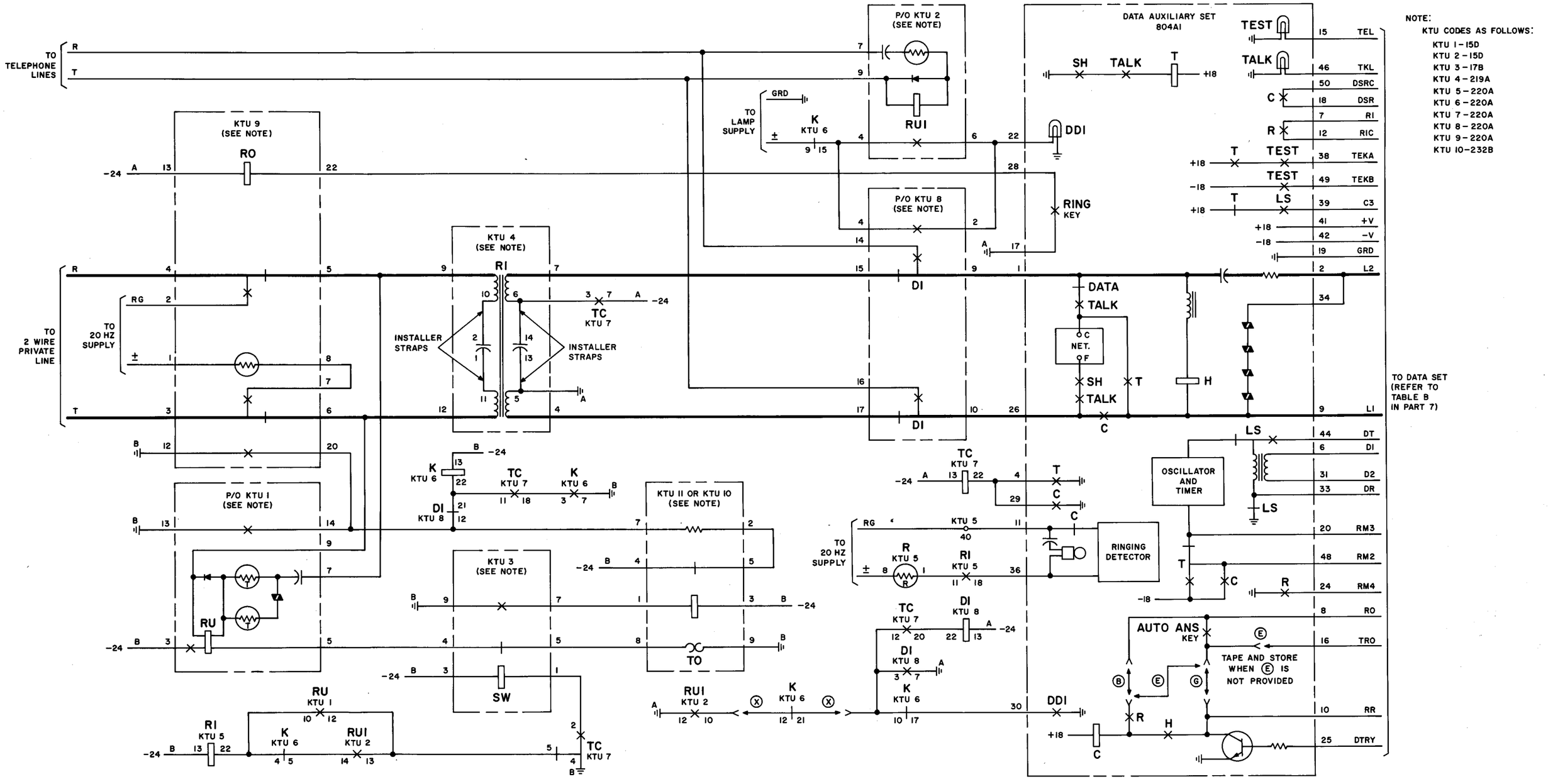
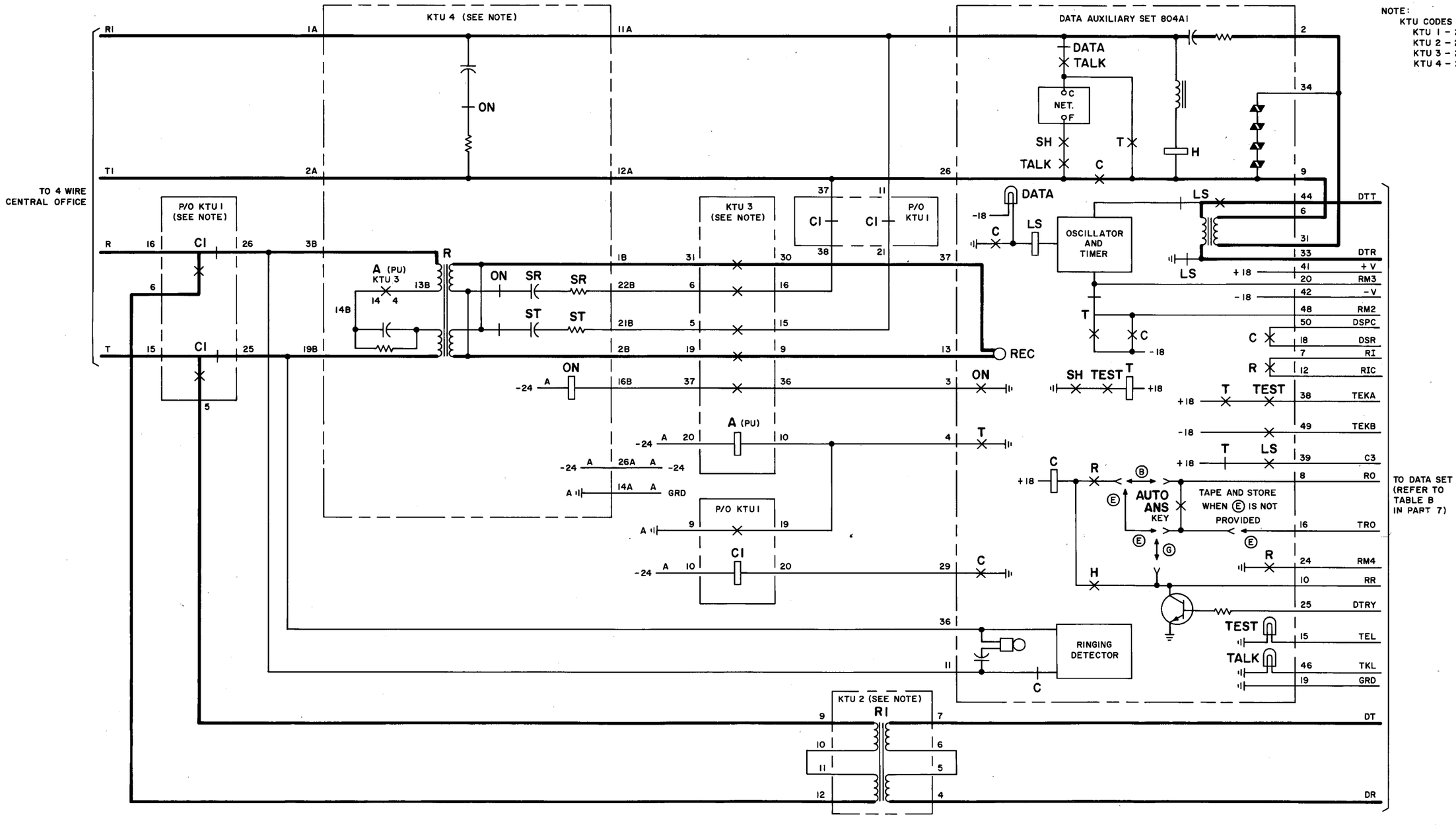


Fig. 5—The 2-Wire Private Line With a DDD Backup Line



NOTE:
KTU CODES AS FOLLOWS :
KTU 1 – 229B
KTU 2 – 219A
KTU 3 – 229B
KTU 4 – 243A

Fig. 6—The 4-Wire Common Battery

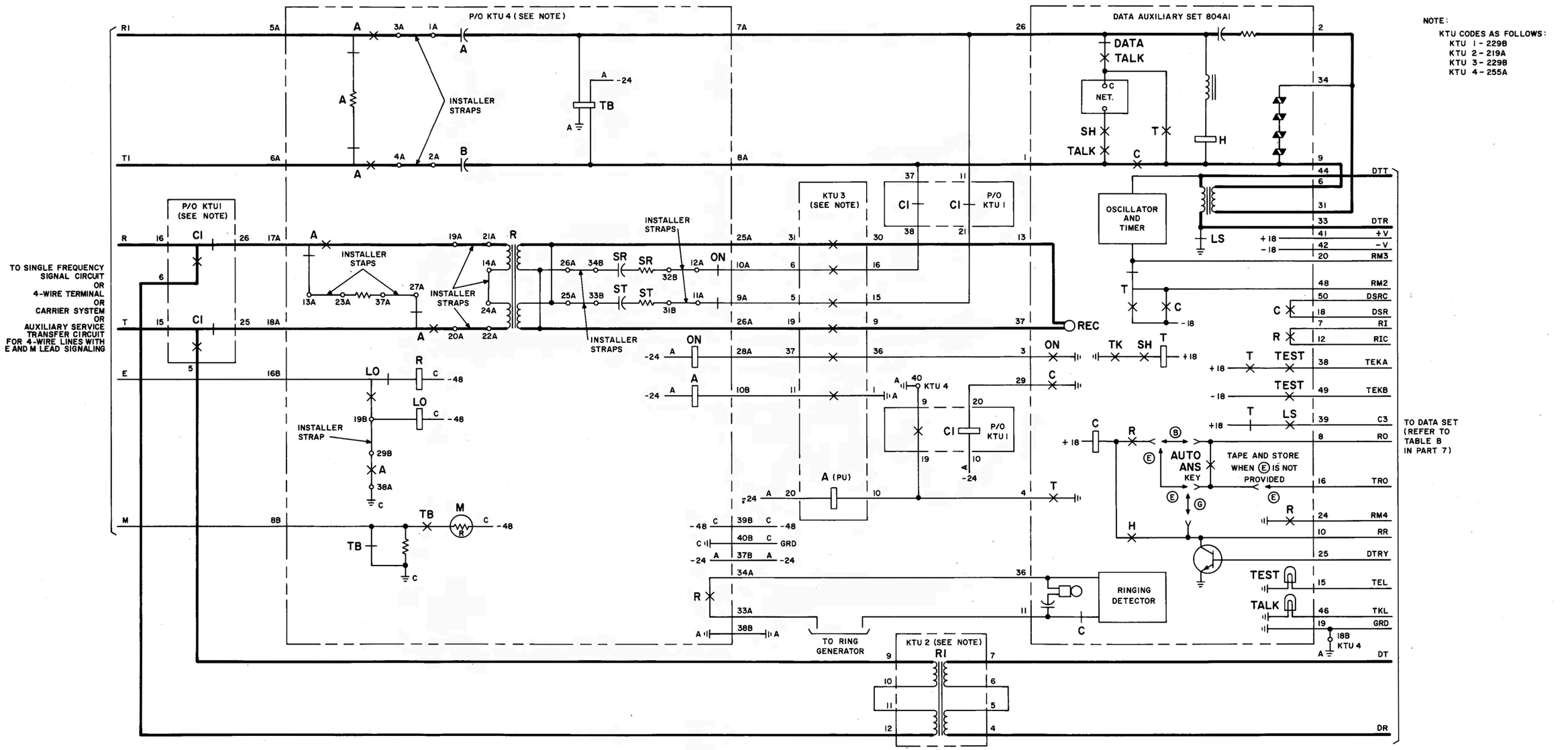
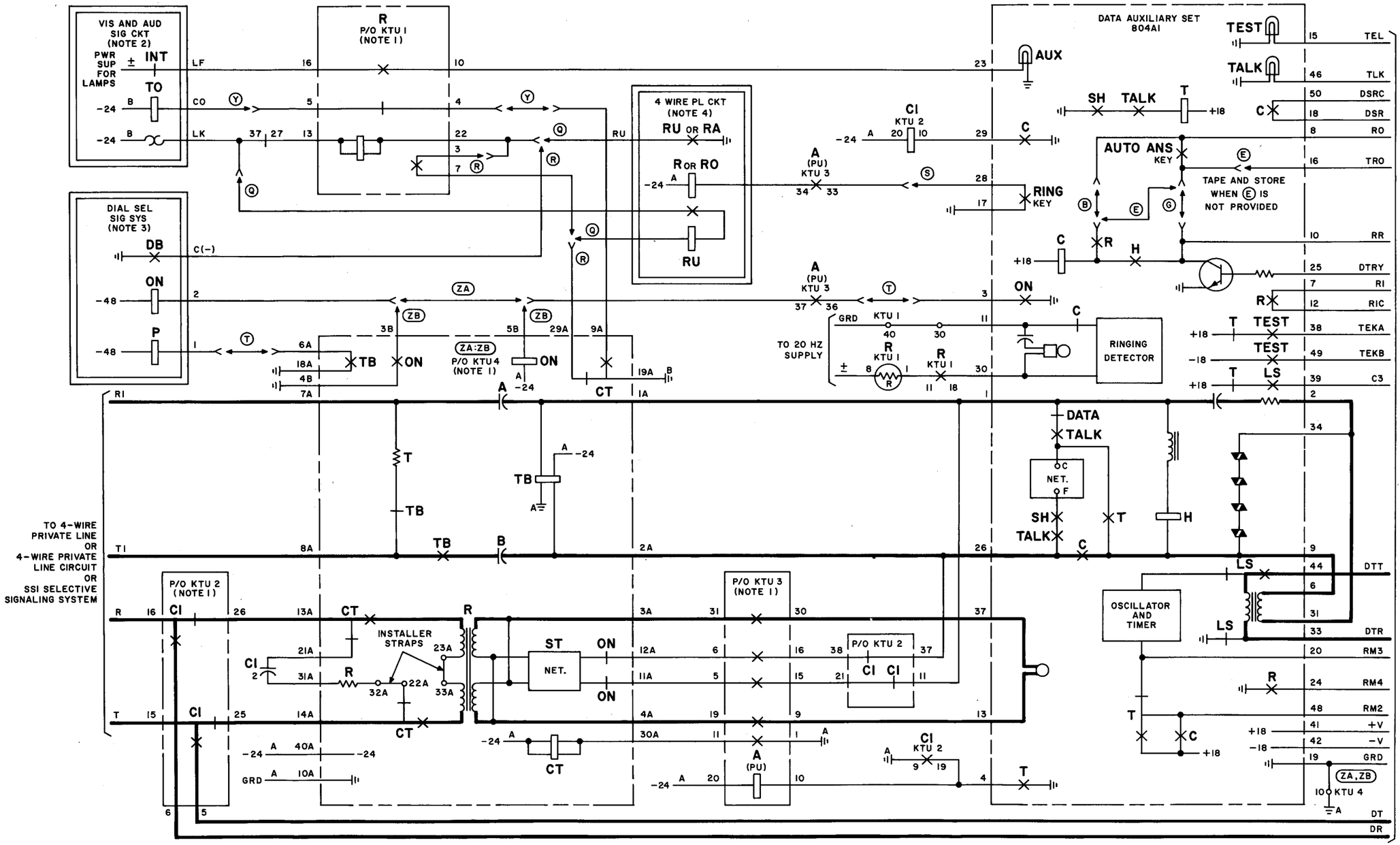


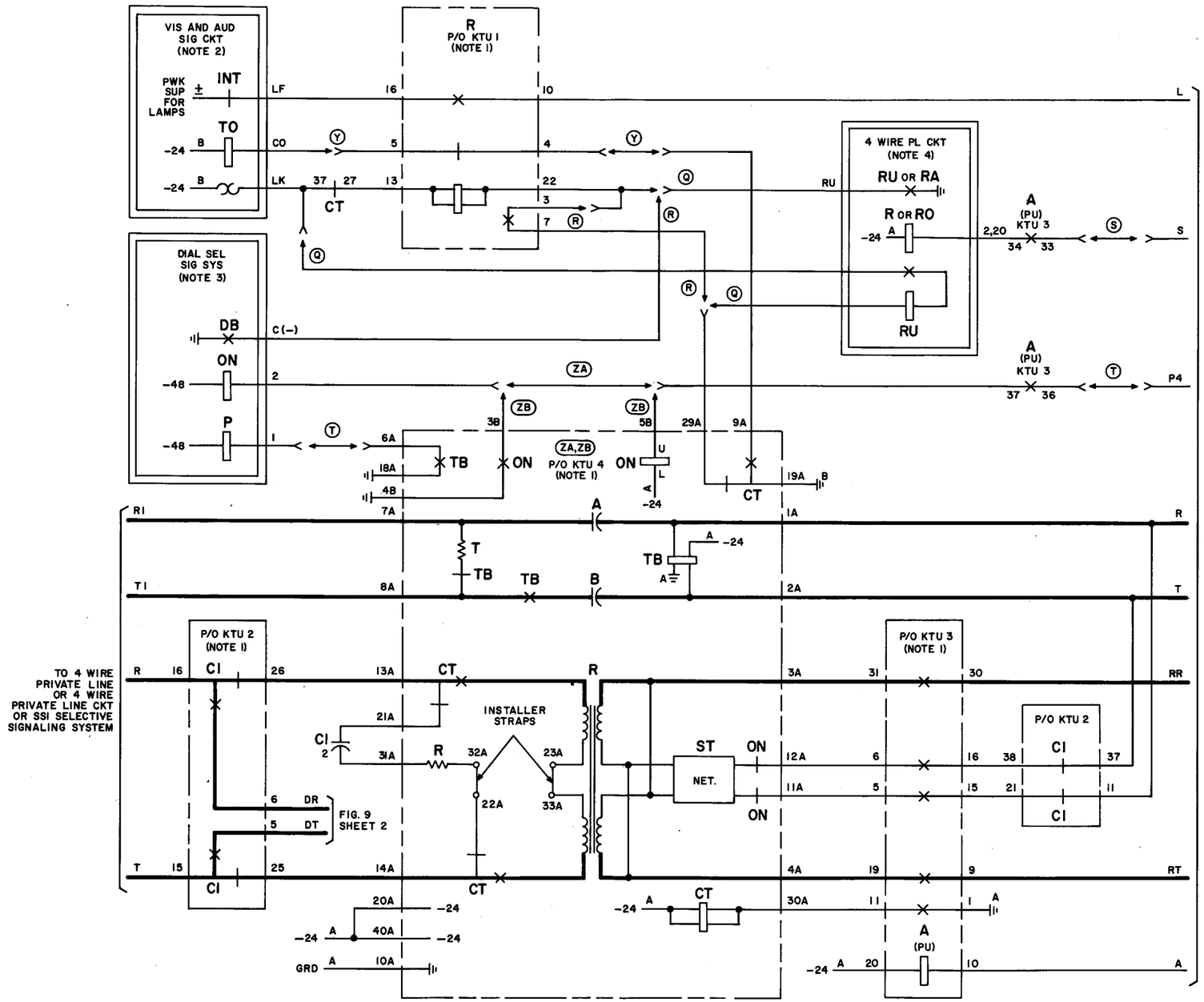
Fig. 7—The 4-Wire E and M Signaling Central Office Circuit



NOTES:

1. KTU CODES AS FOLLOWS:
   KTU 1 - 220A
   KTU 2 - 229B
   KTU 3 - 229B
   KTU 4 - 248A (OPTION ZA)
   248B (OPTION ZB)
2. REFER TO SD-69294-01.
3. REFER TO SD-98093-01.
4. REFER TO SD-69449-01.

Fig. 8—The 4-Wire Private Line



NOTES

1. KTU CODES AS FOLLOWS:
   KTU 1 – 220A
   KTU 2 – 229B
   KTU 3 – 229B
   KTU 4 – 248A (OPTION ZA)
   248B (OPTION ZB)
   KTU 7 – 229B
   KTU 8 – 220A
   KTU 9 – 229B
   KTU 10 – 251A
2. REFER TO SD-69294-01
3. REFER TO SD-98093-01
4. REFER TO SD-69449-01

FIG. 9 SHEET 2

Fig. 9—The 4-Wire Private Line With Alternate Switched Network 2-Wire Line (Sheet 1 of 2)

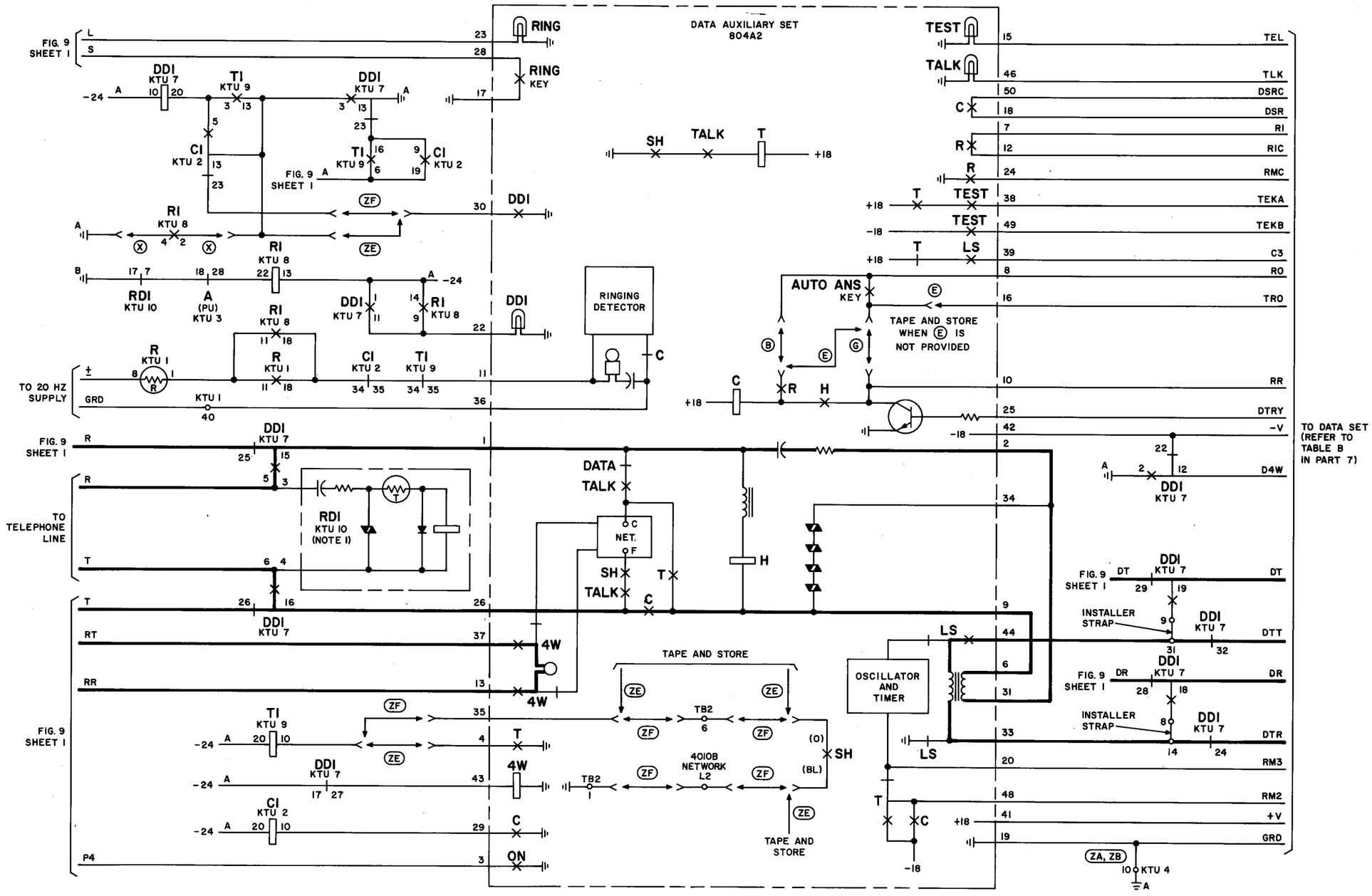


Fig. 9—The 4-Wire Private Line With Alternate Switched Network 2-Wire Line (Sheet 2 of 2)

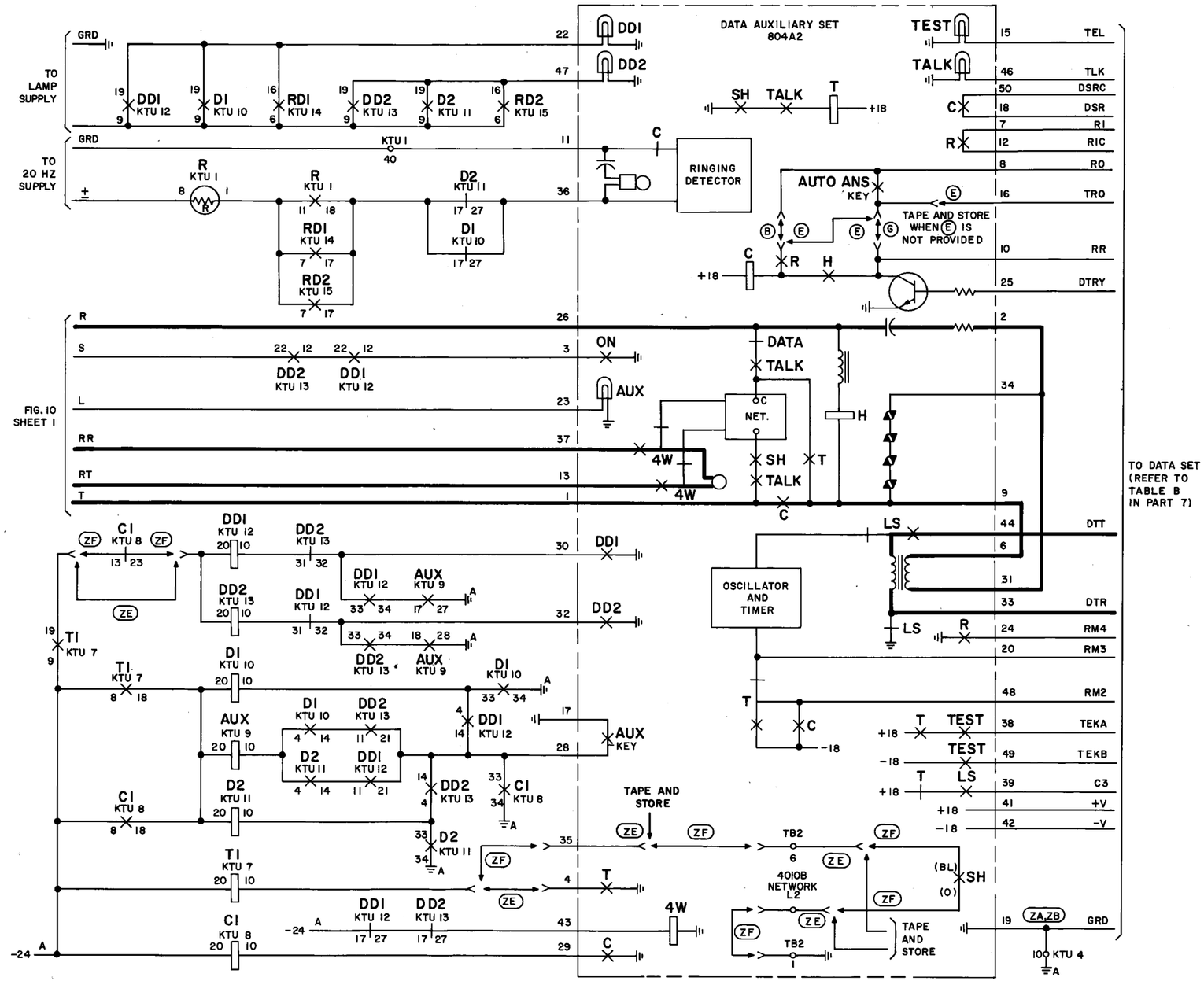
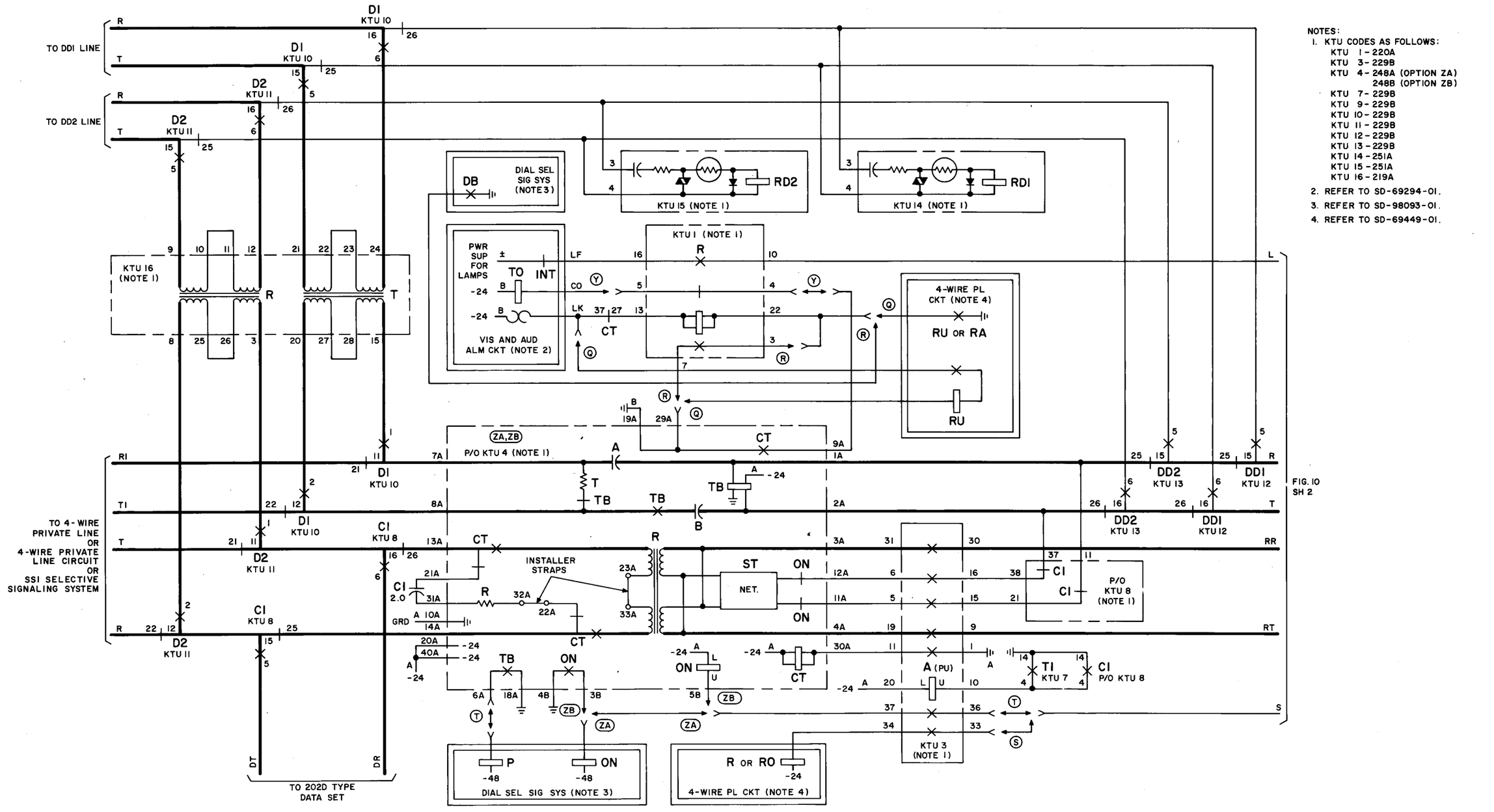


Fig. 10—The 4-Wire Private Line With Two Alternate Switched Network 2-Wire Lines (Sheet 1 of 2)



NOTES:
1. KTU CODES AS FOLLOWS:
   KTU 1 - 220A
   KTU 3 - 229B
   KTU 4 - 248A (OPTION ZA)
   248B (OPTION ZB)
   KTU 7 - 229B
   KTU 9 - 229B
   KTU 10 - 229B
   KTU 11 - 229B
   KTU 12 - 229B
   KTU 13 - 229B
   KTU 14 - 251A
   KTU 15 - 251A
   KTU 16 - 219A
2. REFER TO SD-69294-01.
3. REFER TO SD-98093-01.
4. REFER TO SD-69449-01.

Fig. 10—The 4-Wire Private Line With Two Alternate Switched Network 2-Wire Lines (Sheet 2 of 2)

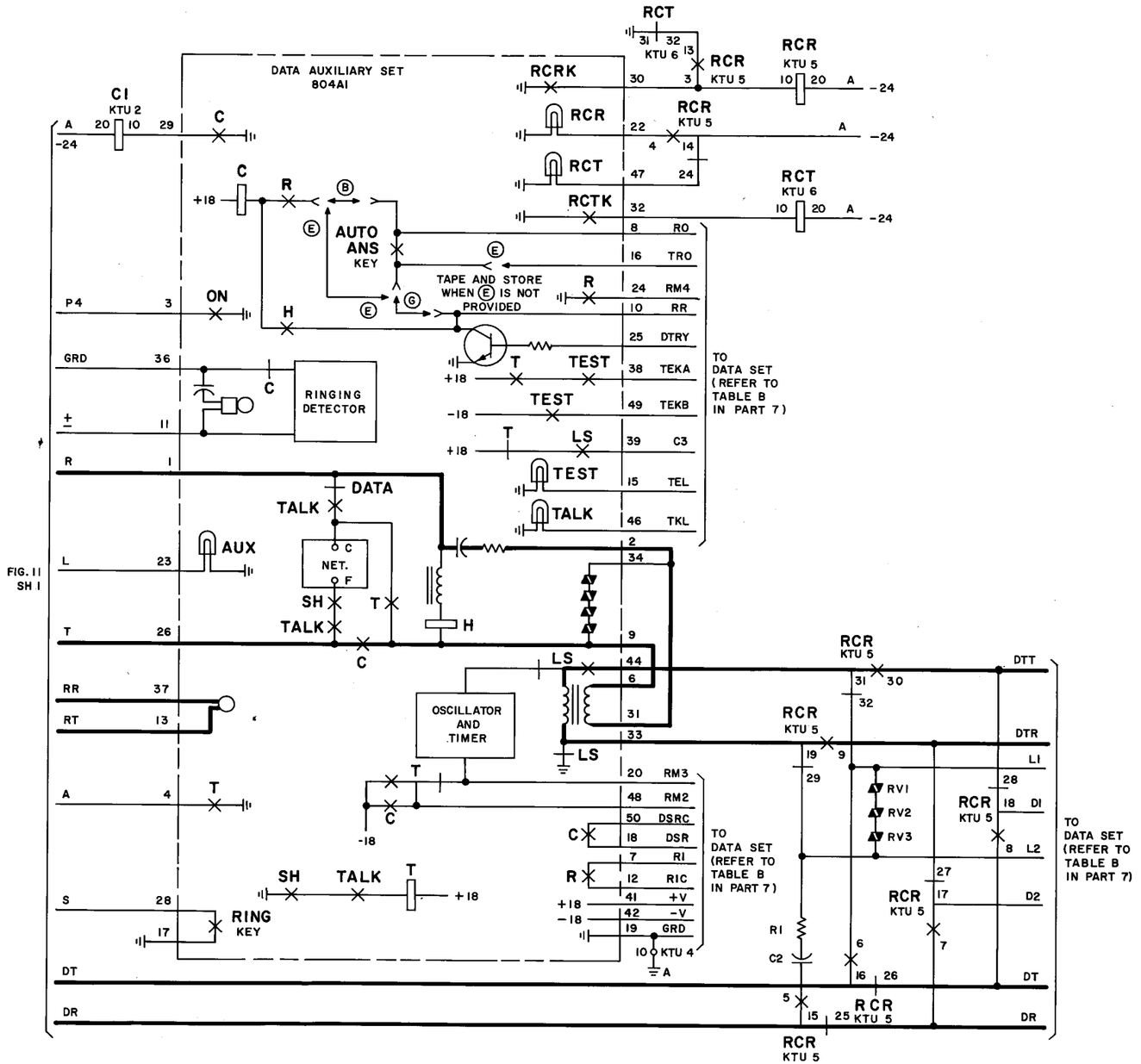
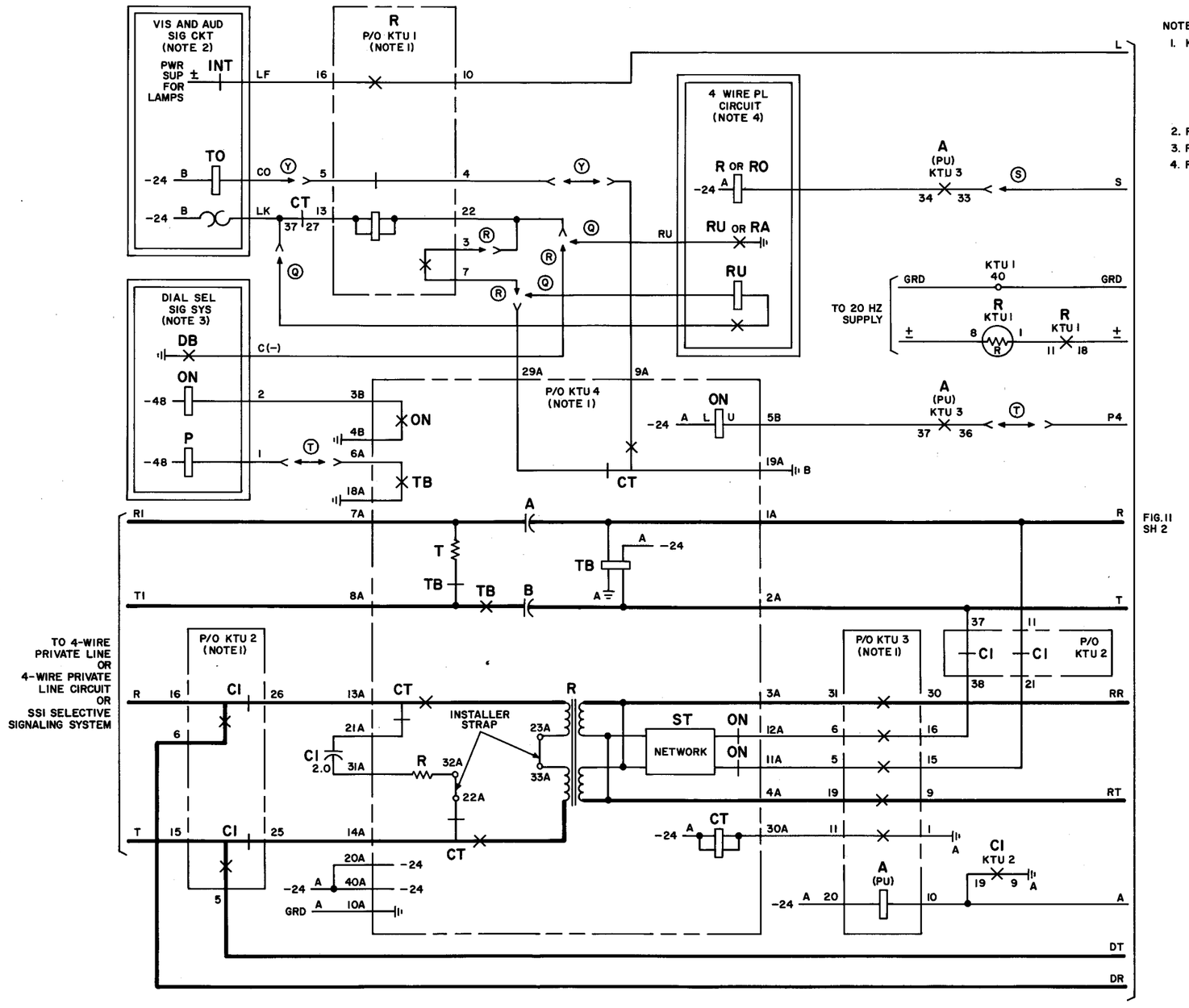


FIG. 11
SH 1

Fig. 11—The 4-Wire Private Line Reverse Channel (Sheet 1 of 2)



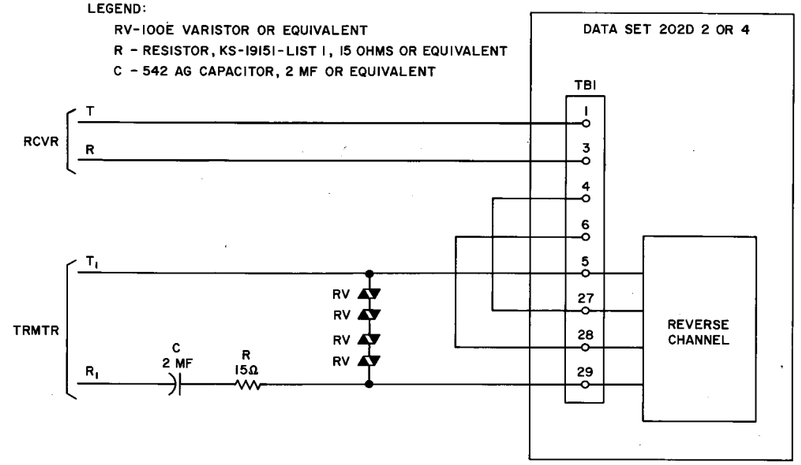
NOTES:

1. KTU CODES AS FOLLOWS:
   KTU 1-220A
   KTU 2-229B
   KTU 3-229B
   KTU 4-248B
   KTU 5-229B
   KTU 6-229B
2. REFER TO SD-69294-01
3. REFER TO SD-98093-01
4. REFER TO SD-69449-01

FIG. 11 SH 2

Fig. 11—The 4-Wire Private Line Reverse Channel (Sheet 2 of 2)

REVERSE CHANNEL TRANSMIT ONLY-NO VOICE-POINT TO POINT



REVERSE CHANNEL RECEIVE ONLY-NO VOICE-POINT TO POINT

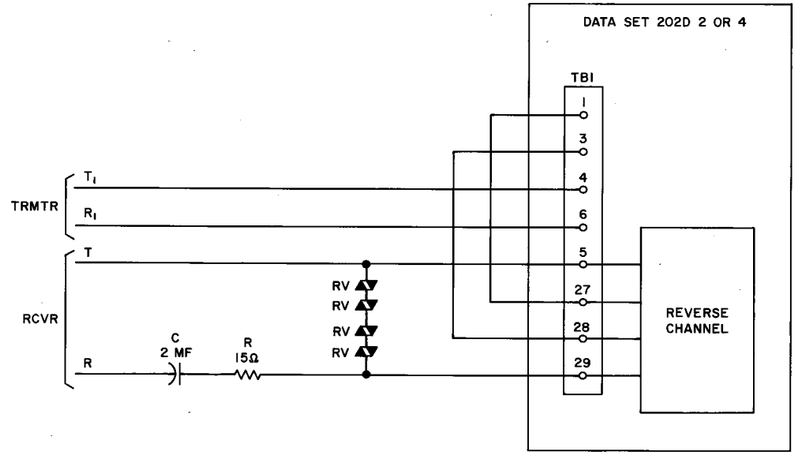


Fig. 12—Reverse Channel Transmit Only—No Voice—Point-to-Point

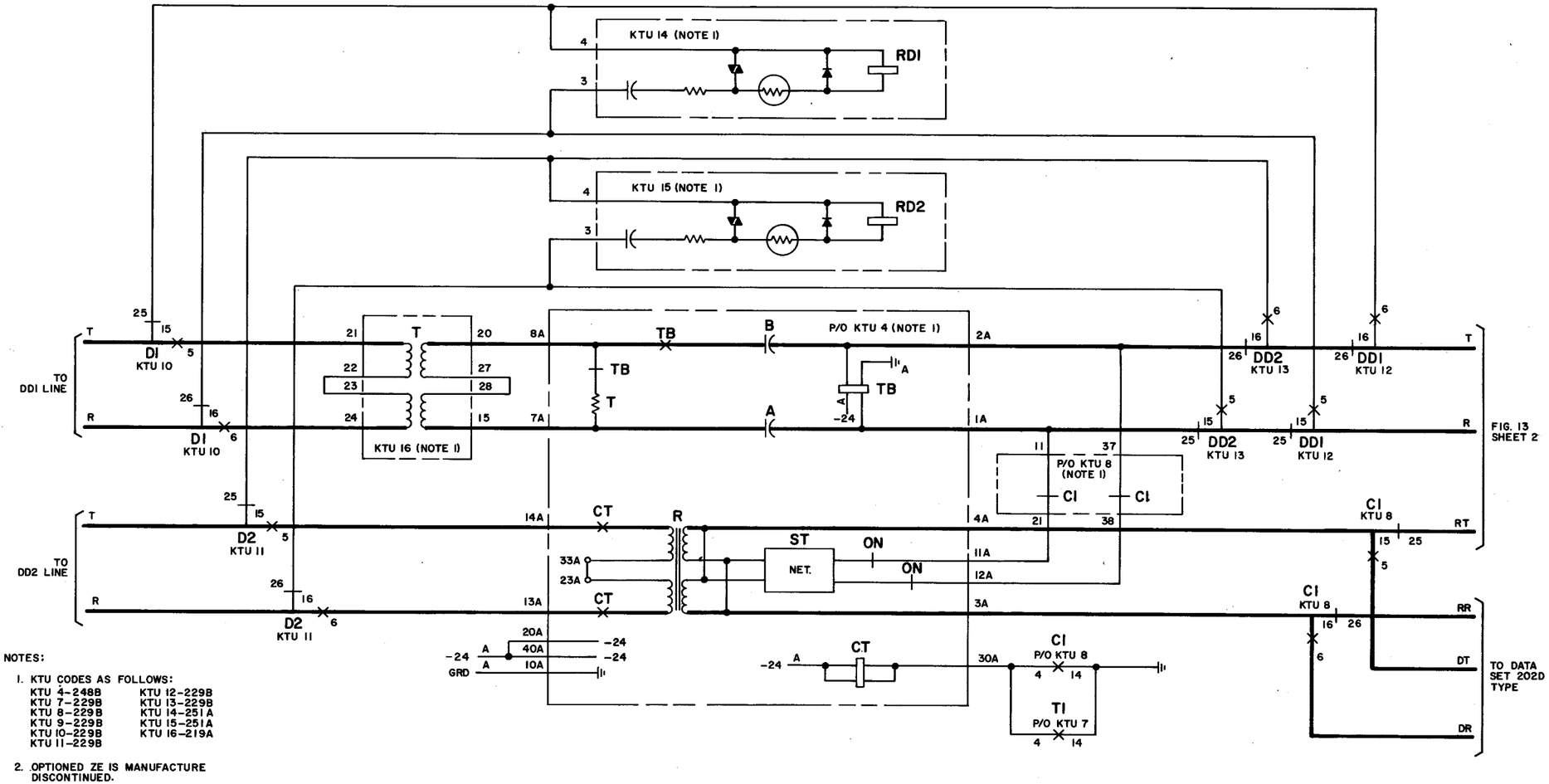


FIG. 13 SHEET 2

NOTES:

1. KTU CODES AS FOLLOWS:

KTU 4-248B	KTU 12-229B
KTU 7-229B	KTU 13-229B
KTU 8-229B	KTU 14-251A
KTU 9-229B	KTU 15-251A
KTU 10-229B	KTU 16-219A
KTU 11-229B	

2. OPTIONED ZE IS MANUFACTURE DISCONTINUED.

Fig. 13—The 2-Wire Switched Networks (Sheet 1 of 2)

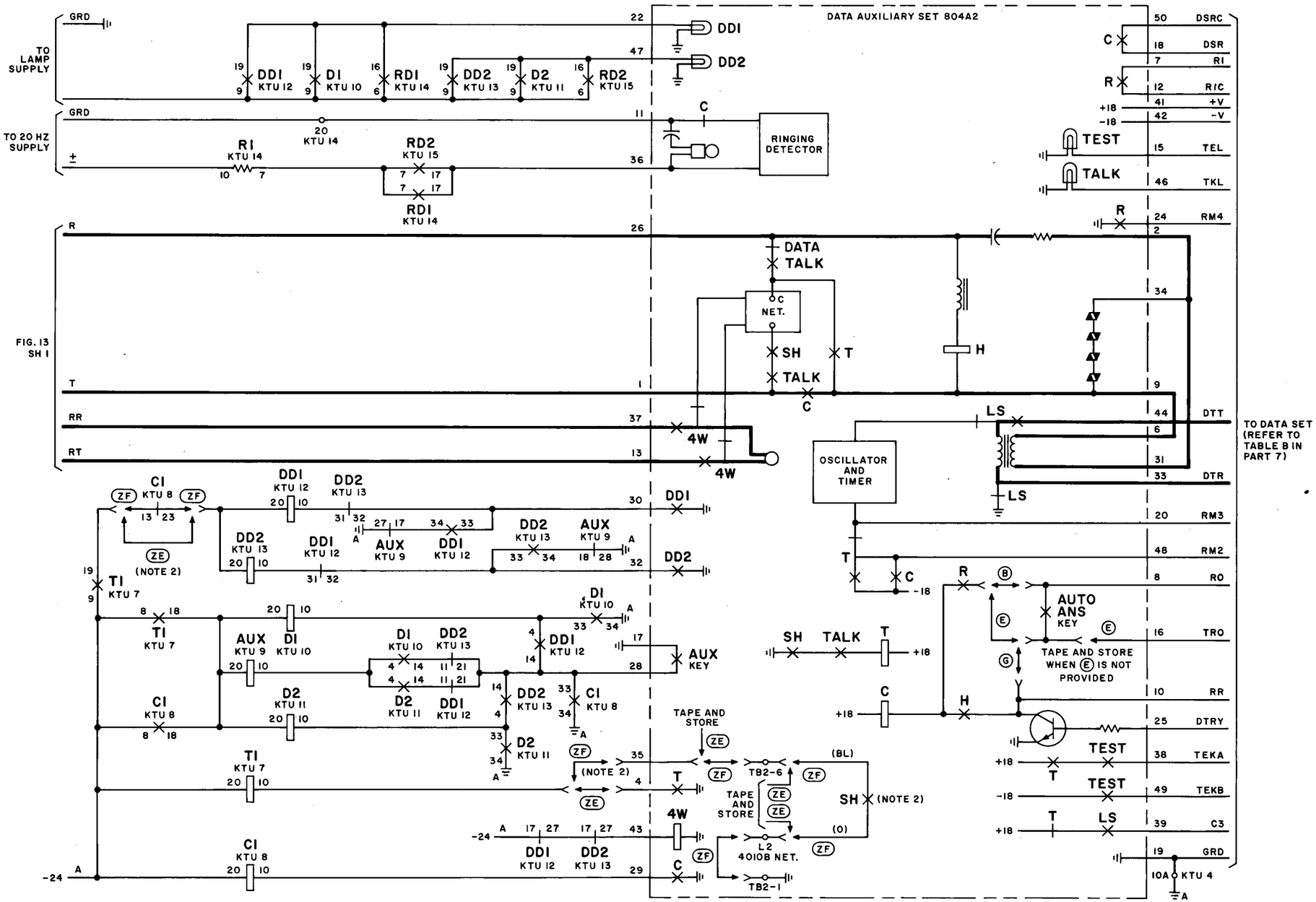
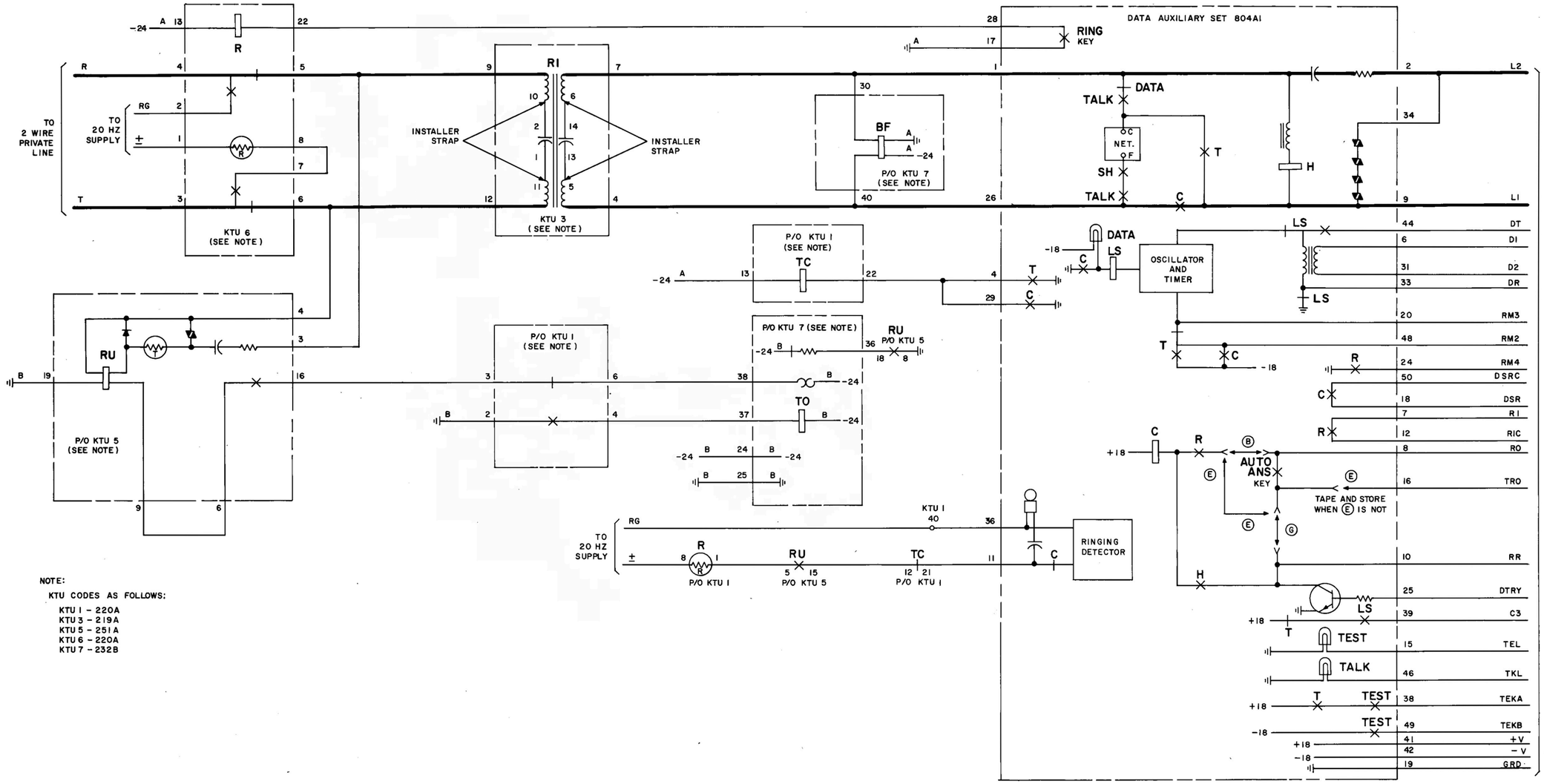


Fig. 13—The 2-Wire Switched Networks (Sheet 2 of 2)



NOTE:

KTU CODES AS FOLLOWS:

KTU 1 – 220A
KTU 3 – 219A
KTU 5 – 251A
KTU 6 – 220A
KTU 7 – 232B

Fig. 14—The 2-Wire Private Line (Using Only 200-Type Key)

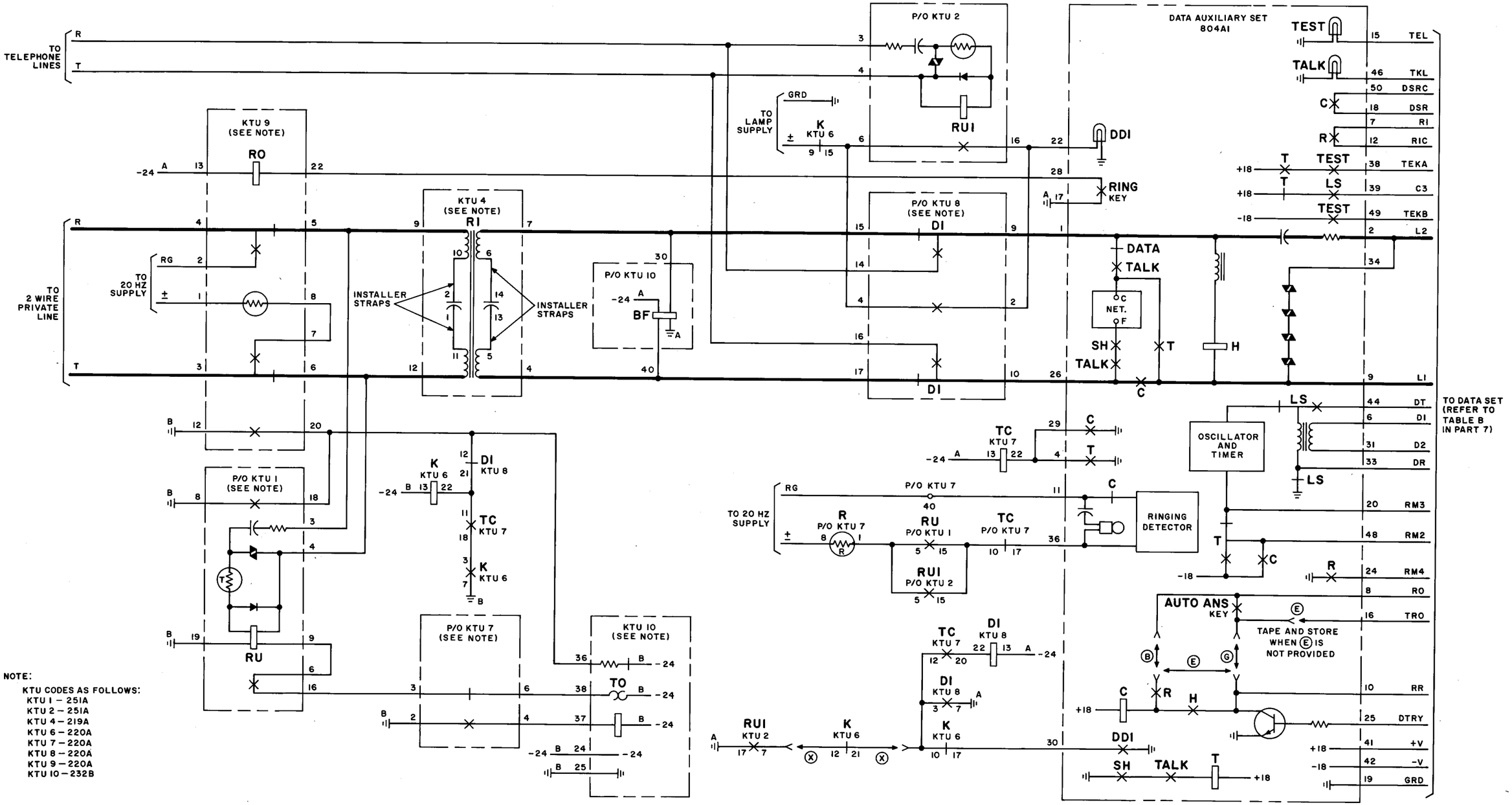


Fig. 15—The 2-Wire Private Line With a DDD Backup Line (Using Only 200-Type Key Telephone Units)