

**TL MICROWAVE RADIO**  
**DESCRIPTION**  
**ORDER WIRE AND ALARM**

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key in this instance allows selection of any of three directions. In addition, a 3-way, 4-wire bridging circuit is provided at junction points for intercommunication between points on the three legs of the wye.

**1.05** The order wire is terminated in a 4-wire appearance at the alarm receiving office. This appearance is included in the same equipment assembly as the alarm receiving circuits.

**1.06** At any point where there is a local appearance of the order wire, provision is made for access to the circuit on a 4-wire basis to permit the order wire to be extended to other points or interconnected with other order wire circuits. Such interconnection or extension may be made on a 2-wire basis; however, 4-wire terminating sets are not included as part of the TL order wire circuit.

**1.07** Signaling on the order wire is restricted to calling the alarm receiving office from a radio station. This is accomplished by generating an alarm. The normal routine is for the office receiving the alarm to challenge on the order wire whenever an alarm is received. No signaling is provided from the alarm receiving office to radio stations, between radio stations, and to or from order-wire extensions.

**1.08** The principal parts of the alarm system are:

- (a) A voice-frequency oscillator tunable by means of keys to 2600 cps or to frequencies in the series 700, 850, 1000 through 2200 cps.
- (b) A 2600-cps detector, delay circuit, and alarm register relays.
- (c) Individual station tone filters and local alarm coding relays.
- (d) An alarm encoder circuit used in conjunction with tower obstruction lighting.

**1.09** The alarm features include an alerting signal, which registers in the receiving office, together with a manual means of interrogating each remote station to localize trouble and to distinguish among types of trouble. Ordinarily, only transmission failure and low battery voltage alarms are provided. An applique circuit

adds three additional functions for tower lighting. Remote control is not provided. Up to 11 stations may report alarms to a given receiving point, the capacity of the system being limited by the number of interrogation tones that the order wire can accommodate.

**1.10** The alarm alert feature is based on continuous transmission and reception of 2600-cps tone over all radio paths. This tone originates at the alarm receiving office, traverses the entire radio route, and is returned to the receiving office. Rectified tone in the receiving circuit supplies operating current to an output relay that controls the alarm indication. Interruption of the tone at any point in the loop sets an alarm at the receiving office. The alarm indication provided by the receiving circuit output relay is connected to a thermal relay delay circuit which provides about 35 seconds delay so that only a persistent interruption of tone will register. The delay circuit activates audible and visual office alarm circuits.

**1.11** It is evident that transmission failure will interrupt the tone. For other alarms, the transmission path is opened by operation of a relay in the radio station alarm circuit for a period of about 80 seconds, then is restored. The duration of interruption is sufficient to overcome the delay in the alarm receiving circuit and the tone path is restored again to enable subsequent alerts to be generated.

**1.12** The office alarm directs the attention of an attendant to the order wire and alarm receiving circuit. A key is provided in this circuit to silence the audible alarm. The attendant challenges on the order wire in case the alarm is the result of a call on the order wire. If no response is received, interrogation proceeds as follows. The attendant operates the tone key corresponding to each remote station in turn and listens on the order wire for a response. Each station is equipped with a filter tuned to a different one of the station tones. These filters are bridged across the two sides of the 4-wire line through contacts on a coding relay. If no trouble exists, the tone is returned to the receiving office and is detected aurally by the attendant. If trouble exists, no tone or modulated tone is received. The tone is modulated by the coding relay in accordance with the type of trouble.

**1.13** A transmission alarm and low battery voltage alarm are provided at all radio stations. Additionally, where air navigation obstruction lighting is required on towers, three codes are provided for the associated alarms by an auxiliary encoder circuit, which is physically part of the tower lighting control cabinet. The following is a tabulation of all of the alarms and corresponding coding of the interrogation tone:

ALARM	CODE
Beacon or top light failure (both lamps) or ac power failure (3 short)	10101000
Flasher failure (2 short)	10100000
Low battery voltage, ac failure, or lightning arrester failure (pulse train)	10101010
Transmission failure (no tone)	00000000
Side light(s) or single beacon or top light failure (1 short, 1 long)	10111100

**Note:** In the tabulation above, a mark interval, during which tone is reverted through the station interrogation path, is denoted by a 1 and a space by a 0. One cycle is shown representing eight equal time intervals. The code is applied repetitively as long as the alarm status remains unchanged.

**1.14** The 2600-cps tone is normally present on the line except for periods of interrogation. To prevent interference to the order wire, 2600-cps elimination filters are included in all monitoring circuits of the order wire. The tone is also blocked at points of connection to order-wire extensions. The interrogation tones are audible on the order wire, but are normally applied for only short periods of time.

## 2. DESCRIPTION OF CIRCUITS

### A. Alarm Receiving Office Circuit

**2.01** A block diagram of the alarm and order wire circuit for the alarm receiving office is shown in Fig. 1. Shown in Fig. 2 are the transmission circuits and alarm register circuit. Speech currents enter the system from either the local talking circuit or an extension tele-

phone circuit and combine in three arm pads R4, R5, and R6. The N1 transmitter of the 53A headset connects to the circuit via the tips of the TEL jack J1 and J2. The talking battery is series fed through resistor R21, which limits the current to about 100 ma. Capacitor C1 bypasses the ac component around R21. Transformer T1 isolates the dc talking battery and transforms the low impedance of the transmitter circuit to 600 ohms for maximum power transfer. Varistors RV6, RV7, and RV8 comprise a limiter circuit. The pad R1, R2, and R3 matches the transmission level of the circuits connected to the respective input arms of R4, R5, and R6. Network Z1 is resonant at 2600 cps so as to suppress speech components around this frequency. Speech currents pass through this network, jacks J3, the TRANS AMPL, pad R9, R10, and R11, jacks J4, and transformer T4 to the outgoing line. The TRANS AMPL has a gain adjustable from 0 to 35 db. Combining pad R9, R10, and R11 connects the oscillator output to the line. Transformer T4 transforms the unbalanced impedance of the circuit to present a balanced impedance to the line.

**2.02** Received speech or tones from the line pass through jack J6 to either the input of the REC AMPL when gain is required, or the primary of transformer T5 when gain is not required. Both the amplifier and transformer present a balanced termination to the line. Signals pass through J5 and are split into two paths by pad R23, R24, and R25. One path leads to the input of the 2600-cps detector circuit, the other to low-pass filter FL1. Speech currents pass through this filter, but 2600-cps tone is blocked from the monitoring circuit or order-wire extension. At the filter output, the path is split by pad R17, R19, and R20; one branch feeding the extension, the other feeding the local telephone receiver. Pad R18 and R22 provides the correct monitoring level and is arranged to reflect a 600-ohm impedance to the splitting pad. R16, a jack termination, maintains constant loss through the splitting pad to the receiving leg of the extension whether or not the telephone set is connected. The HC4 receiver of the 53A headset connects to the circuit via the rings of J1 and J2. Varistor RV9 is a click suppressor. Transformers T2 and T3 present a balanced impedance to the extension, if provided.

**2.03** The oscillator circuit, shown in Fig. 3A, generates 2600-cps tone and the interrogation tones. One section of a miniature twin triode tube V1 is used as a resistance-capacitance (RC) oscillator. The 40 volts for the heater is obtained from dropping resistors R34 and R33, the latter being adjustable.

**2.04** Oscillator frequency is determined by resistors R47 through R70. Normally, a 2600-cps tone is generated by the oscillator with resistors R69 and R70 in the oscillator circuit, but any one of 11 interrogation tones may be generated by depressing one of the keys S3 to S13. The capacitance portion of the circuit is provided by capacitors C6 and C7 with C9 through C20 acting as trimming capacitors for individual frequencies. Option V is provided for short radio systems needing six or less interrogation tones. Resistors R37 and R41 prevent oscillation in the television (TV) range. Positive voltage feedback is supplied to the oscillator grid through R35 and C6 to sustain oscillation. Resistor R35 is used to meet the requirements of the oscillator for low frequency. Negative feedback is supplied to the oscillator cathode through thermistor RT1 and the oscillator level rheostat R38. The control of the negative feedback by thermistor RT1 stabilizes the oscillator output against power supply voltage variations. The level rheostat provides sufficient adjustment of oscillator power to take care of circuit element variations. It is not advisable to set the oscillator level potentiometer to its maximum position because of distortion and degradation of output stability. Blocking capacitor C5 is bypassed by resistor R36 to provide a dc voltage across thermistor RT1 sufficient to start oscillation. The output of the oscillator section of V1 is fed to the triode amplifier section through coupling capacitor C8. The output of the amplifier section V1 is coupled by means of the output transformer T6 to the output attenuator. The 24-db range of the attenuator permits setting the oscillator injection level to the order-wire line.

**2.05** The 2600-cps amplifier detector circuit is shown in Fig. 3B. This circuit detects the presence or absence of the 2600-cps alarm alert tone. The input filter FL2 has an unbalanced configuration and matches the high-impedance grid circuit to the splitting pad R23, R24, and

R25 in Fig. 2. Resistors R73 and R74 connected in parallel terminate the output of the filter. The DET SENS potentiometer adjusts the voltage applied to the grid of the tube V2. The output of V2 is stabilized by negative feedback provided by the cathode resistor R75. The output voltage of tube V2 is stepped down by the output transformer T8 and applied to diode bridge rectifier CR1. The rectifier CR1 and filter capacitor C24 supply dc operating current to relay K5. Relay K5 is a polar with biasing voltage applied to it from +130 volt battery through resistor R77. The RC jack provides access to measure relay operate and release currents. Screen voltage is supplied from the +130 volt supply through resistor R76, and capacitor C23 is the associated ac bypass to ground. The use of the polar relay provides a high ratio of release currents to operate currents for maximum margin against being held operated by any interference when the 2600-cps tone is removed. The pilot lamp DS2 is lighted when tone is present. Tube V2 heater requires 20 volts, which is provided from the 48-volt supply by dropping resistor R78 and FIL ADJ rheostat R79.

**2.06** The output relay K5 of the detector circuit connects to the alarm register circuit via lead F. When tone is removed at the input of the detector, relay K5 releases, extinguishing lamp PILOT and connecting ground on lead F to lead D. This ground originates on lead F, Fig. 3B, and is passed to lead D through a series of break contacts on the interrogation keys S3 to S14, shown in Fig. 3A, to prevent alarm registration when 2600-cps tone is removed for the purpose of interrogation. Referring to Fig. 2, ground on lead D energizes thermal relay K3, which operates after about 10 seconds. Relay K3 then extends the ground on lead D to relay K4 which operates and locks up through its own make contact. Relay K4 operated de-energizes the thermal relay, which starts to cool. After about 25 seconds, the thermal relay cools sufficiently for its contact to close. At this time, the combination of K3 released and K4 operated applies ground to the winding of relay K2, which operates and locks up to the ACO key released. Relay K2 operated lights lamp ALM and grounds the office alarm leads 3 and 4. Subsequent operation of the ACO key operates relay K1, which locks

up to relay K4 operated and K3 released, assuming that the tone detector is still released. This causes K2 to release, but the ALM lamp remains lighted since it now is connected to battery via contacts on relay K1. When tone is later restored at the detector input, the pilot lamp is lighted, relay K5 reoperates, causing relays K4 and K1 to release in turn, extinguishing the ALM lamp. The circuit is then ready to register a subsequent alarm alert.

**2.07** Fuse alarms for the +130 and -48 volt supplies are provided as shown in Fig. 3C.

**2.08** A nonlocking key, OSC CHK, when operated disconnects the oscillator output from the outgoing line and connects it through pad R12, R13, and R14 to the local monitoring circuit. This provides a local test of the oscillator. A break contact on the OSC TST key is in series with the F lead to the alarm register circuit so that an alarm will not be generated when the key is operated.

#### **B. Order Wire and Alarm Circuits for Radio Stations**

##### **General**

**2.09** Circuits are provided to take care of different route layout requirements as follows:

- (a) Near-end terminal station
- (b) Intermediate repeater station
- (c) Far-end terminal station
- (d) Junction station with radio spur
- (e) Intermediate repeater with order-wire spur

##### **Near-end Terminal Station**

**2.10** This circuit is part of the radio terminal at the end of the route nearest the control terminal. A block diagram is shown in Fig. 1 and the circuit in Fig. 4.

**2.11** At a near-end radio terminal, the order wire and alarm circuit connects to the radio system on one side and the line to the alarm receiving office on the other. The latter may be any length, ranging from short office cable to a long voice-frequency facility, de-

pending on the physical separation between the near-end terminal and the alarm receiving point. One extreme is represented by the radio terminal and alarm receiving point located in the same office. For flexibility as to levels, the near-end terminal order wire circuit provides a plug-in pad in the receiving side and an amplifier in the transmitting side to terminate the line. The balanced line is matched to the unbalanced order wire circuit by transformer T13 and the A AMPL. Outgoing speech currents or alarm tones pass through transformer T13, the A pad, and 11.5-db fixed pad R97, R96, and R98, and enter the low-pass branch of a combining filter, one half of FL3. The multiplex signal is injected into the high-pass branch of FL3, is combined with the order-wire signal, and appears at the input to the splitting pad R92, R93, and R94. This pad provides a dual feed to a pair of transmitters of a diversity system. If diversity is not employed, one of the two output arms is terminated in a resistor. From the splitting pad, the signal enters the input to the transmitter baseband amplifier.

**2.12** The transmission path through the order wire circuit in the opposite direction is as follows. The signal from the receiving baseband output enters the common leg of the associated half of FL3, passes through contacts on relays D and A, through the 11.5-db fixed pad R99, R100, and R101, then through contacts on the SIG key to the input of the A AMPL. The output of the A AMPL feeds the line to the alarm receiving office.

**2.13** The path of the interrogation tone is through filter FL5, which bridges the outgoing line and the incoming line through contacts on relays A, C, and P. The filter passes only the tone assigned to the near-end terminal.

**2.14** The 4-wire telephone set circuit terminates in the TEL jacks J11 and J12. The N1 transmitter of the 53A headset connects to the circuit via the jack tips. The talking battery is series fed through the combination of resistors R89 and R90, which limit the current to about 100 ma. Capacitor C28 bypasses the ac component around the battery supply circuit. Capacitor C27 and resistor R89 serve as filtering for the talking battery. Transformer T11 transforms the low impedance of the order wire cir-

cuit to a higher impedance so that, in series with network Z4 and resistor R87, the talking circuit has a low bridging loss across the through line. Network Z4 is parallel resonant at 2600 cps and, therefore, suppresses speech components about this frequency. Series varistors RV1, RV10, and RV11 across the secondary of transformer T11 act as speech limiters. Resistor R87 builds out the bridged impedance of the telephone circuit and adjusts the signal injection level to the line. The bridged connection to the line is made through the DIR key.

**2.15** The monitoring side of the telephone set circuit also bridges the line through the DIR key in such a way that it is connected to the outgoing line when the talking side is connected to the incoming line and vice versa. For communications in a direction toward the alarm receiving office, the DIR key is operated to the NEAR position. For communication in the opposite direction, the key is operated to the FAR position. The SPUR position has application only at a spur junction point. Signals from the line appear across the input to the 2600-cps rejection filter comprised of networks Z2 and Z3. This filter suppresses the alarm alert tone to a tolerable interference level at the receiver. Resistor R114 serves to build out the impedance of the telephone set circuit and to adjust the listening level. The input impedance of the B AMPL reflected back to the line by transformer T12 is high so that the bridging loss to the line of the bridged monitoring circuit is small. The signal amplified by the B AMPL appears across the rings of jacks J11 and J12, to which the HC4 receiver of the 53A headset connects. Varistor RV2 is bridged ring-to-ring to act as a click suppressor.

**2.16** The ground return of the secondary winding of transformer T11 and the primary of T12 passes through make contacts on jacks J11 and J12. This eliminates the bridging loss of the telephone set circuit when the headset plug is not inserted in the jack.

**2.17** The circuit of Fig. 4 is part of the NT, or near-terminal bay. If diversity is provided, the tip, sleeve, and ground return connections to the TEL jacks J11 and J12 are multiplied to another order-wire TEL appearance in the NTD, or near-terminal diversity bay.

**2.18** The basic mechanism of initiating alarms is: (a) interruption of the 2600-cps path, and (b) coded interruptions of the interrogation tone reverting path through filter FL5. Relays A, C, P, and D, and key SIG perform these functions. In addition, transmission failure in a nondiversity system will interrupt the tone paths, in which case the local alarm relays are not involved. Assuming a diversity system, the onset of a transmission failure will cause a continuous open of the reverting path, while other alarm conditions will cause coded interruptions of this path as described in 1.13. If the station has tower light alarms, the alarm encoder circuit, Fig. 5, is used in addition to the basic order wire and alarm circuits. The former is described under a separate heading. The operating sequence of the basic alarm circuit will be described in the following two paragraphs, assuming a station without lighted towers.

**2.19** Connections to individual alarm circuits are via leads G, M2, and D. Lead D is connected only at stations equipped with the alarm encoder circuit, Fig. 5. Ground is present on lead M2 when no alarm condition exists and is removed when the alarm occurs. No ground is present on lead G under normal conditions and is applied when the alarm occurs. Assuming that a pilot monitor has released, ground will be removed from lead M2. This causes normally operated relay A to release which, in turn, de-energizes normally operated thermal relay D. At the same time, relay A released opens the order-wire line to block 2600-cps tone to the alarm receiving office. It also opens the interrogation path. Relay D takes about 80 seconds to cool to the point where its contacts close. Since the alarm receiving office will respond to a 2600-cps interruption in excess of about 35 seconds, the alarm alert will have been registered at the receiving office before closure of the D relay contacts restores the tone path. When the interrogation tone corresponding to the station in question is transmitted from the receiving office, it will be blocked by the open interrogation path indicating that a transmission failure has occurred. Had no alarm condition existed, tone reverted through the station would have given an audible signal to the attendant at the receiving office.

**2.20** In the case of low battery voltage, ac power failure, or lightening arrester failure, the alarm sequence is as follows. Any of these events cause ground to be removed from lead M2 which causes relays A and D to operate in precisely the manner described in 2.19. As a result, an alarm alert is initiated and the reverting path is opened. In addition, however, the coding circuit consisting of transistor Q, relay P, and the associated components is energized. Contacts on relay P in parallel with those on relay A in the reverting path then open and close at the rate of about 1 pulse per second. When the interrogation tone is transmitted from the alarm receiving office, the response heard by the attendant is a pulsed tone corresponding to the particular trouble. The pulser circuit is a relaxation oscillator circuit in which relay P is operated by the collector current of transistor Q1. Bias of the transistor is controlled by transfer contact 8 of relay P in such a way that when ground is first applied to lead G, it causes the transistor to conduct and operate the relay. This connects the base of the transistor to -27.6 volts through the charging resistor R91. Capacitor C29 charges and carries the base of the transistor negative until the current through relay P is reduced below the release value. This causes the relay to release, which grounds resistor R91 and starts discharge of capacitor C29. When the capacitor has sufficiently discharged, the base of the transistor again reaches the bias potential which produces the operate value of current in relay P, whereupon the cycle begins again. Varistor RV1 assures cutoff current by guaranteeing a fraction of a volt difference between emitter and base of the transistor. Operation of the pulser circuit causes make contact 4 on relay P to make and break the interrogation path.

**2.21** When used in conjunction with the TL radio alarm encoder circuit, Fig. 5, relays A and C are controlled by the alarm encoder. Relay C is used to provide additional coding of the interrogation tone. Relay D serves no useful purpose in the circuit when the alarm encoder is used. A thermal relay in the encoder times the opening of the alarm loop by releasing relay A for 80 seconds when an alarm condition occurs. The pulser of the basic alarm circuit is prevented from operating by battery on lead E when the external encoder circuit operates.

### Intermediate Repeater Station

**2.22** The order wire and alarm circuit for intermediate repeater stations is shown in block diagram form in Fig. 1. It is comprised of two separate circuits shown, respectively, in Fig. 6 and 7.

**2.23** At an intermediate station, the order wire and alarm circuit connects between the baseband input and output of the NR, or near radio bay, and corresponding points of the FR, or far radio bay, and in this respect the circuit differs from the near-end terminal circuit. The telephone set circuit and alarm features are essentially identical to the near-end terminal circuit. A significant exception is the lead from break contact 3 on the D quadrant of the DIR key to punching 19 on TS2. This lead is associated with the SPUR position of the DIR key and is not used at an intermediate station without a spur.

**2.24** Connections to the baseband input and output in the direction toward the alarm receiving office are shown in Fig. 6. Corresponding baseband connections in the opposite direction are shown in Fig. 7. Output from the NR receiver is separated into order-wire and multiplex signals by the upper half of FL3. The lower half combines the respective signals transmitted in the opposite direction. Splitting pad R111, R112, and R113 feeds the NR transmitter, with the unused arm terminated in R95; or additionally, it feeds the NRD transmitter if provided, in which case R95 is removed. Connection to local multiplex equipment, if required, may be made on a 75-ohm basis, or on a 135-ohm basis using optional transformers T15 and T16.

**2.25** The circuit of Fig. 7 associated with the FR bay also provides a set of split-apart filters FL3, a splitting pad R92, R93, and R94, and optional 75:135-ohm transformers T17 and T18. In addition, this circuit provides 11-db pads (R127, R128, and R129; and R130, R131, and R132) and 14.5-db pads (R124, R125, and R126; and R133, R134, and R135) in the order-wire and multiplex paths between the split-apart and combining filters for the purpose of maintaining unity gain through the system. The 14.5-db pads are used only for through transmission of multiplex signals. An order-wire TEL jack appear-

ance is also provided for the FR bay as shown in Fig. 7, which multiples to the appearance in the NR bay order wire circuit.

#### Far-end Terminal Station

**2.26** The order wire and alarm circuit for far-end terminal stations is shown in Fig. 8, and in block diagram form in Fig. 1. Connections to the baseband input and output shown on the left-hand side of Fig. 8 are the same as the circuit associated with the NR bay, shown in Fig. 6. On the right-hand side of Fig. 8, filter FL4 is shown. This is a bandpass/band-elimination (BP-BE) combination, which (1) provides a tone reverting path at 2600 cps to close the alarm alerting loop, (2) provides 4-wire access to the circuit for extension of the order wire if required, (3) blocks 2600-cps tone from entering the extension, and (4) blocks speech components around 2600 cps originating at the extension from entering the order wire. Transformers T13 and T14 allow connection of a balanced line to the unbalanced order wire circuit. The plug-in A PAD allows adjustment of transmission level to a fixed value. Selection of the 89-type resistor for this pad will depend on the level received from the extension.

**2.27** The telephone set circuits and alarm features of the far-end terminal station are essentially identical to the near-end terminal station circuit.

#### Intermediate Repeater with Order-wire Spur

**2.28** An arrangement is provided for deriving an extension of the order wire at an intermediate point along the route. A typical application of this arrangement is in a situation where multiplex circuits are dropped at a way point and extended over wire to a remote terminal. An order-wire extension may then be provided from the branching point to the terminal, also via wire facilities. Access to the TL order wire is on a 4-wire basis; that is, a terminating set is not provided.

**2.29** The block schematic for an order-wire spur at an intermediate radio repeater is shown in Fig. 9. The circuits are shown in detail in Fig. 6 and 10. Fig. 6 is also part of the intermediate repeater (without order-wire spur)

described in 2.01. Fig. 10 provides a 3-way, 4-wire bridge consisting of six hybrid coils. One set of outlets of this bridge receives from and transmits toward the alarm receiving office. The second set is associated with the FR T/R bay, and the third set of outlets is associated with the order-wire extension. This arrangement allows order-wire voice signals from any given direction to pass to the other two branches of the wye configuration formed by the bridging circuit.

**2.30** The right-hand side of Fig. 10 provides a set of split-apart filters FL3 and a splitting pad R92, R93, and R94. Multiplex connections to the high-pass sections of FL3 may be on a 75-ohm basis or optionally on a 135-ohm basis using transformers T17 and T18.

**2.31** The receiving leg of the extension terminates in transformer T25, which provides for connection of balanced circuits to the unbalanced order wire circuit. The purpose of the B PAD is adjustment of transmission level to a fixed value. The local telephone set circuit of Fig. 6 bridges the extension at a fixed level point, the output of B PAD, Fig. 10, via lead S. This bridging point is associated with the SPUR position of the DIR key of Fig. 6. The bridging point associated with the NEAR position of the key is terminal 5 of FL3.

**2.32** A 4.5-db pad R146, R147, and R148 builds out the loss of the hybrid bridging circuit to 11.5 db. Pads R140, R141, and R142, and R143, R144, and R145 are provided for the same purpose. The C AMPL amplifies the low-level signal available from the radio baseband output to a level suitable for a wire extension. Low-pass filter FL7 passes speech signals below 2600 cps, but blocks the 2600-cps alarm alert tone from the extension. Low-pass filter FL6 blocks speech energy at 2600 cps and above to prevent interference to the 2600-cps tone.

#### Order Wire and Alarm Circuit for Converging Radio Routes

**2.33** A radio route segment having a wye configuration requires the use of the circuit shown in Fig. 11, comprising Fig. 6 associated with the NR T/R bay, Fig. 6 associated with the FR bay, and Fig. 13 associated with the S, or spur, bay. The circuit of Fig. 6 is described in

2.01. Provision is made in Fig. 13 for the set of split-apart filters, dual diversity splitting pad, and multiplex line (optional) impedance matching transformers associated with the S T/R bay. The circuit per Fig. 12 provides the split-apart filter set FL3 and splitting pad associated with the FR bay. Multiplex signals may optionally be branched (drop only) by means of 14.5-db splitting pads R155, R156, R157, R158, and R159, R160, R161, R162, or dropped and added by local multiplex equipment. In the latter case, multiplex connections to the high-pass sections of the split-apart filters may be optionally connected on either a 75-ohm basis or on a 135-ohm basis using transformers T17 and T18.

2.34 The 3-way, 4-wire bridging circuit shown in Fig. 12 consists of hybrid transformers T19, T20, T21, T22, T23, and T24 and low-pass filters FL6, FL7, and FL8. The speech and 2600-cps tone paths through this arrangement are as follows. Speech entering the bridge from any given direction branches in the two remaining directions of the wye, so that speech transmission follows the most direct path. Because of the low-pass filters, however, 2600-cps alarm alert tone entering from the west, for example, passes through the bridge only to the east. Tone entering from the east passes only to the south, and so on. These tone paths, together with the tone reverting paths of far-end terminals, form the alarm alerting loop of a network radio route configuration. The three 4.5-db pads build out the loss of the bridging arrangement to 11.5 db. When the direction key of Fig. 6 is in the SPUR position, the telephone set receiving circuit bridges the line at the input to pad R146, R147, and R148. When the key is in the FAR position, the bridging point is terminal 5 of filter FL3.

### C. Alarm Encoder Circuit

#### General

2.35 Three distinct alarm functions are required to indicate failure of towers equipped with flashing beacons plus side lights. Also, two functions are required for shorter towers equipped only with duplex continuously illuminated top lights. These functions are provided by the alarm encoder circuit per SD-97100-01. Since some towers require lighting

and some do not, the encoder circuit is equipped only where required and mounts in the tower lighting control cabinet.

2.36 The encoder circuit is interposed circuit-wise between the tower light control circuit and the basic TL alarm equipment that is part of the radio bay. Where the encoder circuit is equipped, the alarm circuit in the radio bay acts as a slave to the encoder circuit opening and closing the 2600-cps loop and the interrogation path under external control.

2.37 The encoder circuit receives indications from the individual alarm circuits, both in the tower lighting control circuit and the radio bay or bays. Changes in the status of alarm conditions are recognized by the encoder circuit which generates the code corresponding to the condition ranked as most important. The interrogation path is repetitively keyed in accordance with this code as long as the status remains unchanged. Since only one code can be generated at a time, but more than one trouble condition may exist concurrently, the encoder includes a preference circuit. A tabulation of alarm conditions in order of rank and the corresponding code signals is given in 1.11. Changes in the coded keying of the interrogation path at a remote station are accompanied by an alarm alert or interruption of the 2600-cps loop at that station, in order that the alarm receiving office will be aware that interrogation is required.

#### Detailed Description

2.38 *General:* The encoder circuit comprises groups of relays that may be identified as distinct functional elements, namely, preference circuit, counter, exciter, symmetric check circuit, and code networks. These will be described individually, followed by a description of the over-all operation of the circuit. The circuit and sequence diagrams for the alarm encoder are shown in Fig. 5.

2.39 *Preference Circuit:* The preference circuit ranks the individual alarms connected to the alarm relays via leads W, X, Y, A, and G in the order that these relays are shown in Fig. 5 from top to bottom. Ground is applied to leads X, Y, and G when an alarm occurs, but ground is removed from relay AC and relay D when an

alarm occurs. If, for example, ground is present on lead W (both lamps of top light or beacon normal) and ground is placed on lead X (flasher failure), relay F will operate and the ensuing operations of the encoder will initiate the corresponding alarm. If, on the other hand, no ground is present on lead W, then none of the lower ranking alarm relays may operate. A given alarm will not register if higher ranking alarms are present.

**2.40 Symmetric Check Circuit:** This circuit consists of a contact network on the alarm, or preference relays. It assures that if a trouble of high priority occurs while another trouble still exists, a new alarm alert will be transmitted to the alarm center. It also enables an existing alarm of lower priority to cause an alarm alert after one of high priority clears out. In addition, as a special case, it causes an alarm alert to denote clearing out of the top priority alarm. This feature is provided to indicate restoration of beacon or top light illumination after a power failure, whereas an alarm alert is not required when other troubles are cleared. The symmetric check circuit also acts as a steering circuit, applying ground to the individual elements of the code network according to which relay of the preference circuit is operated.

**2.41 Exciter Circuit:** The exciter generates uniform recurring pulses that drive the counter circuit. This is a relaxation oscillator circuit in which relay E is operated by the collector current of transistor Q1. Bias of the transistor is controlled by transfer contact 4 of relay E. Ground through the break contact causes the transistor to conduct, operating the relay. This connects the base of the transistor to -27.6 volts through resistor R1. Capacitor C1 charges, carrying the base of the transistor negative until current through relay E is reduced by the amount of the release value. Release of relay E grounds resistor R1 and starts discharge of capacitor C1. When the capacitor has sufficiently discharged, the base of the transistor again reaches a bias potential that produces the operate value of the current in relay E, whereupon the cycle repeats itself.

**2.42 Counter:** The counting circuit recognizes the appearance of each pulse from the exciter and establishes a unique state, or combi-

nation of relays operated or released, for each pulse received. After each four pulses, the circuit recycles, that is, it repeats the same sequence of operations as long as pulses are received from the exciter. The circuit is a scale-of-four pulse counter, developing eight unique states in each cycle, which is sufficient to generate the three unique codes required.

**2.43 Code Network:** A series connection of make and/or break contacts on the counting relays provide a closed path during any particular state of the counter relays. Series parallel combinations of these contacts sequentially close or open a path during the counting relay sequence. A given path, to which ground has been connected by the symmetric check circuit, provides intermittent ground via lead D to the C relay in the transmitter receiver (T/R) bay order-wire and alarm panel. As the counting circuit sequences, the C relay modulates the interrogation tone path in accordance with the code selected. The code networks are enabled by contacts on the alarm, or preference relays. Referring to Fig. 5, the make contact 10 on relay S enables the network producing one short and one long; make contact 8 on relay F enables the network associated with 2 shorts; and break contact 8 on alternating current produces 3 shorts. Operation of either relay DS or B, corresponding respectively to transmission failure and low battery voltage alarms, puts steady ground on lead D. In the case of transmission failure, this constitutes the desired "code", namely, a continuous interruption of the interrogation path by relay C in the T/R bay alarm panel. In the case of a low battery voltage alarm, release of relay C is accompanied by operation of the pulser in the T/R bay panel, which produces a uniform pulse train corresponding to this alarm.

**2.44 Flasher or Side Light Failure:** The sequences for these two alarms are the same except for the preference relay operated and code generated (refer to Fig. 14). If either of these alarms occur, the pulser in the T/R bay alarm panel is disabled by application of battery to terminal 9. This prevents a low battery voltage alarm, whose priority is lower, from interfering with the high priority alarm should the two occur together. Assuming a flasher failure while the beacon and ac power are normal, relay F

operates. Relay F operated extends ground through the symmetric check circuit to its output on the upper level, which enables the exciter via make contact 4 and energizes relay G through a break contact on relay M. By extending ground through make contact 8, operation of relay F also selects the code corresponding to flasher failure. In addition, operation of relay F enables the counter by applying battery through make contact 1. When relay G operates, ground is removed from terminal 7 which causes an alarm alert by breaking the 2600-cps path in the associated T/R bay order wire and alarm circuit. Operation of relay G energizes thermal delay relay T, which operates after 80 seconds causing relay SL to operate. Relay SL operated extends the ground present on the upper level of the symmetric check circuit to relay M, which operates and locks up to this same ground. Operation of relay M removes ground from relay G, which releases and applies ground to terminal 7 causing the 2600-cps alarm loop to be restored. Relay G released also de-energizes relay T, which, after some delay in cooling, releases relay SL. The circuit will remain in this state with the M relay locked up to the ground present on the upper level of the symmetric check circuit until there is a change in alarm status. During this time, coded keying of the interrogation path continues. When the alarm is cleared out and the F relay releases, ground is removed from the upper level of the symmetric check network and relay M releases. At the same time ground is removed from the exciter circuit and battery is removed from the counter circuit halting the transmission of code.

#### **2.45 Beacon, Top Lights, or AC Power Failure:**

The sequence for any of these troubles is the same as flasher failure except that the action is initiated by release of the AC relay which then releases the PR relay. Relay PR prepares the circuit for action upon restoration of ac power in order to generate a new alarm alert to call attention to restoration of illumination of the beacon or top lights. Referring to Fig. 14, when the trouble clears out and relay AC reoperates, the M relay releases and the exciter and counter are disabled as with other alarms. In addition, however, relay G reoperates through break contact 6 on relay PR initiating an alarm alert by breaking the 2600-cps path in the associated T/R bay alarm panel. Relay G operated

also energizes thermal relay T, which operates after 80 seconds causing relay SL to operate. Operation of relay SL causes relay PR to operate and lock up to relay AC. Relay PR operated releases relay G, which, in turn, releases relays T and SL, thereby returning the circuit to normal.

#### **2.46 Low Battery Voltage and Transmission**

**Failure Alarm:** The sequences for these alarms are shown in Fig. 14. Assuming a low voltage alarm, ground on terminal 4 operates relay B, which puts ground on terminal 8 via break contact 8. This operates relay C in the T/R bay alarm circuit which prepares the interrogation path for keying by the pulser in that circuit. At the same time, the external pulser is enabled independently of the encoder. Operation of relay B also causes ground to be extended through to the output of the upper level of the symmetric check circuit, which operates relay G through the break contact on relay M. The remainder of the sequence is identical to that shown for an ac power failure described in 2.44. If instead of a low voltage alarm a transmission failure alarm had occurred, the D relay would release by virtue of ground removed from lead A on terminal 6. This causes the DS relay to operate, which applies ground to lead C via make contact 1. Ground on lead C operates relay C in the T/R bay alarm circuit, thereby opening up the interrogation path so that no tone is returned to the alarm receiving office when the station is interrogated. Operation of relay DS also extends ground through the symmetric check circuit to operate relay G via break contact 6 of the M relay. The remainder of the sequence is identical to that shown for an ac power failure described in 2.44. Operation of relay F and release of relay S is accompanied by a shift in the coding selected by contacts on the lower level of the symmetric check circuit.

#### **2.47 Alarm Condition Standing Followed by Higher Priority Alarm.**

This sequence is shown in Fig. 14 using as an example the onset of a flasher failure with a side light failure already existing. The sequence beginning with the operation of relay S follows the sequence of a flasher or side light failure. Assuming that this sequence has been completed, the flasher failure causes relay F to operate from ground applied within the tower lighting control cir-

cuit. Operation of relay F causes relay S to release because of the preference circuit. Because the alarm relays are all slow acting, relay S does not release until about 100 milliseconds after relay F operates. With two alarm relays operated, ground is interrupted at the upper level output of the symmetric check circuit during this interval. The M relay has an average release time of 1 millisecond and is locked to this ground. It therefore releases returning the circuit to normal, ready to register the flasher failure in the normal manner. When relay S has released, the G relay operates from ground again present on the upper level of the symmetric check circuit. The remainder of the sequence is identical to the corresponding part of the flasher or side light failure sequences as described in 2.44.

**2.48 Alarm of Low Priority Takes Over After Higher Priority Alarm Clears Out:** If, as shown in Fig. 14, an alarm such as flasher failure has been established, relays M and F will be operated following the alarm alert. If, subsequently, a lower priority trouble condition occurs such as side light failure, the associated relay S cannot operate because of the preference circuit. If next relay F releases, relay S will be energized. It takes, however, about 100 milliseconds for relay S to operate. During the period after F has released and before S has operated, holding ground to the M relay via the symmetric check circuit is interrupted. The M relay therefore releases, normalizing the circuit. When relay S has operated, the ground is restored. The remainder of this sequence is identical to the corresponding part of the sequence for a flasher or side light failure. Release of relay F and operation of relay S is accompanied by a shift in the coding selected by contacts on the lower level of the symmetric check circuit.

**3. DESCRIPTION OF EQUIPMENT**

**A. Alarm Receiving Office Panel J99262M**

**3.01** The J99262M unit comprises the equipment for attended offices that receive alarms from remote radio stations. It includes the alarm oscillator, 2600-cps detector, transmission circuits, and telephone set circuit. The panel, shown in Photograph A, is 12-1/4 inches

high and is designed to mount on 19-inch bay framework. Interrogation keys and interrogation tone frequency adjustments (one for each station), order-wire jacks, alarm lamps, and transmission jacks are located on a flush-deck panel without a cover. The oscillator components, relays, and other equipment are located on a recessed subpanel and enclosed with a common cover. The panel is designed for maintenance from the rear.

**B. Order-wire and Alarm Panels for Radio Stations**

**3.02** The basic remote station equipment is made up of eight different panels of uniform size. These panels, of which Photographs B and C are typical, mount individually in T/R bays. An additional panel provides alarms for obstruction lighting when required. This panel is mounted in the ED-97092-30 tower lighting control cabinet. The panels required to meet the various functional requirements at any given type of station are given in Table A.

TABLE A	
TYPE OF RADIO STATION	J99262 CODES
Near-end Terminal	N
Intermediate Repeater Station	R & S
Intermediate Repeater Station with Order-wire Spur	R & AC
Far-end Terminal	P
Junction of Converging Radio Routes	R, T, & AD
Stations Requiring Obstruction Lighting	AB

**3.03** All of the panels mounting in T/R bays are 5/14 inches high and are designed to mount on 19-inch bay framework. Components such as filters, networks, transformers, etc, are located on the rear of the main panel. The front of this panel is the wiring side. With the exception of the J99262 S, T, and AD panels, all panels are provided with a hinged subpanel, which mounts telephone jacks, test points, keys, and, in some cases, a 227-type amplifier. Maintenance access to the wiring side of the hinged panel is obtained by turning a Dzus fastener and swinging the panel on its hinge. The construction of the J99262 S, T, and AD panels is generally similar to the others with a main panel and a subpanel. The latter in this case is stud-mounted rather than hinged. The front

of all panels is provided with a common cover having an opening which provides operating access to the jacks test points, and key, (if provided) mounted in the subpanel.

**3.04** Table B cross references the remote station panels as to code letter, the functional equipment included, and the type of T/R bay in which it is mounted.

**3.05** The J99262AB alarm encoder circuit is equipped only as required for tower lighting alarms. It consists of 15 relays plus a small miniplas assembly of pigtail components mounted on a 6-1/2 by 11-1/2 inch flanged panel. This panel is shop-wired and is equipped with a hinged bracket on one end and mounting studs on the other so that it can be mounted in the associated tower lighting control cabinet as shown in Photograph D. It may be rotated on the hinge for access to wiring on the rear of the panel.

TABLE B		
J99262 CODE	DESIGNATION OF BAY IN WHICH MOUNTED	PRINCIPAL FUNCTIONAL EQUIPMENT INCLUDED
N	NT	Split-apart filters; interrogation filters; alarm relays, tel set circuit; wire line equipment
P	FT	Split-apart filters; interrogation filter; alarm relays; tel set circuit; wire line equipment; 2600-cps BP-BE filter
R	NR	Split-apart filters; interrogation filter; alarm relays; tel set circuit
S	FR	Split-apart filters; transformers; pads
T	S	Split-apart filters; pad
AC	FR	Split-apart filters; 3-way, 4-wire bridging circuit; wire line equipment; low-pass filters
AD	FR	Split-apart filters; 3-way, 4-wire bridging circuit transformers; pads

#### 4. TRANSMISSION CONSIDERATIONS

##### A. General

**4.01** The order-wire net loss is 15 db between telephone set transmitters and receivers. Order-wire appearances at radio stations and the alarm receiving office panel are four wire. The transmitter circuit of 4-wire telephone sets is defined as a +3 db transmission level point (TLP) and the receiving level is accordingly -12 db. It is desirable that the net loss to and from extensions be maintained at the same value. At intermediate points of the radio system, the order wire circuits provide pad and amplifier level adjustments to meet this objective. At the far terminal, a plug-in pad is provided for adjusting level received from an extension to -15 db. The transmitting level to the extension is -15 db. Gain for the order-wire extension is provided externally. If extensions terminate in 2-wire telephone set circuits, the line side of these circuits should be assigned levels of 0 db transmitting and -9 db receiving to accommodate the difference between 2-wire and 4-wire telephone sets. The alarm receiving office panel provides 4-wire input and output terminals to which an optional extension may be connected, but no level adjustment is provided at these points. The levels at these points are -4 entering the panel and -5 at the outlet. Assuming nominal 4-db losses, the levels at the 2-wire line side of a terminating set would be 0 db transmitting and -9 db receiving, which just meets the previously stated requirements for 2-wire extensions. Accordingly, it is intended that extensions from the receiving office panel be short or that appropriate pad and amplifier be provided external to the panel.

**4.02** The TLP corresponding to the EQ OUT jack of the receiving office panel is 0 db. The 2600-cps tone and the interrogation tones are injected ahead of this jack at -7 dbm. The losses of filters in all tone reverting paths are such that tones are returned to the alarm receiving office, 3 db below the power at an equal level point at which they are transmitted. The TLP at the REC AMPL OUT jack of the receiving office panel is +7 db, hence, the tone power at this point is 0 dbm.

**B. Oscillator**

**4.03** The output power of the oscillator is normally adjusted to +6 dbm (0 dbm as measured at the EQUIP OUT jack) by means of OSC LEVEL potentiometer R38 with OSC OUT attenuator R45 set for minimum loss. This is an optimum setting of the OSC LEVEL adjustment from the standpoint of stability and harmonic output. Adjustment of the oscillator output to -7 dbm at the EQUIP OUT jack is accomplished by varying the OSC OUT attenuator after the OSC LEVEL adjustment has been made.

**C. Detector**

**4.04** The normal input to the 2600-cps detector is 0 dbm as measured at the MON DET IN jack. The detector sensitivity is set so that this input provides 9-db margin against release. This is considered adequate margin against false release due to line and circuit deviation. Any increase in margin increases the likelihood of false operation of the detector on interfering signals; hence, the stated margin is a compromise between false release and false holdup. To assist in obtaining an adequate margin against both false release and false holdup, a high ratio of release to operate current is desirable. The polar relay K5 provides this high ratio, and when properly adjusted, the change in input power corresponding to this ratio should exceed not more than 1.5 db.

**D. Radio Station Order Wire Circuits**

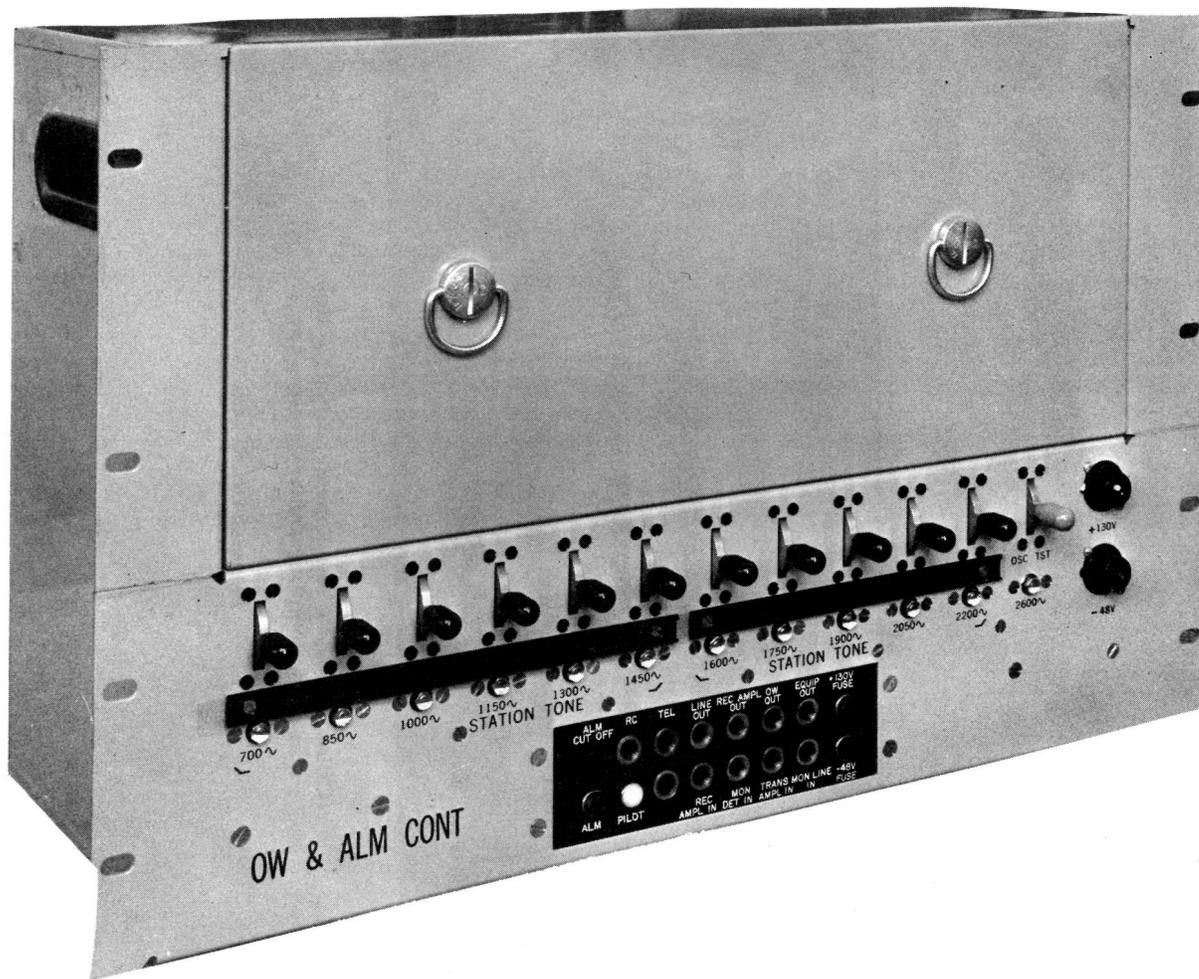
**4.05** The order-wire/multiplex split-apart filters provide separate access to the radio system at the end of each hop. The points are provided at the high-pass ports of these filters designated MX IN and MX OUT. Test points at the low-pass ports are designated OW IN and OW OUT. It is convenient to refer levels to this interface between the radio system and connecting circuits rather than the receiver or transmitter baseband amplifier even though the split-apart filters and diversity splitting pad are part of the order-wire and alarm panel.

**4.06** As shown in Fig. 15, the input modulation sensitivity of the radio transmitter referred to the MX OUT test point is -8 dbm sine-

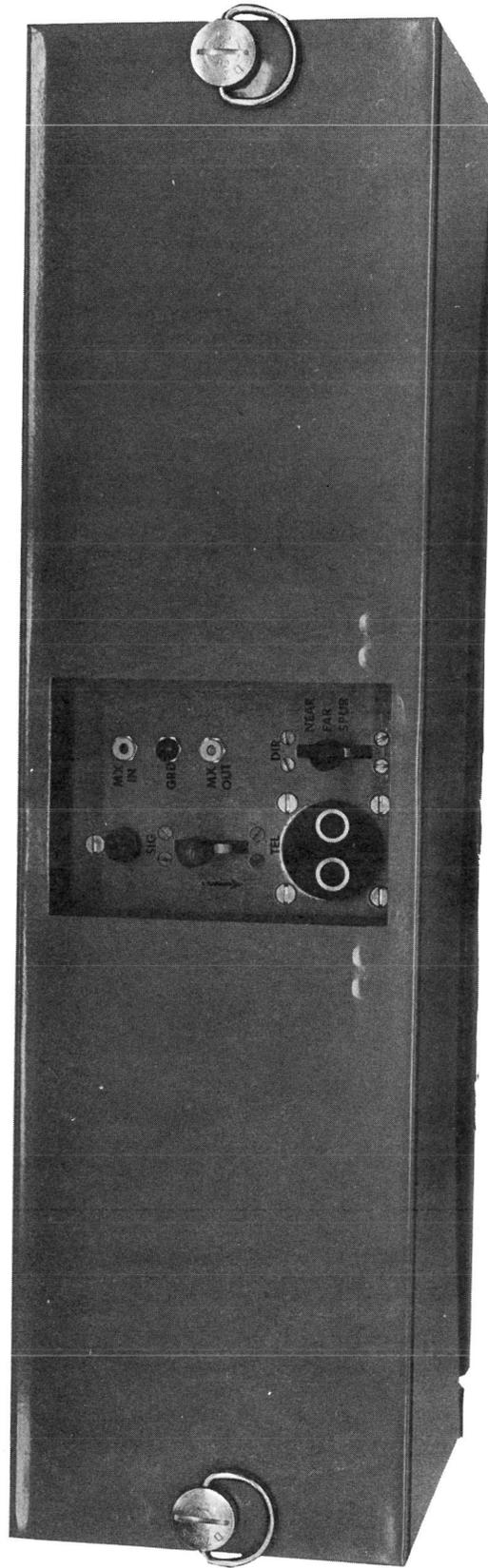
wave power for an arbitrary  $\pm 4$  mc deviation. The corresponding value referred to the OW OUT test point is -6.5 dbm. The difference in sensitivity is attributable to the fact that the high-pass branch of the filter has negligible loss, while the loss through the low-pass branch is 1.5 db. An attenuation characteristic for the split-apart filter is shown in Fig. 16. The net baseband gain for the radio system is such that with the stated deviation the output power at the MX IN test point would be +6.5 dbm and at the OW IN test point would be +5 dbm. Individual multiplex channel levels at MX test points are covered in another section. The order-wire transmission level is -26.5 db and -15 db at the OW OUT and OW IN points, respectively. This represents a transmitter deviation of 20 db down on  $\pm 4$  mc for a tone of 0 dbm referred to the 0 TLP of the order wire. Since the alarm tones are -7 dbm at 0 TLP, the nominal tone power is -33.5 dbm and -22 dbm at OW OUT and OW IN, respectively.

**4.07** Referring to Fig. 1, it is seen that the interrogation filter bridges between the -15 db and -26.5 db level points in all circuit configurations. Also, the -15 TLP is the bridging point for the telephone set circuits. The loss between filter-out and filter-in in a given direction of transmission is 11.5 db provided either by an 11.5-db pad at through repeaters or a 4.5-db pad plus hybrid coil losses where the 3-way, 4-wire bridging circuit is employed. At terminal stations the same level relations are maintained. The plug-in A pads are so chosen that the level received from connecting lines is -15 db at the drop side of these pads.

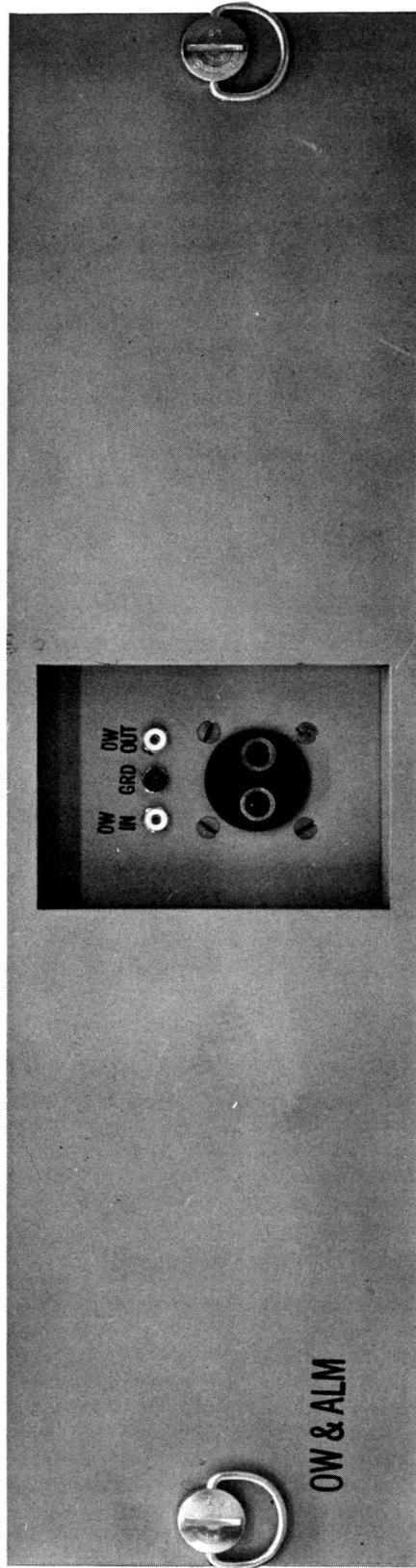
**4.08** The attenuation limit of connecting lines between alarm receiving office and the near terminal order wire circuit is approximately 13 db. The attenuation slope between 1000 cps and 2600 cps should exceed not more than 1 db. The loss of facilities used as order-wire extensions from the far terminal and intermediate points will depend on whether facilities are 2- or 4-wire and whether gain is provided in the facility. Since the alarm signaling tones are not carried on these lines, no special requirement is made on attenuation slope. It is desirable to meet the net loss objectives of 4.01 on order-wire extension.



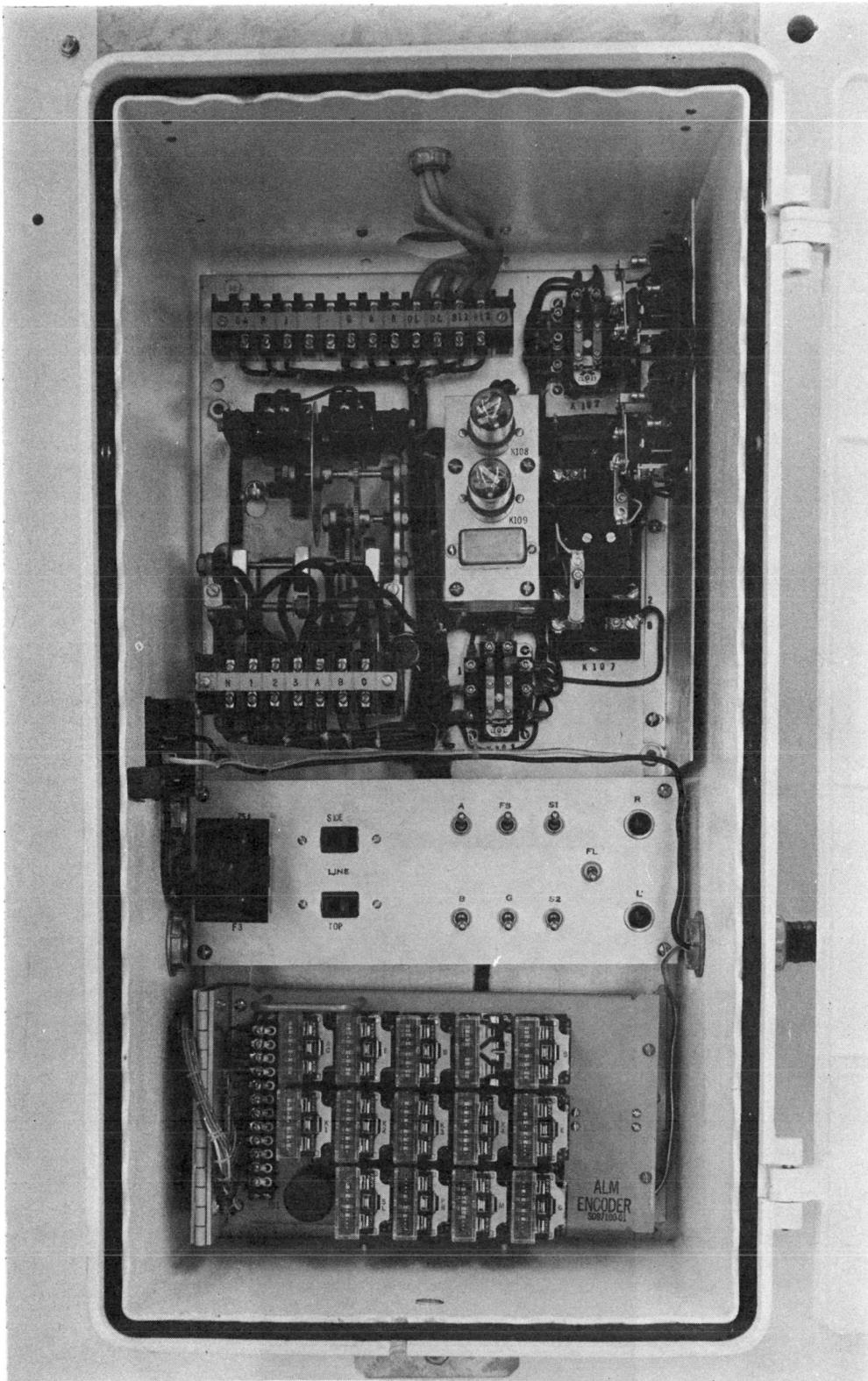
Order-wire and Control Unit for  
Alarm Receiving Office



Order-wire and Alarm Repeater Panel for Near Repeater (NR) Transmitter-Receiver Bay



Order-wire and Alarm Unit for Far Repeater (FR)  
Transmitter-Receiver Bay



**Tower Light Control Cabinet with  
Alarm Encoder Panel**

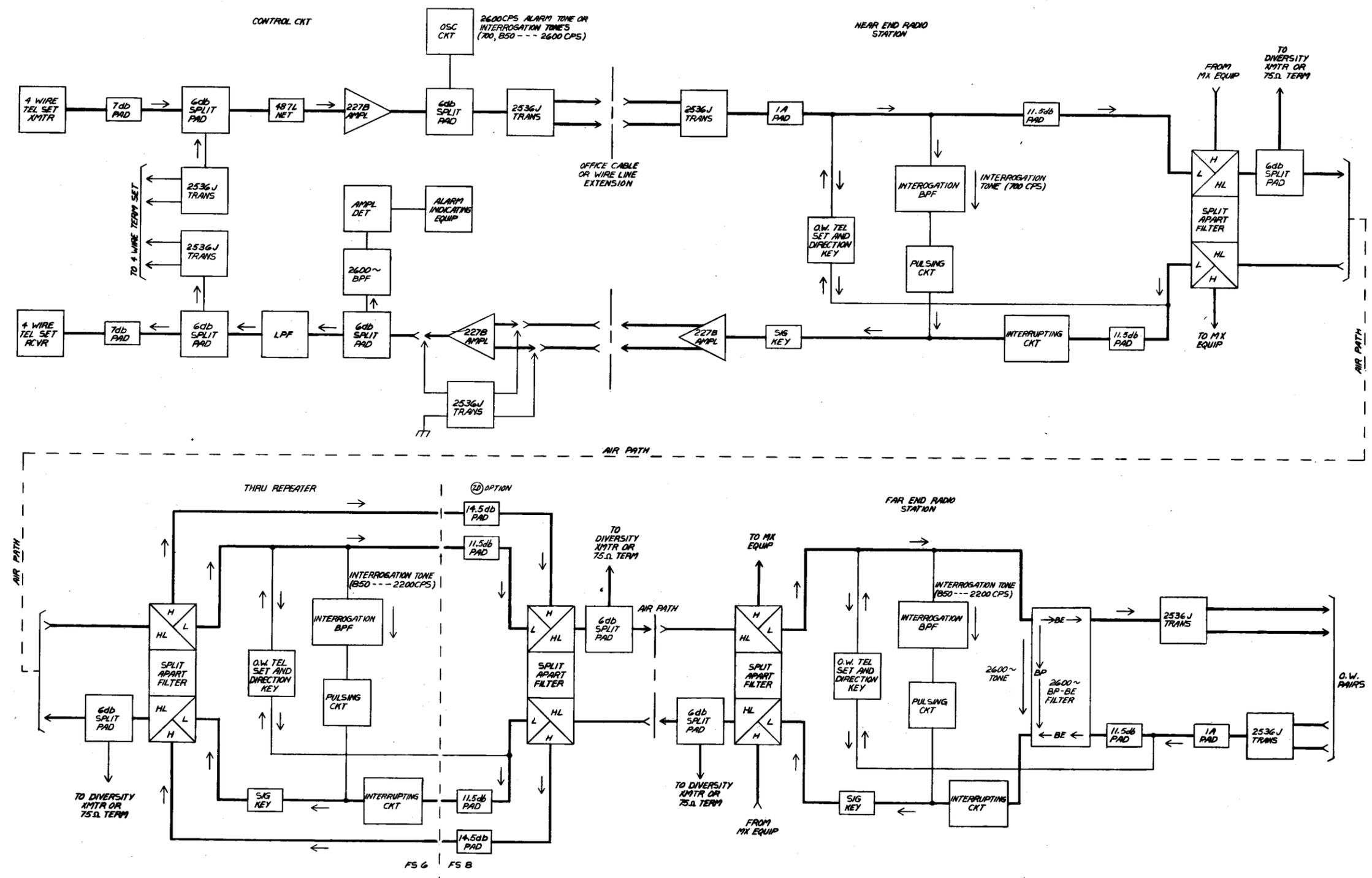


Fig. 1 — Typical Order Wire Circuit for 2-hop System

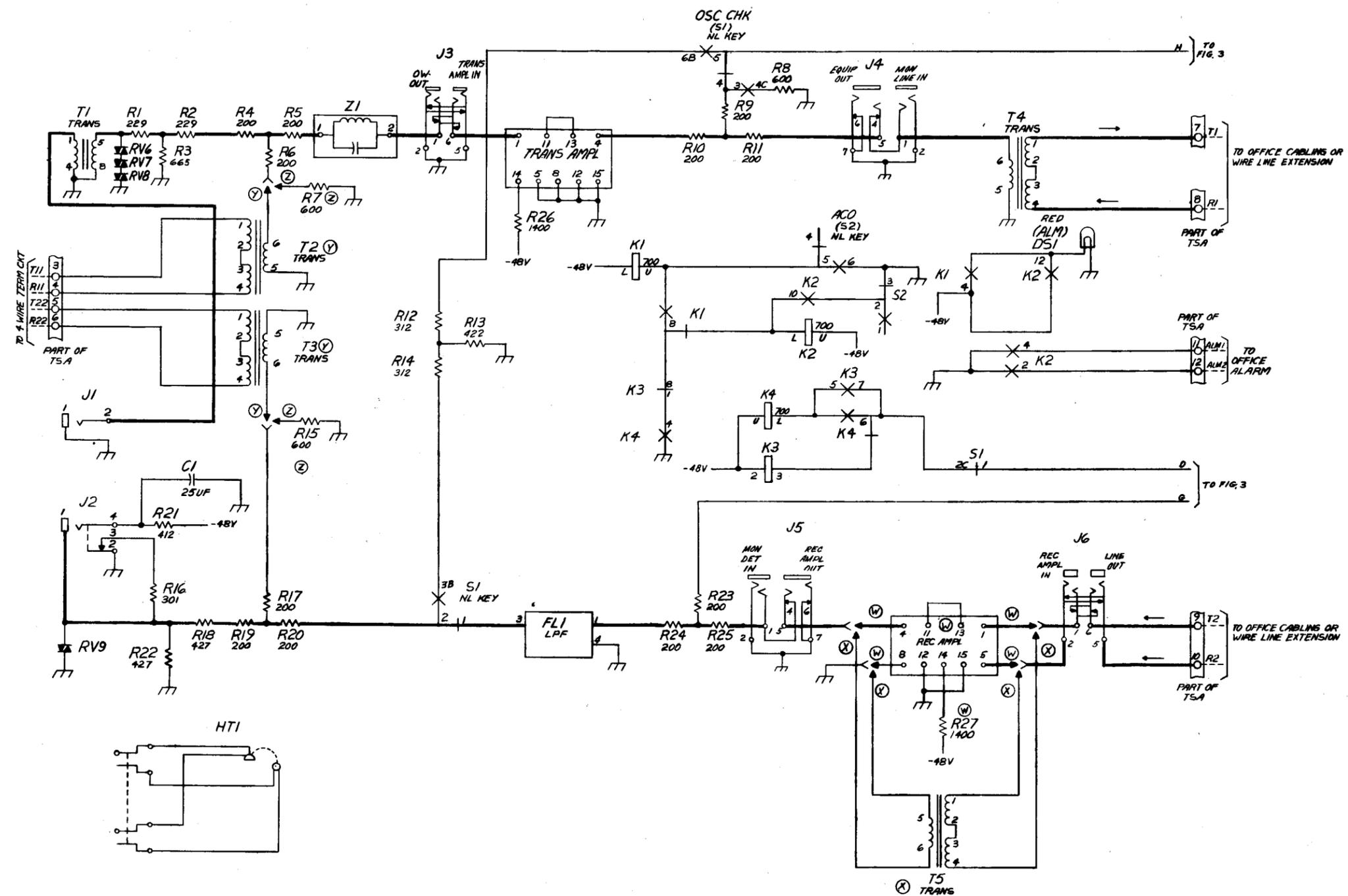


Fig. 2 - Typical Order Wire and Alarm Control Circuit

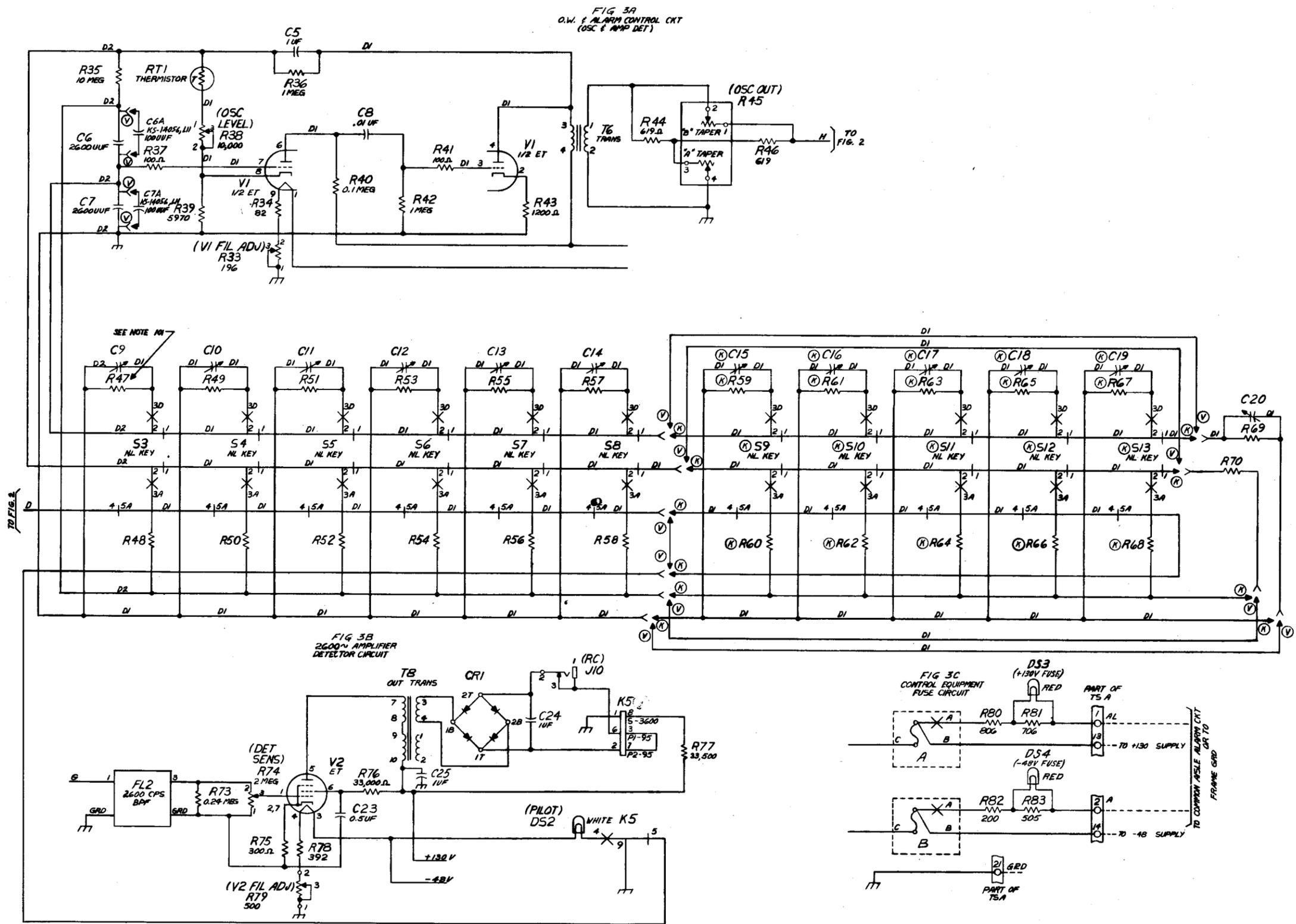


Fig. 3 — Typical Oscillator Circuit

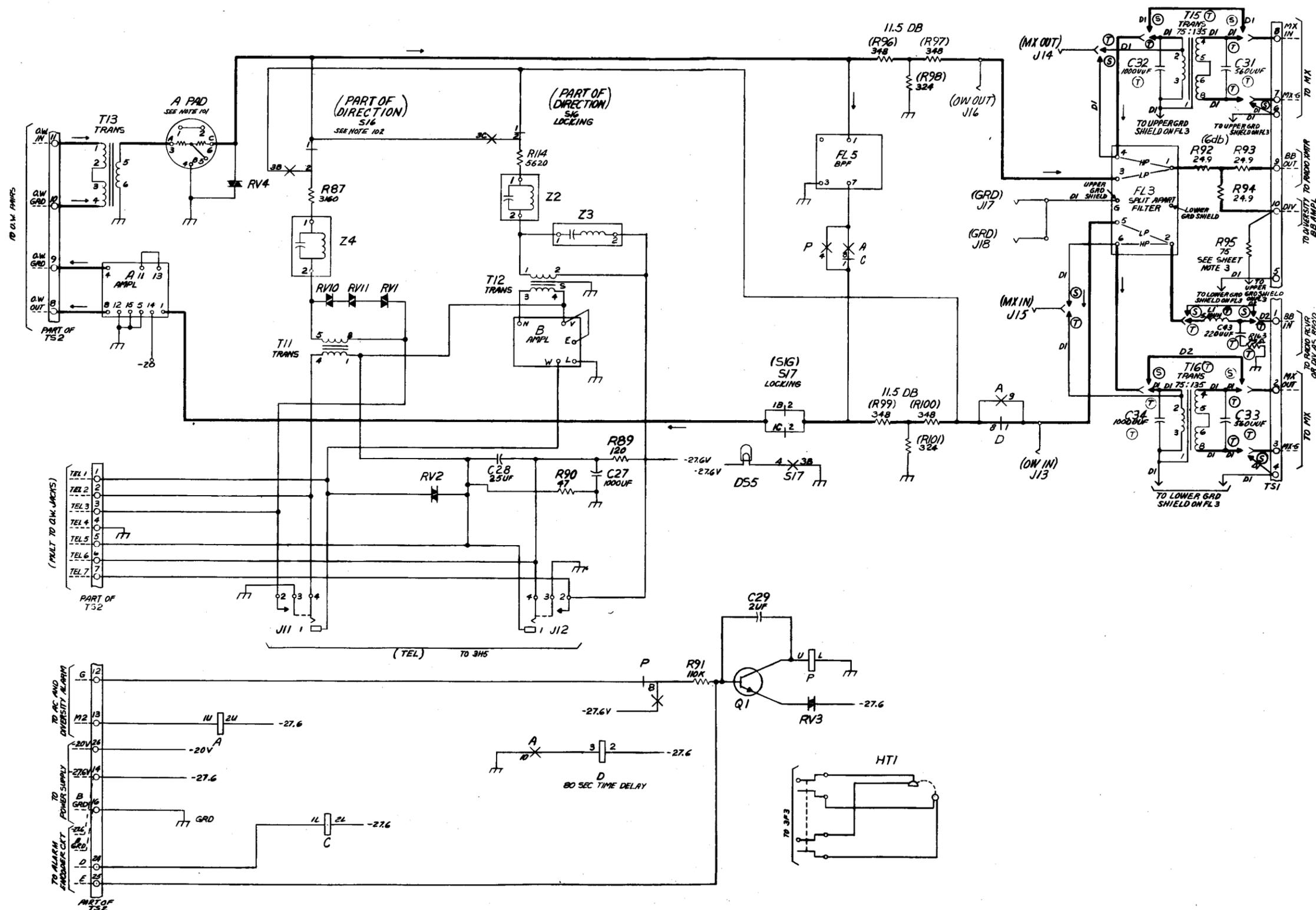


Fig. 4 - Typical Order Wire and Alarm Circuit for Near Terminal Transmitter-Receiver Bay

NOTES

101. COMPONENT CODES AND VALUES SHOWN MAY NOT AGREE WITH THE LATEST ISSUE OF SD-97100-01.

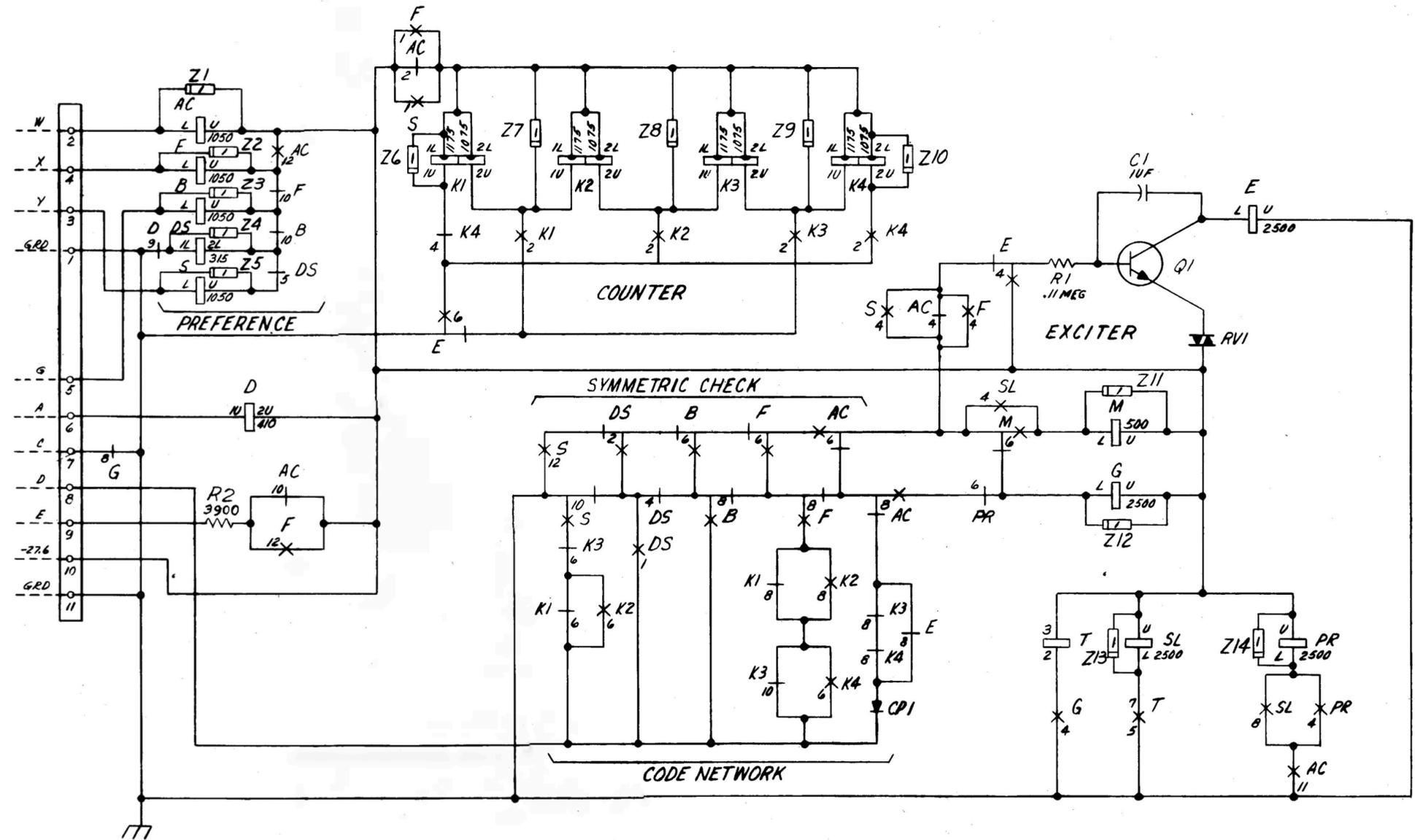


Fig. 5 - Typical Alarm Encoder Circuit

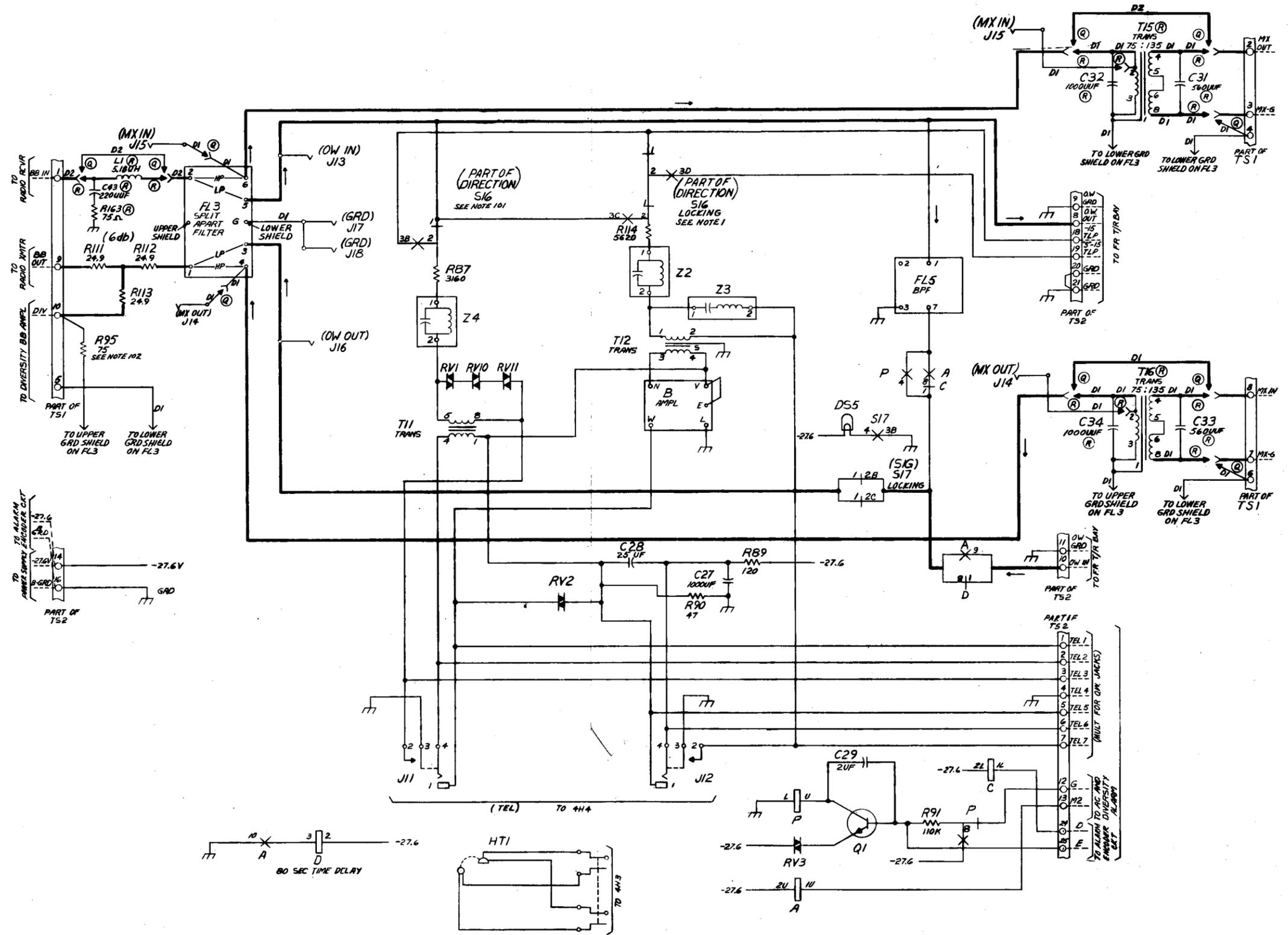


Fig. 6 - Typical Order Wire and Alarm Circuit for Near Repeater Transmitter-Receiver Bay

NOTES:  
 101. COMPONENT CODES AND VALUES SHOWN  
 MAY NOT AGREE WITH THE LATEST  
 ISSUE OF 80-77041-01.  
 102. R115 IS REMOVED FOR DIVERSITY APPLICATION.

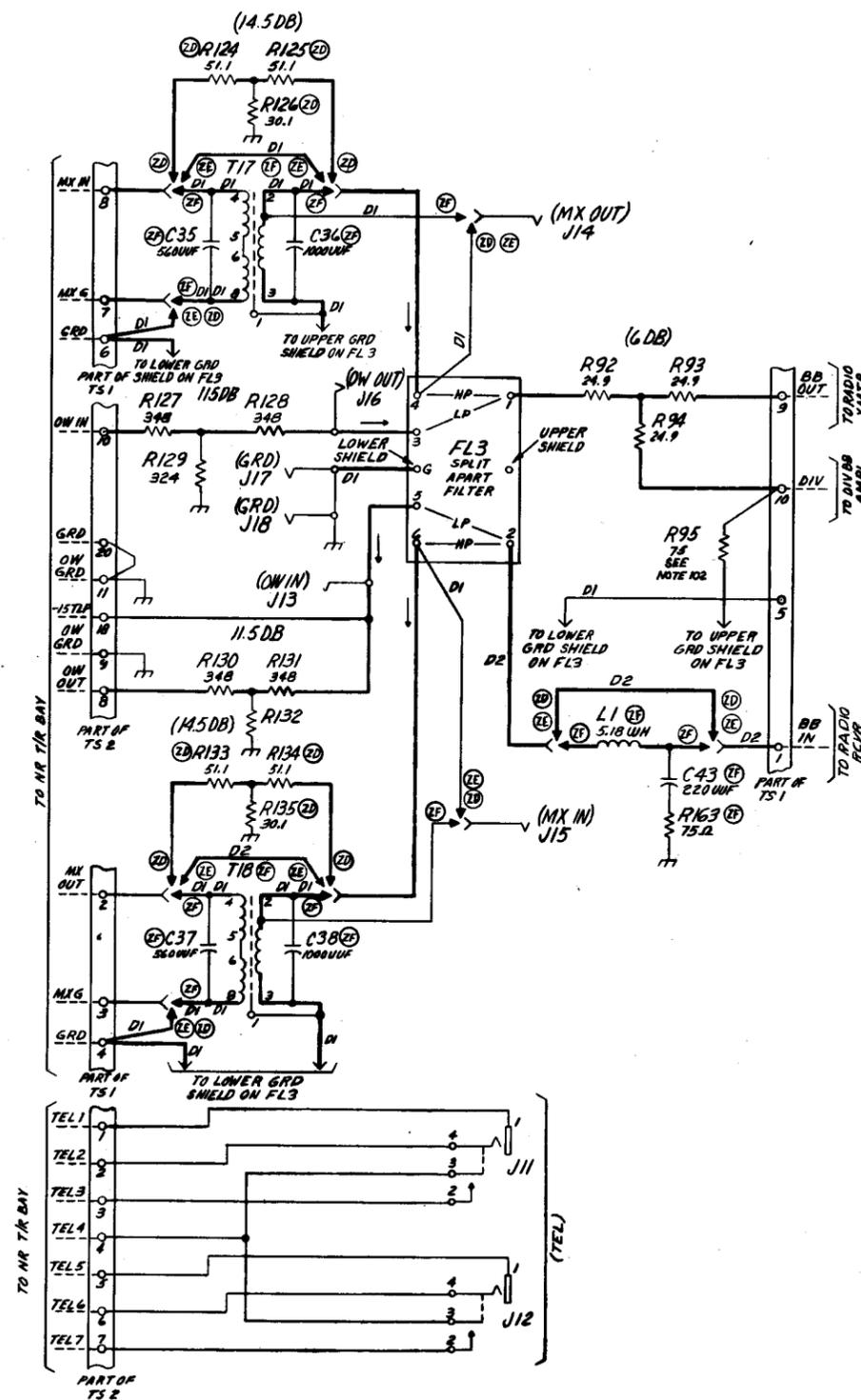


Fig. 7 - Typical Order Wire and Alarm Circuit for Far Repeater Transmitter-Receiver Bay, Through Repeaters, or Connection to Local Multiplex Carrier Spur

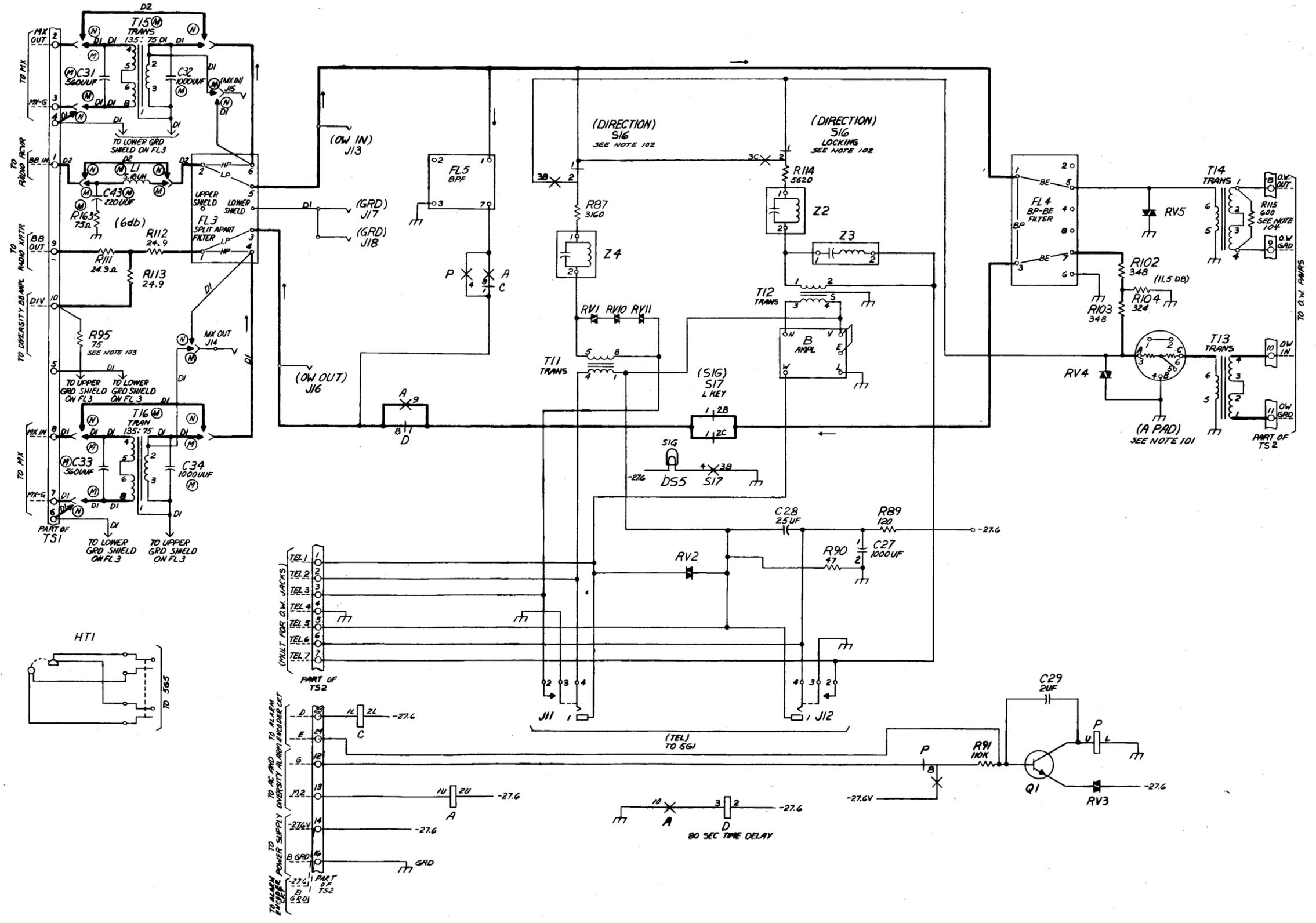


Fig. 8 - Typical Order Wire and Circuit for Far-end Terminal Station

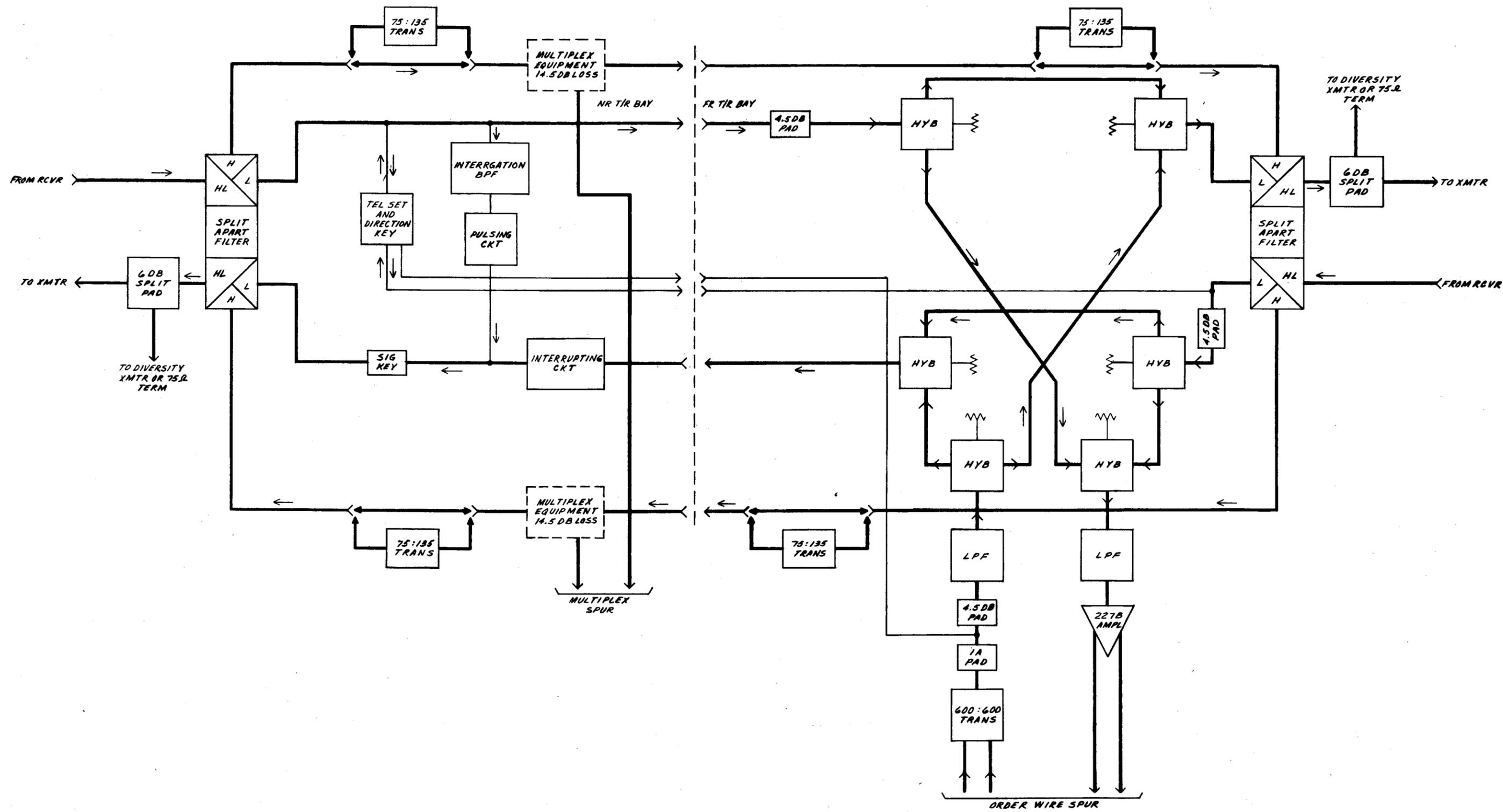


Fig. 9 — Block Schematic Order-wire Spur at Intermediate Radio Repeater

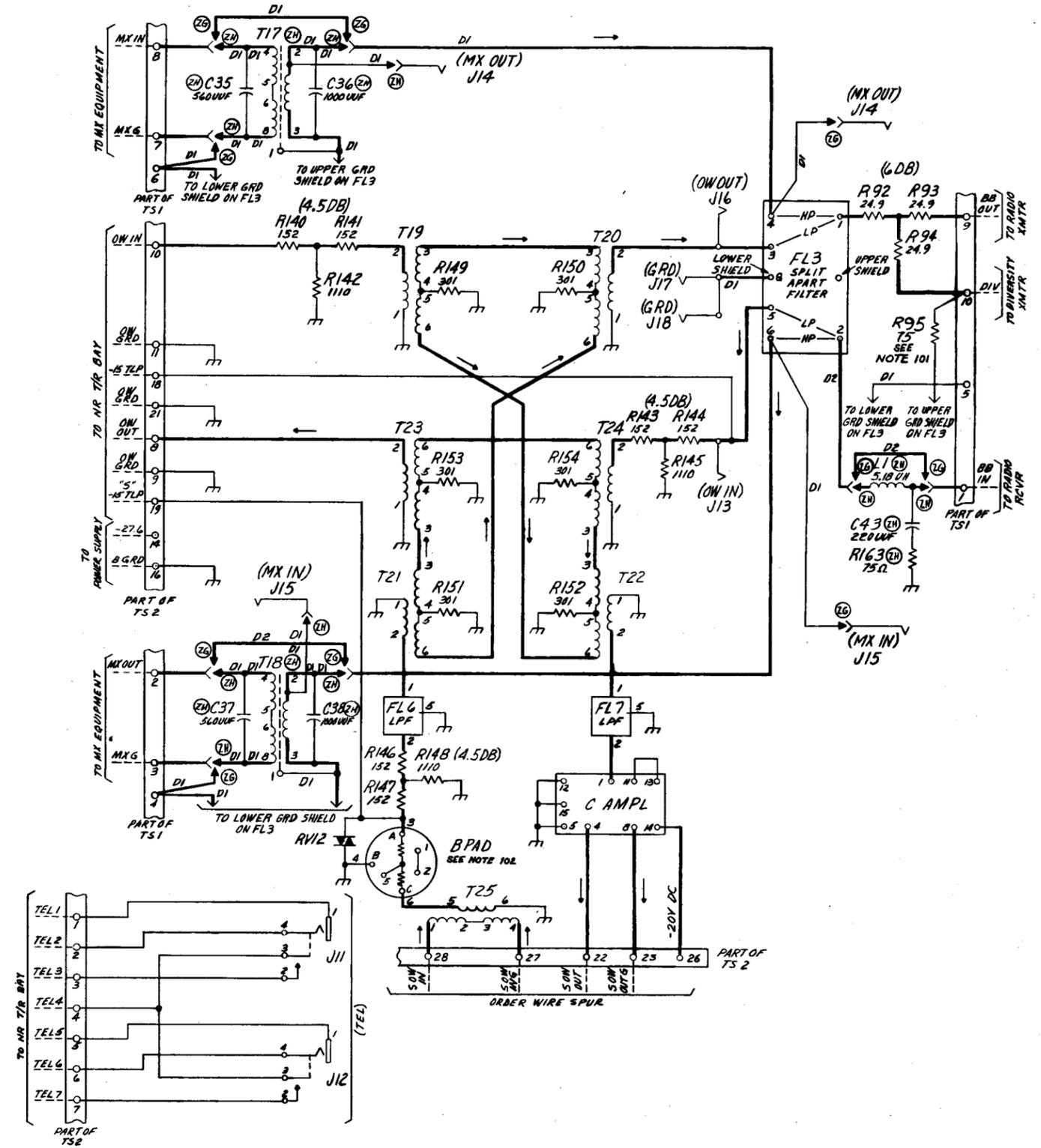


Fig. 10 — Typical Order Wire and Alarm Circuit for Far Repeater Transmitter-Receiver Bay for Connection to Carrier and Order-wire Spur

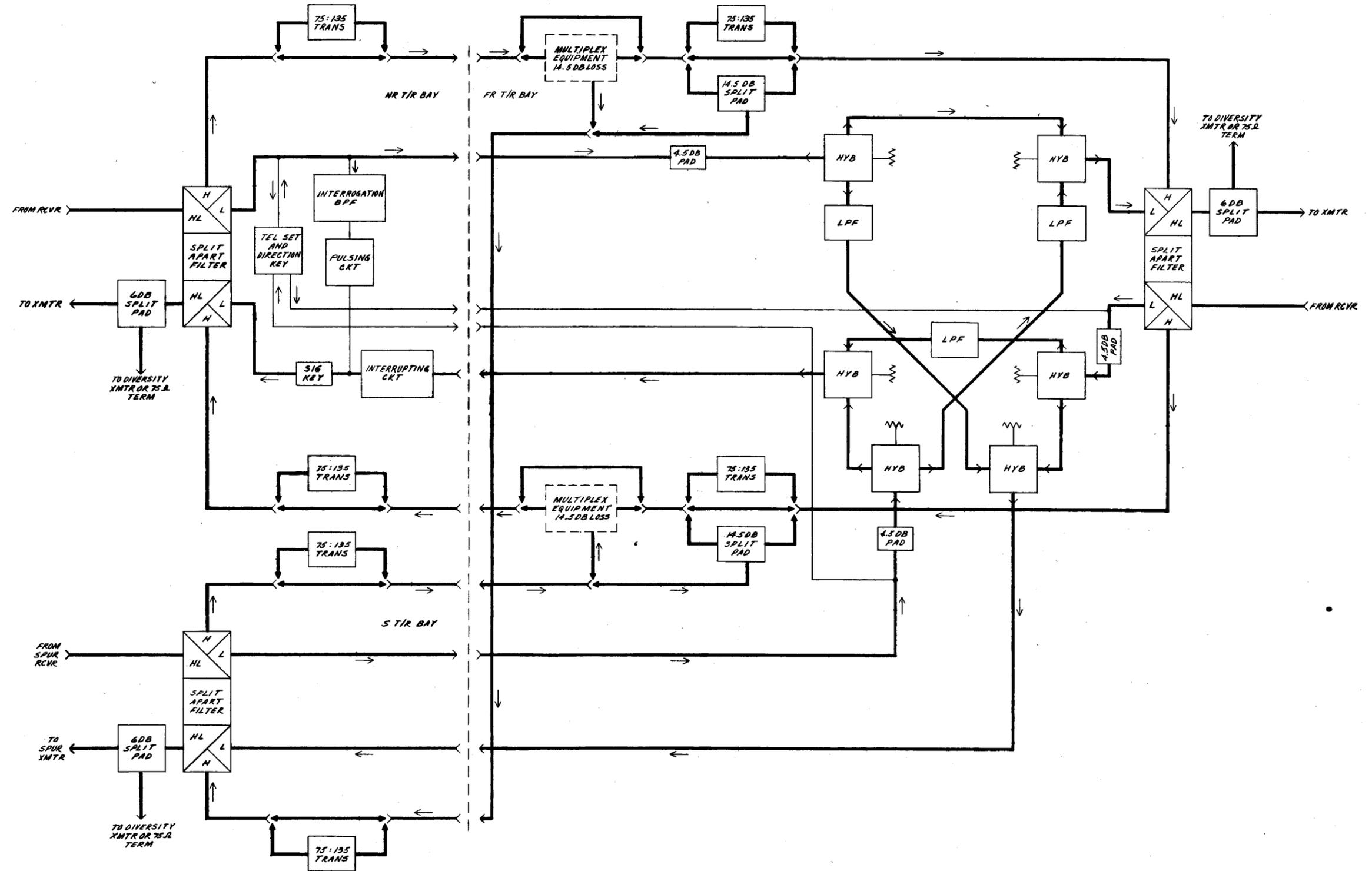


Fig. 11 - Block Schematic Radio Spur Station

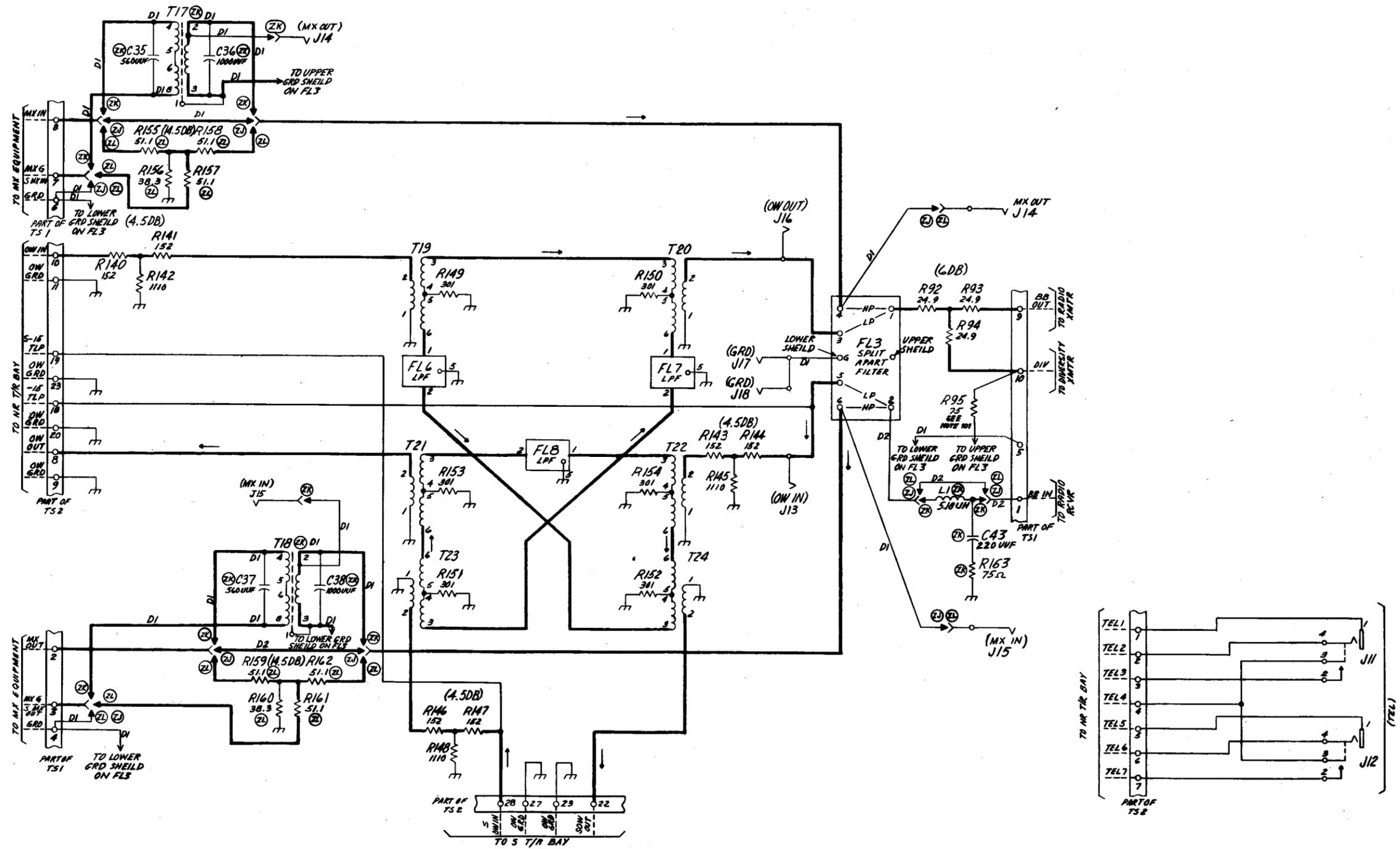


Fig. 12 - Typical Order Wire and Alarm Circuit for Transmitter-Receiver Bay for Extension to Radio Spur

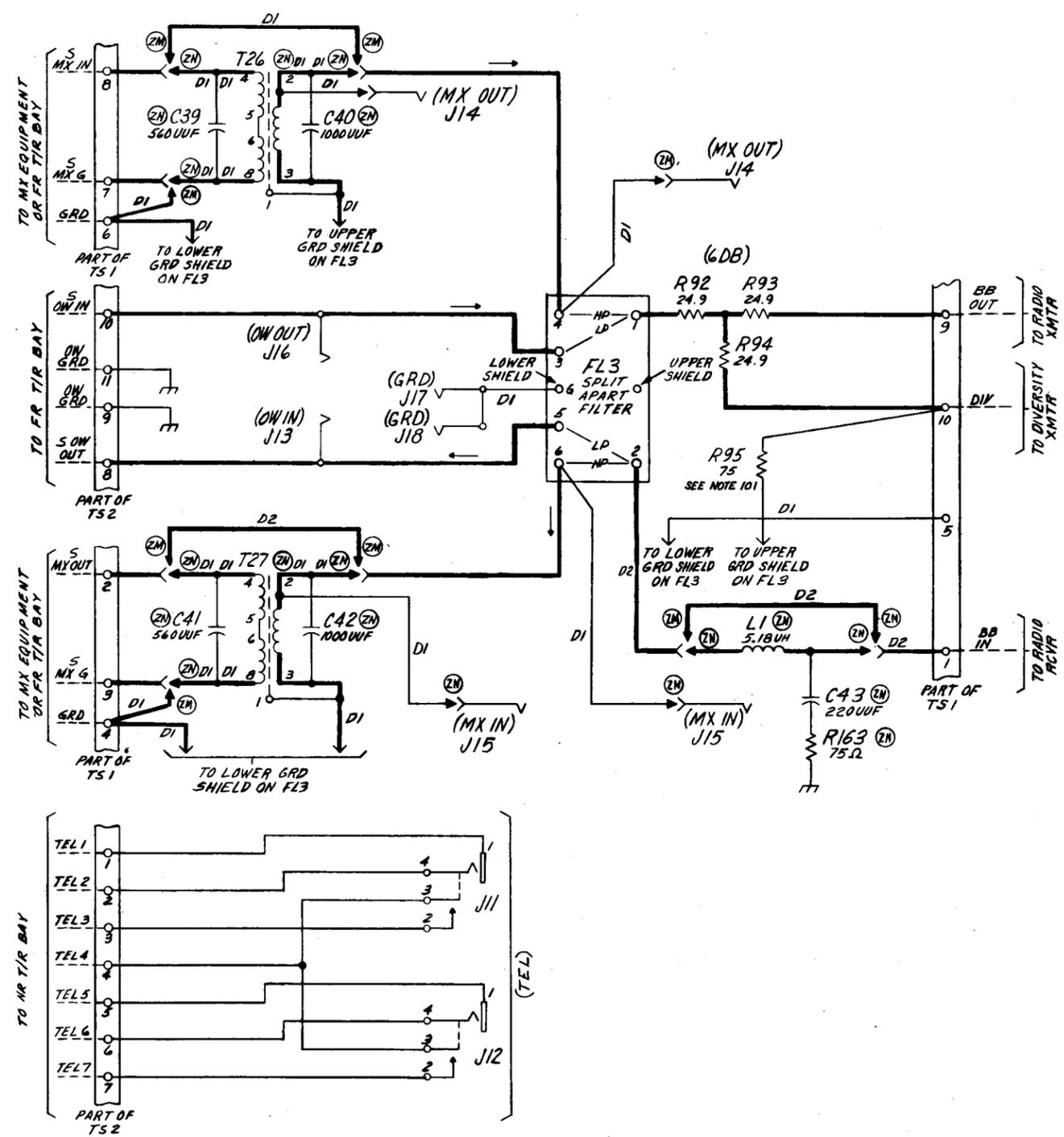


Fig. 13 — Typical Order Wire and Alarm Circuit for Spur Transmitter-Receiver Bay

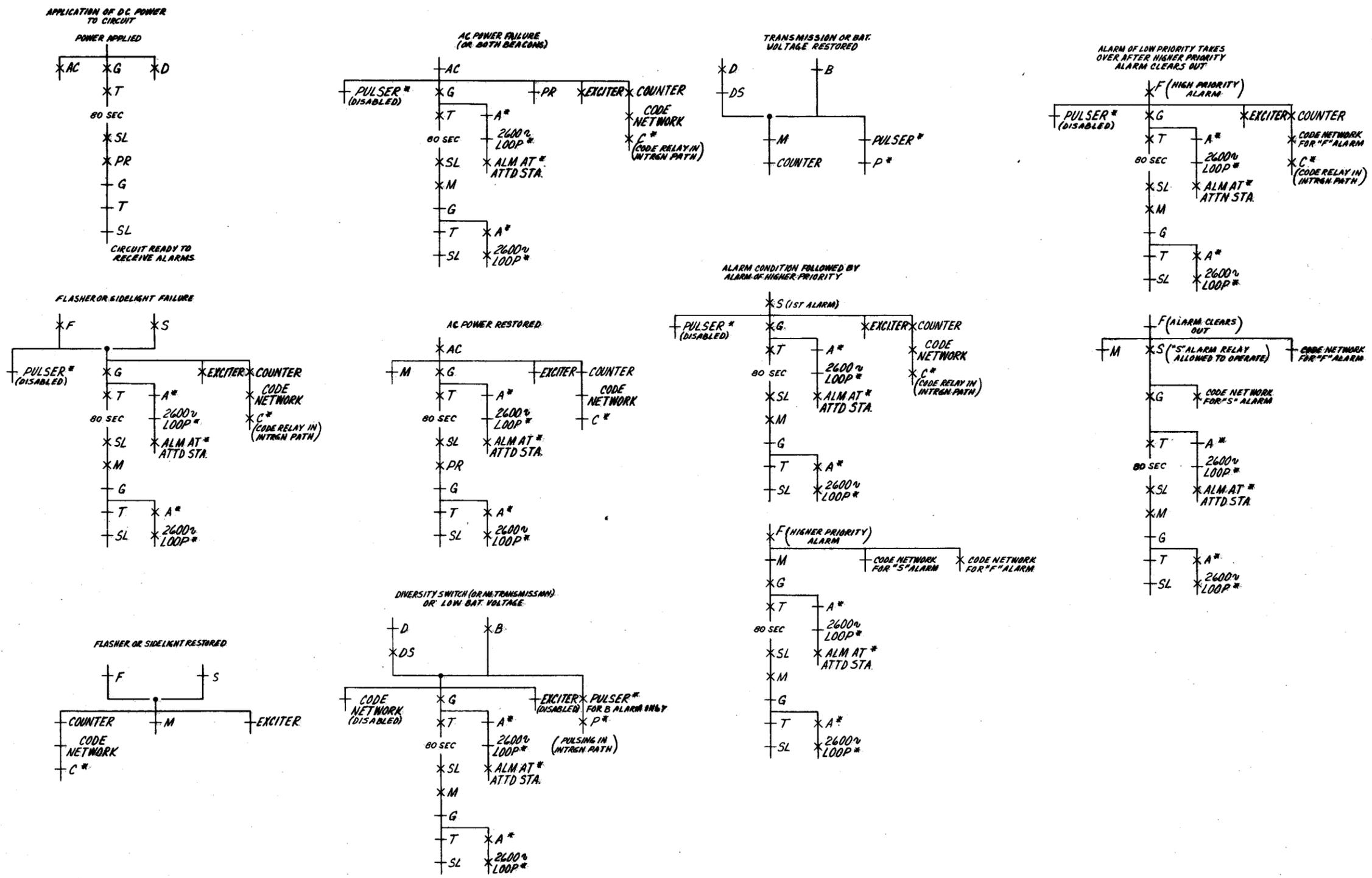


Fig. 14 - Sequence for Alarm Encoder Operation

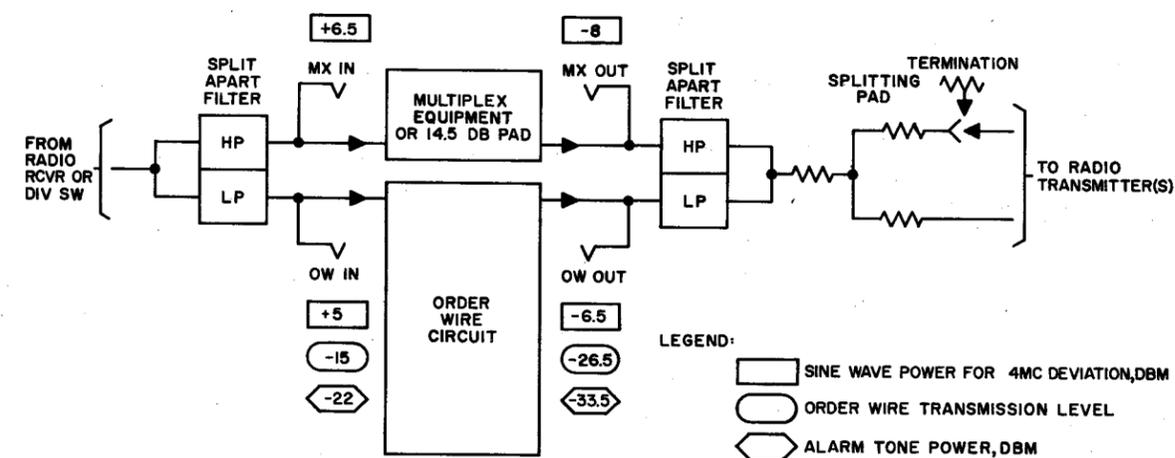


Fig. 15 - Baseband Level Diagram

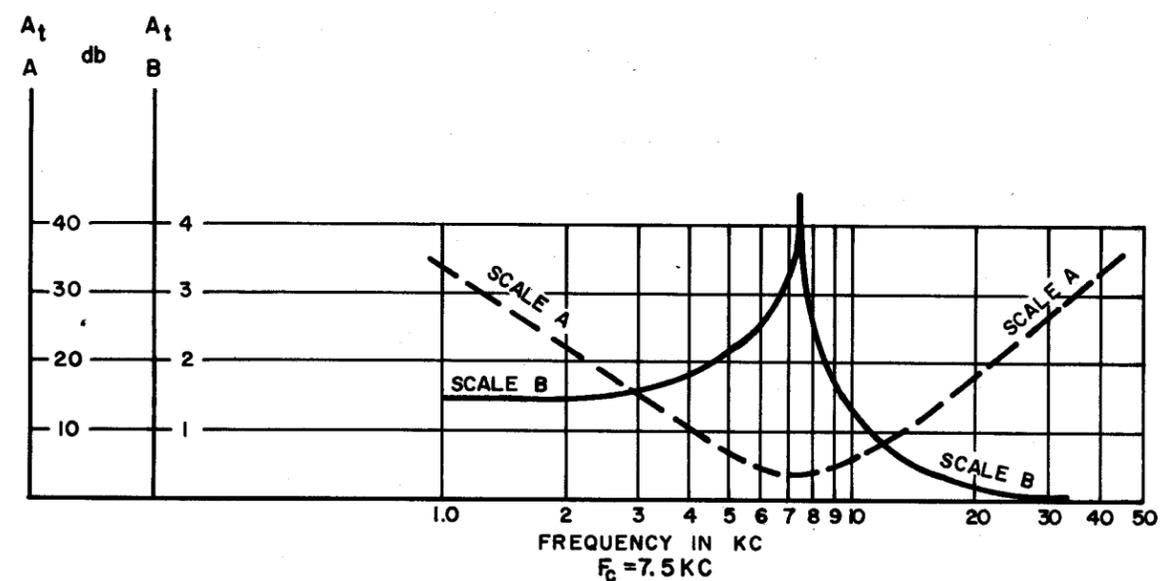


Fig. 16 - Transducer Loss 226AU Split-apart Filter