

MULTIFREQUENCY PULSING SYSTEM

COMMON SYSTEMS

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| A. General | 4 | <u>A. Supervision and Pulsing</u> | |
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| C. MF Transmitters | 7 | 1.02 Supervision in trunks includes the connect and disconnect signals to the called end, and the on and off switchhook signals to the calling end. The supervision signals can be used under certain conditions for other signal classes; for example, to control the start of pulsing, for dial pulsing, and to rering. Supervision means are required practically all of the time for good dial service. | |
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| 3. METHOD OF OPERATION ON A TYPICAL CALL . | 12 | 1.03 Pulsing properly covers only the switch-path selecting signals going toward the called end, and these are required only at the time a connection is being established. Accordingly, the means for pulsing can be detached from a connection most of the time. | |
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| 4. MAINTENANCE FEATURES | 12 | <u>B. Features of MF Pulsing</u> | |
| A. Current Supply and Distribution Circuit | 12 | 1.05 The multifrequency pulsing system provides transmitting and receiving equipment for transferring called number information over telephone trunks. It uses voice frequency pulses that can pass through any line facility suitable for voice. At trunk terminals, MF receivers operate senders or registers, which control routing switches to establish connections. | |
| B. Receiving Circuit | 13 | | |
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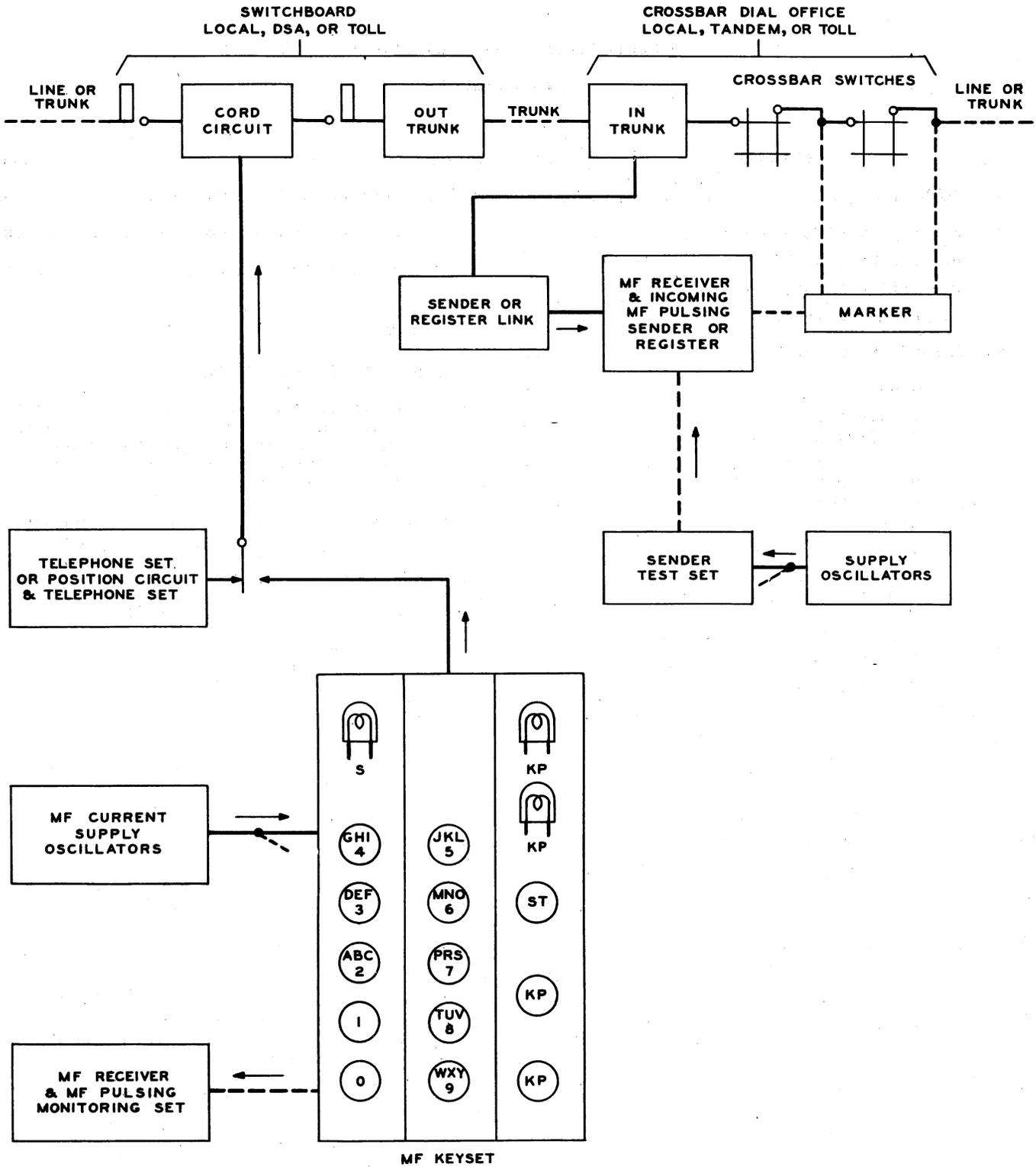


Fig. 1 - Plan of MF Pulsing System

1.07 The auxiliary signals indicate the beginning and end of pulsing to the MF receiver. They are called KP and ST signals, respectively.

1.08 The plan of MF pulsing from a switchboard position to a crossbar office is shown in Fig. 1. In such an arrangement, MF pulses are transmitted manually by an operator using a keyset. The operator can key about 2 digits per second, the same speed as dc key pulsing. However, since MF pulses are voice frequencies, they do not experience the distance limitations of dc pulses.

1.09 MF pulses are also transmitted automatically by senders. The senders receive numbers from operators or subscribers and transmit these numbers as MF pulses. The speed of MF senders is 7 digits per second.

1.10 The advantages of MF pulsing are speed and range. Keysets are faster than switchboard dials, and similarly, MF senders transmit more rapidly than dial senders. Consequently, receiving equipment at trunk terminals requires less holding time per call.

1.11 Since MF pulses can pass through any line facility suitable for voice, they have a decided advantage in range over other types of pulsing. Routing information can be directly transmitted to an office thousands of miles away. MF is thus readily adaptable to the requirements of nationwide toll switching.

C. Applications of MF Pulsing

1.12 Because of their rapidity in switching, crossbar offices are able to utilize the speed of MF pulsing. Hence, the main application of MF is on trunks to this type of office.

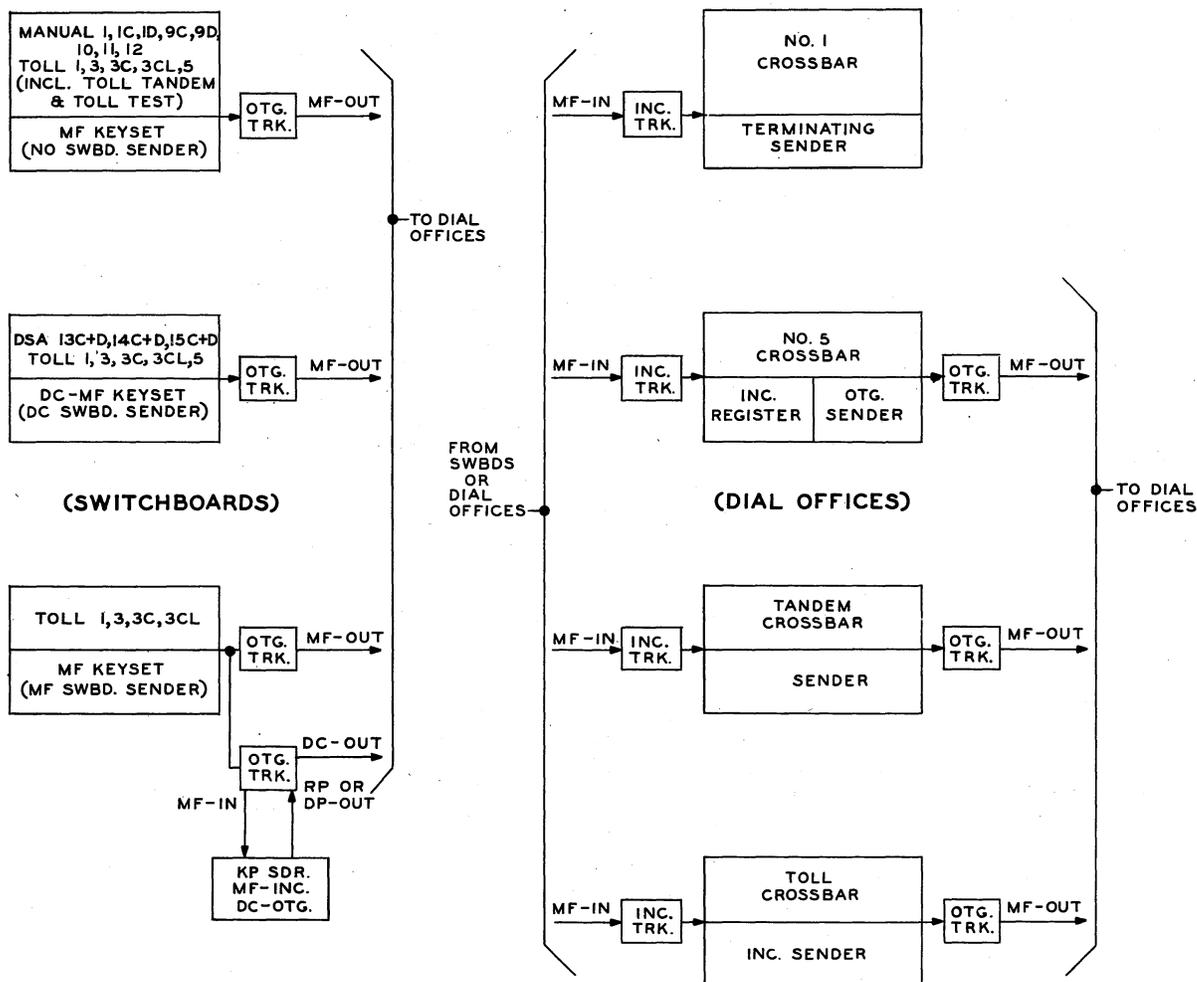


Fig. 2 - Application Plan of MF Pulsing System

1.13 The general plan of MF pulsing is illustrated in Fig. 2. Crossbar offices receive MF pulses from senders at other dial offices and from MF and DC-MF keysets at switchboards.

1.14 One group of switchboards in Fig. 2 has KP senders associated with outgoing trunks to step-by-step and panel offices. These KP senders receive MF pulses from the operator keysets, and transmit either dial or revertive pulses. This permits the operators to establish calls through step-by-step and panel as well as crossbar offices.

1.15 The usual application of MF receivers is to incoming senders or registers for establishing calls in crossbar offices. However, as shown in Fig. 1, the receivers are also used with auxiliary equipment such as key monitoring circuits, sender test circuits, service observing circuits, or position test circuits. Another application at No. 5 offices has the receiver associated with automatic monitors.

D. Range of MF Pulsing

1.16 The normal power output of MF transmitters in toll, combined toll and DSA switchboards, toll test boards, test frames, and senders is -3 dbm per frequency at zero transmission level. On local calls, the MF tones are heard by the calling subscribers, and to avoid being objectionable, the sending power from local manual switchboards is -6 dbm per frequency. The engineering limit for operate sensitivity of the receiver is -22 dbm per frequency. These margins permit the use of MF pulsing on trunks having maximum over-all losses of 19 db when connected to toll and DSA switchboards, test boards, and senders, or 16 db when connected to local manual switchboards. Little interference from crosstalk, noise, and echoes on the line is encountered.

2. PRINCIPAL EQUIPMENT ELEMENTS

A. General

2.01 The MF pulsing system consists of the following elements:

- (a) The signaling current supply and distribution arrangements with suitable protection and alarm features.
- (b) The signal transmitters; either manual MF keysets or dial system MF pulsing senders.
- (c) The signal receivers, which translate the MF pulses into dc form.

B. MF Current Supply and Distribution Equipment

2.02 The six MF pulsing frequencies are 700, 900, 1100, 1300, 1500, and 1700 cycles per second. Each frequency is generated by a separate oscillator, which operates continuously. Six oscillators, one for each of the required frequencies, make up an oscillator group.

Oscillator Stabilization

2.03 Each oscillator is a high-gain pentode vacuum tube arranged in a bridge-type circuit. This circuit dependably stabilizes the amplitude and the frequency of the oscillator.

2.04 One arm of the bridge contains a parallel resonant circuit which is arranged to provide negative feedback from the plate to the grid of the tube. A resistance arm in the bridge supplies the grid with positive feedback.

2.05 At resonance, the impedance of the tuned circuit is maximum, and negative feedback through the tuned circuit is minimum. Positive feedback to the grid exceeds negative feedback and sustains oscillations at the resonant frequency.

2.06 For other frequencies, the impedance of the tuned circuit decreases sharply. Negative feedback exceeds positive feedback and suppresses oscillations at these frequencies. The frequency of the oscillator is thus stabilized at the resonant frequency of the tuned circuit.

2.07 The tuned circuit of the bridge has a shunt varistor whose resistance varies inversely with the amplitude of the output voltage. Thus, an increase in output voltage decreases the impedance of the tuned circuit causing more negative feedback. Similarly, a decrease in output voltage reduces negative feedback. By controlling the amount of negative feedback, the varistor stabilizes output amplitude at the desired level.

Distribution and Alarm

2.08 As shown in Fig. 3, the usual MF current supply contains two oscillator groups, which are designated odd and even. In a central office, the odd group is wired to supply odd-numbered keysets and senders, and the even group supplies even-numbered equipment. In this way, the load is conveniently assigned equally to the two groups. However, if a failure occurs in one group, the other is capable of carrying the entire load without serious drop in output voltages.

2.09 Each pair of adjacent oscillators in a group has a sensitive voltage relay connected between output circuits. A difference in output voltage of 1.5 db is sufficient to actuate the relay, which in turn gives an alarm and operates transfer relays. The transfer relays shift the load of the group containing the affected oscillator to the other group. Transfer and alarm equipment is shown in Fig. 3 immediately above the oscillator groups. Connections between principal equipment elements are illustrated by the block diagram in Fig. 4.

2.10 The transfer equipment is arranged to prevent the transmission of pulses by senders during the transfer period. When the transfer is completed, pulsing is resumed.

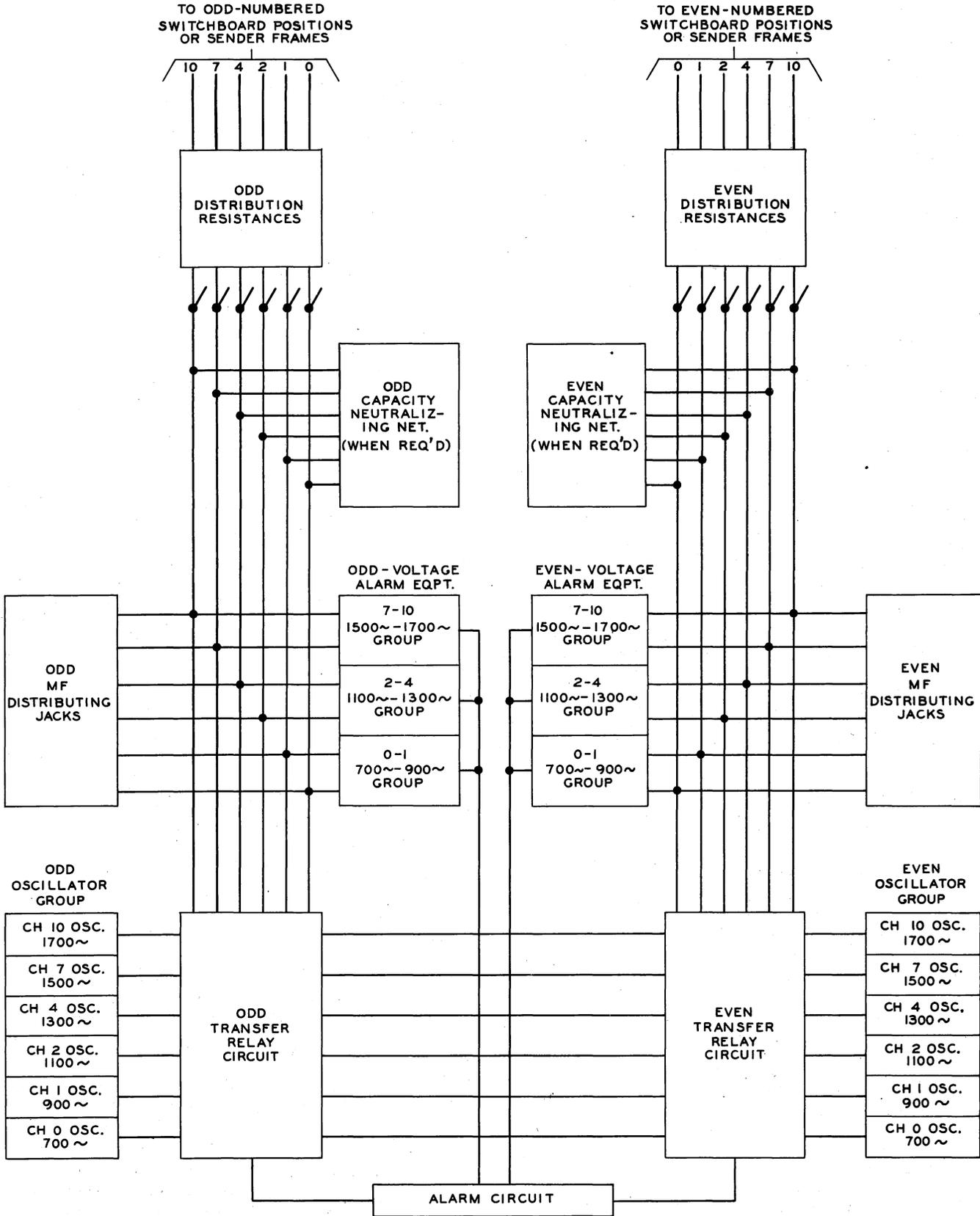


Fig. 4 - MF Supply and Distribution Plan

2.11 The six-wire distribution arrangement which carries MF current to keysets and senders is illustrated by the block diagram in Fig. 4. Distributing resistances are provided in each of the wires. These prevent individual lead troubles from affecting the supply. The resistances and distribution jacks are shown in Fig. 3. An earlier 24-wire distribution arrangement now rated "Mfr. Disc." is replaced by the 6-wire system.

2.12 In offices with long distribution leads, the capacitance between these leads causes a drain on the supply. In such cases, a network of capacitance neutralizing inductances is connected directly across the output leads. (See Fig. 4.)

Bay Arrangements

2.13 A typical bay installation of the MF supply and distribution equipment is illustrated in Fig. 5. In addition to the major components already described, the bay contains transfer and alarm applique equipment. Also shown are a test battery jack, a jack strip for pad circuits, and telephone jacks.

2.14 One MF supply bay is provided for each office in Nos. 1, and 5, and tandem crossbar systems. As a precaution against service loss, two supply bays in separate locations are provided in each No. 4 toll crossbar office.

C. MF Transmitters

2.15 The signal transmitters are positional MF keysets in switchboards or dial system senders arranged for MF pulsing. They are connected singly to trunks, as required. These units combine and send out two of the six frequencies in one pulse for each signal. The combinations of frequencies used for digits 1 to 9, inclusive, provide an additive code as the sum of the frequency designations equals the number. The frequency designated 10 is not used for numerals. The combination sum is 11 for numeral 0, 12 for KP (the beginning of pulsing signal), and 17 for ST (the end of pulsing signal). The complete code is as follows:

Table A
Frequencies and Digit Codes
For MF Pulsing

| <u>Numeral</u> | <u>Code</u> | <u>Frequencies</u> |
|----------------|-------------|--------------------|
| 1 | 0 + 1 | 700 + 900 |
| 2 | 0 + 2 | 700 + 1100 |
| 3 | 1 + 2 | 900 + 1100 |
| 4 | 0 + 4 | 700 + 1300 |
| 5 | 1 + 4 | 900 + 1300 |
| 6 | 2 + 4 | 1100 + 1300 |
| 7 | 0 + 7 | 700 + 1500 |
| 8 | 1 + 7 | 900 + 1500 |
| 9 | 2 + 7 | 1100 + 1500 |
| 0 | 4 + 7 | 1300 + 1500 |
| <u>Control</u> | | |
| KP | 2 + 10 | 1100 + 1700 |
| ST | 7 + 10 | 1500 + 1700 |

D. MF Receiver

2.16 The following discussion is based on a new receiver which uses thyatron tubes in the channel circuits. Figs. 7 and 8 show the front and rear views of this unit.

2.17 An earlier-type receiver uses six relays in place of the thyatron tubes. This unit is still in use in some offices but is now rated "Mfr. Disc." Both types perform essentially the same function.

Functions Of Receiver

2.18 The receiver is connected to a trunk as part of a sender or register as required. It does not respond to voice frequency currents until it receives the KP signal. The unit then can receive and pass on the number codes and the ST signal to its associated sender or other connected equipment.

Receiver Equipment

2.19 Referring to Fig. 9, it is seen that the major features of the receiver include an input circuit, a volume-limiting amplifier, a biasing circuit, a signal present and unlocking circuit, and the receiving channel circuits.

Input Circuit

2.20 The input circuit of an MF receiver must function in several ways. It must operate as an eliminator of longitudinal currents, as an impedance-changing device when the receiver is used as a monitoring unit, and as a point of reception for dc supervisory signals. The receiver must present a correct terminating impedance to the connected incoming line facility so that echo effects may be minimized.

2.21 In the receiver, the incoming transmission pair from a trunk is connected through a sender link to the primary of a repeating coil. The coil is electrically balanced to reduce the effect of longitudinal currents. Taps in the primary winding are made available to a sender or register for the reception of dc supervisory signals. The secondary of the coil is connected to a resistance pad which attenuates incoming signals about 7 db and provides proper input impedance to the volume-limiting amplifier.

Volume-limiting Amplifier

2.22 The volume-limiting amplifier not only produces sufficient amplification of the incoming frequencies for proper channel operation, but also limits the level of strong signals to such a value that they will not cause interference in neighboring channels. The required receiver operating range for incoming signal amplitude is from -22 dbm to -3 dbm per frequency. Limiting action in the single push-pull stage results from the use of grid

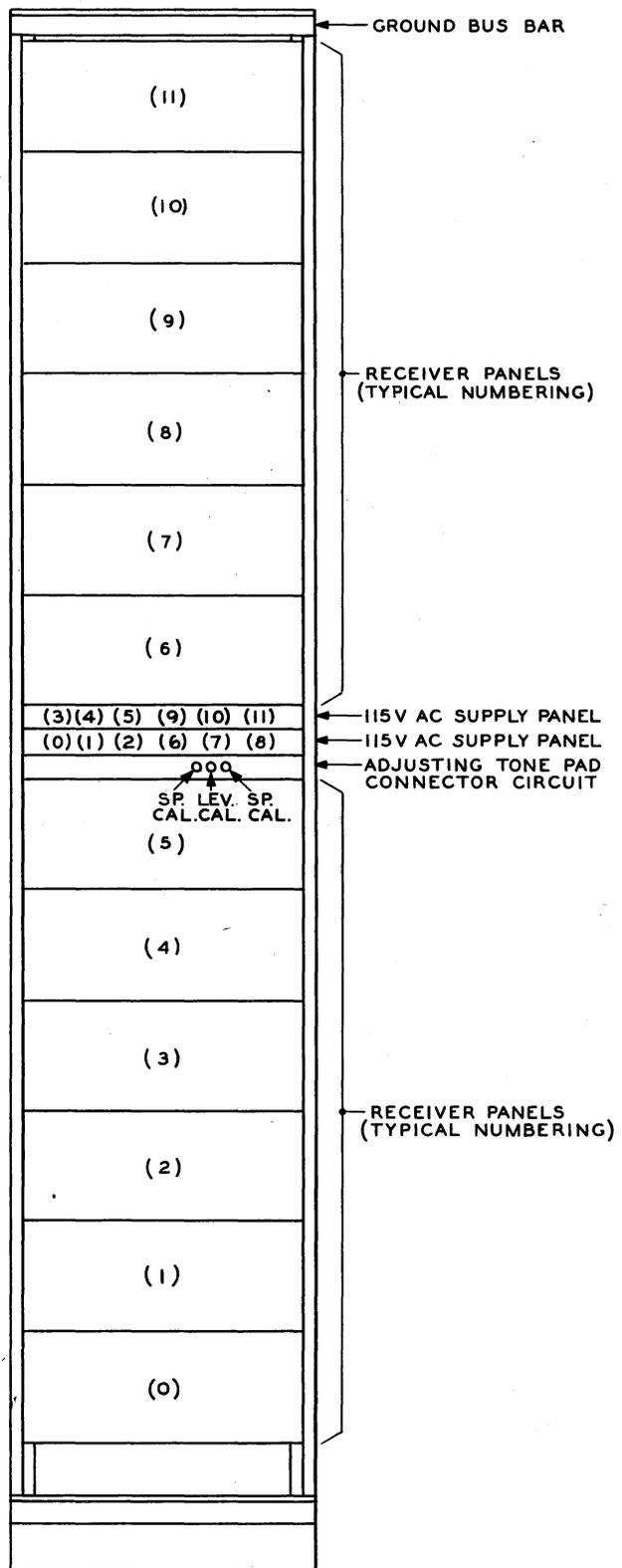
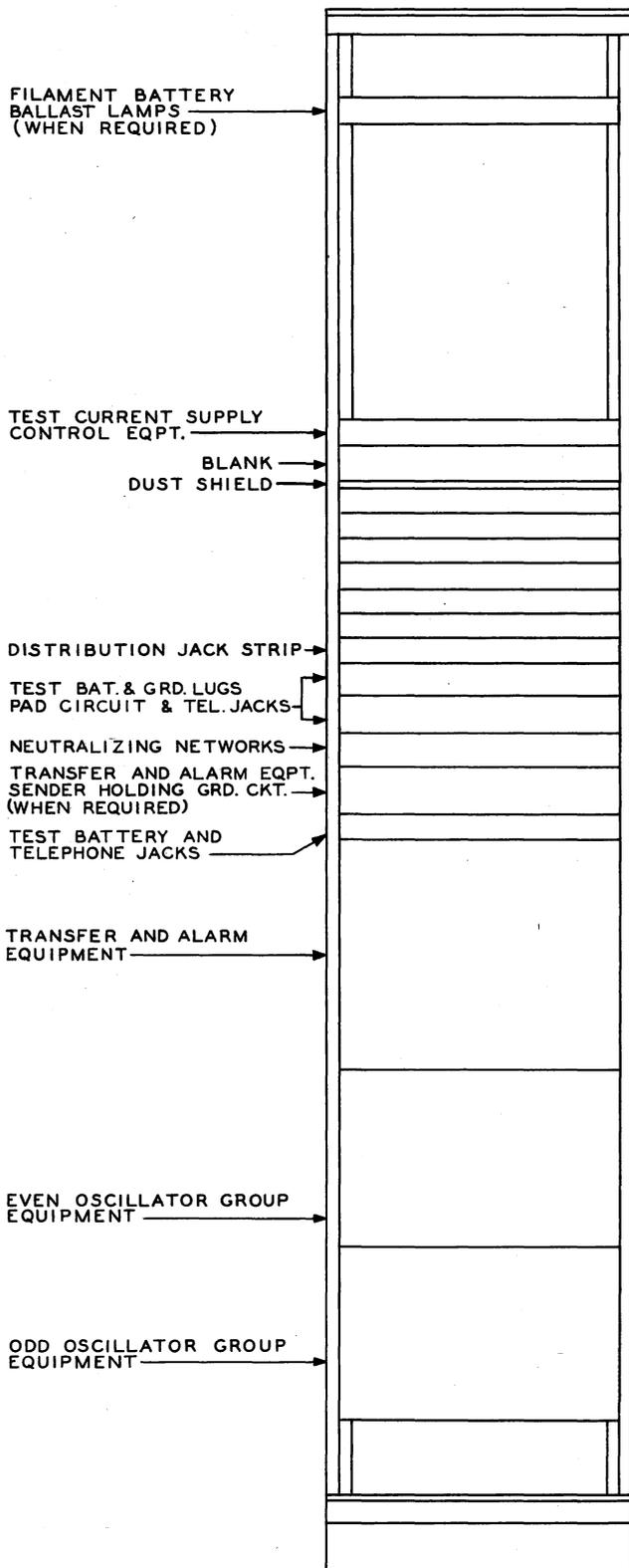


Fig. 5 - MF Supply Units - Bay Arrangement

Fig. 6 - MF Receiver Units - Bay Arrangement

resistances and condensers which cause the grid potential to become more negative when the incoming signal becomes large enough to cause conduction on positive half-cycles. Limiting action is determined not only by the constants used in the control grid circuit, but also by the voltages on the screen grid and cathode elements. Provision is made for adjusting the voltage applied to the screen by means of a potentiometer. (See Fig. 7.)

2.23 The amplifier tubes and associated components are mounted together in a unit which plugs into the receiver panel.

2.24 The output of the volume-limiting amplifier is connected to the receiving channel circuits, the biasing circuit, and the signal present circuit. The volume-limiting action presents a relatively constant signal strength to the channel circuits.

Receiving Channel Circuit

2.25 Each receiving channel circuit consists of a filter, a detector, a thyatron, and a relay. There are six channels, one for each

of the signaling frequencies, which are coded 0, 1, 2, 4, 7, and 10, correspondingly.

2.26 The band-pass filters are assembled with the elements for two channels under one cover. All filter inputs are connected in parallel through a 6 db impedance-improving pad to the volume-limiting amplifier output. The pad acts as a smoothing device between the varying output of the limiter and the input to the filters.

2.27 At the filter output, each channel makes use of one half of a twin-triode tube connected as a diode to rectify or detect the signal. A positive potential in the detector output is added to a negative potential from the variable bias circuit, and the resultant voltage appears on the control grid of the associated thyatron.

2.28 The thyatron will not "fire" and conduct current into its plate circuit even with rated plate voltage applied, if the bias on its control grid is more negative than some rated "trigger" voltage. When the bias

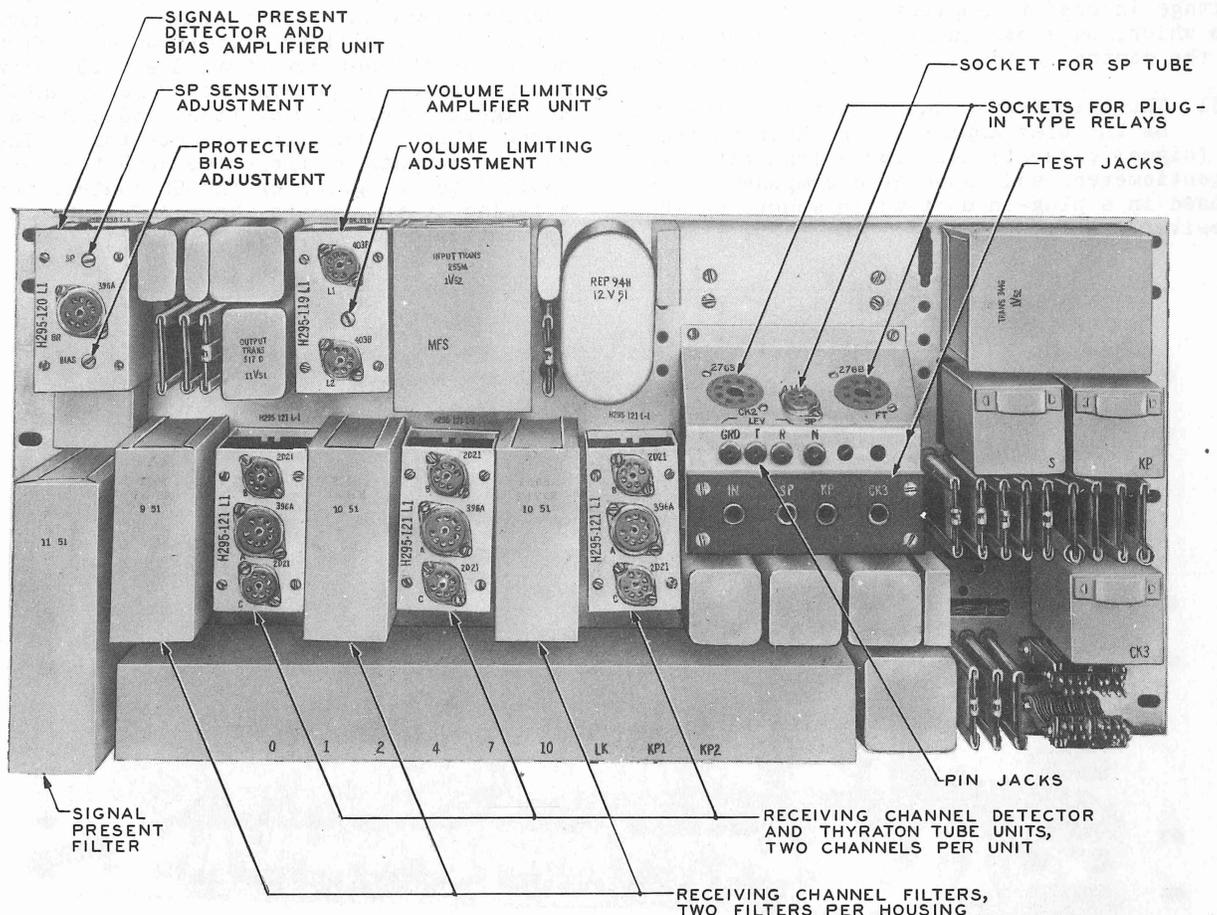


Fig. 7 - MF Receiver Unit - Front View

is changed sufficiently in a positive direction to exceed the "trigger" bias value, the tube will "fire" and continue to conduct current until the plate voltage is removed. The grid loses control and no longer will influence the current in the plate circuit. A relay in the plate circuit operates as soon as the thyratron "fires."

2.29 Three identical plug-in units, containing components for two receiving channels each, mount on the receiver panel. Each unit contains two channel thyratrons, one twin-triode detector tube, and associated condensers and resistances.

Biasing Circuit

2.30 The purpose of the variable bias circuit is to make signal channel sensitivity vary inversely with the amplitude of the signal at the output of the limiting amplifier. Channel sensitivity is determined by the negative bias voltage on the control grid of each channel thyratron. The negative dc potential, developed in the bias dc amplifier output circuit, is proportional to the signal being applied at the input, the level of which is adjusted with a potentiometer. The output voltage is used to augment a fixed bias voltage which, as shown in Fig. 9, is connected to the control grids of all channel thyratrons.

2.31 The twin-triode tube, half of which acts as the bias amplifier and half as the SP (signal present) detector, along with two potentiometers and associated components, is housed in a plug-in unit which mounts on the receiver panel.

Signal Present Circuit

2.32 As the name implies, this circuit recognizes the presence of an incoming signal and remains in an operated condition until the signal ends. An important function of this circuit is to delay recognition of incoming signal frequencies in the channels until any "shock" transient voltages set up in the filters are dissipated. A second function is to prevent duplicate registration on a prolonged incoming digit signal which might result from manual keying. Another function of this circuit is that of establishing the sensitivity of the receiver, an adjustment which is made during calibration by the setting of the SP potentiometer. (See Fig. 7.)

2.33 The voltage for this circuit is impressed on the input terminals of a band-pass filter which has a pass band of 560 to 1850 cycles. The filter output is applied to the grid of a detector tube which is also biased negatively through a potentiometer. The output of the detector is connected to a control circuit. In the digit receiving condition, the presence of a signal in the SP circuit causes an SP relay to prepare sender and channel relays for receiving pulses. However, the control circuit is initially under the control of a signaling voltage obtained from the output of channel detectors 2 and 10 and will not function to operate the SP relay until a KP signal consisting of tones coded 2 and 10 passes through the channel detectors. The voltage outputs of these two detectors are applied to the grids of the SP control tube, allowing it to prepare the receiver for pulsing as mentioned previously.

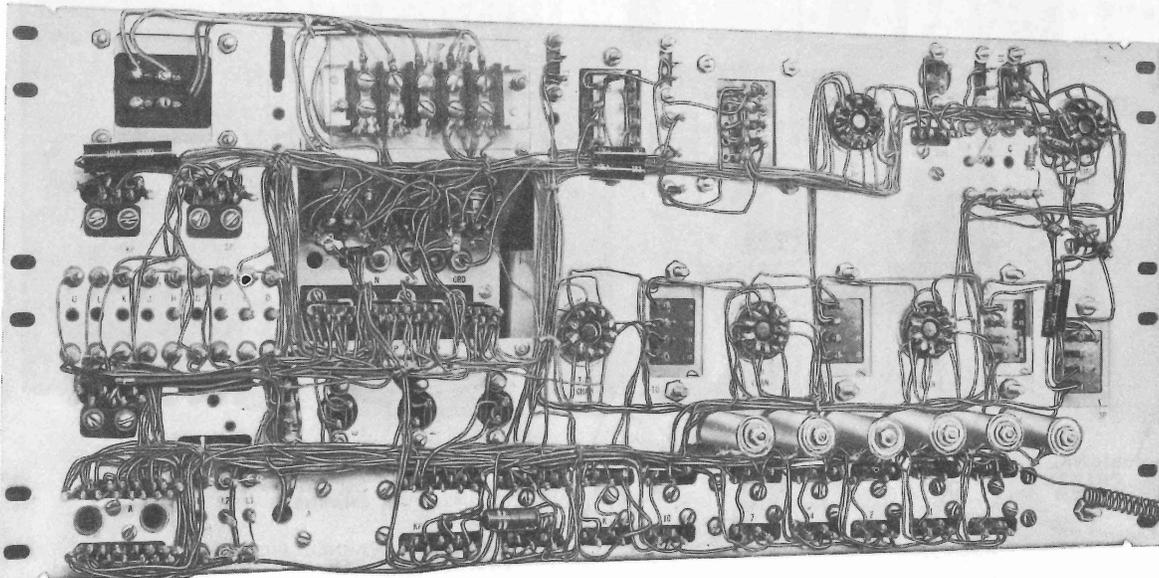


Fig. 8 - MF Receiver Unit - Rear View

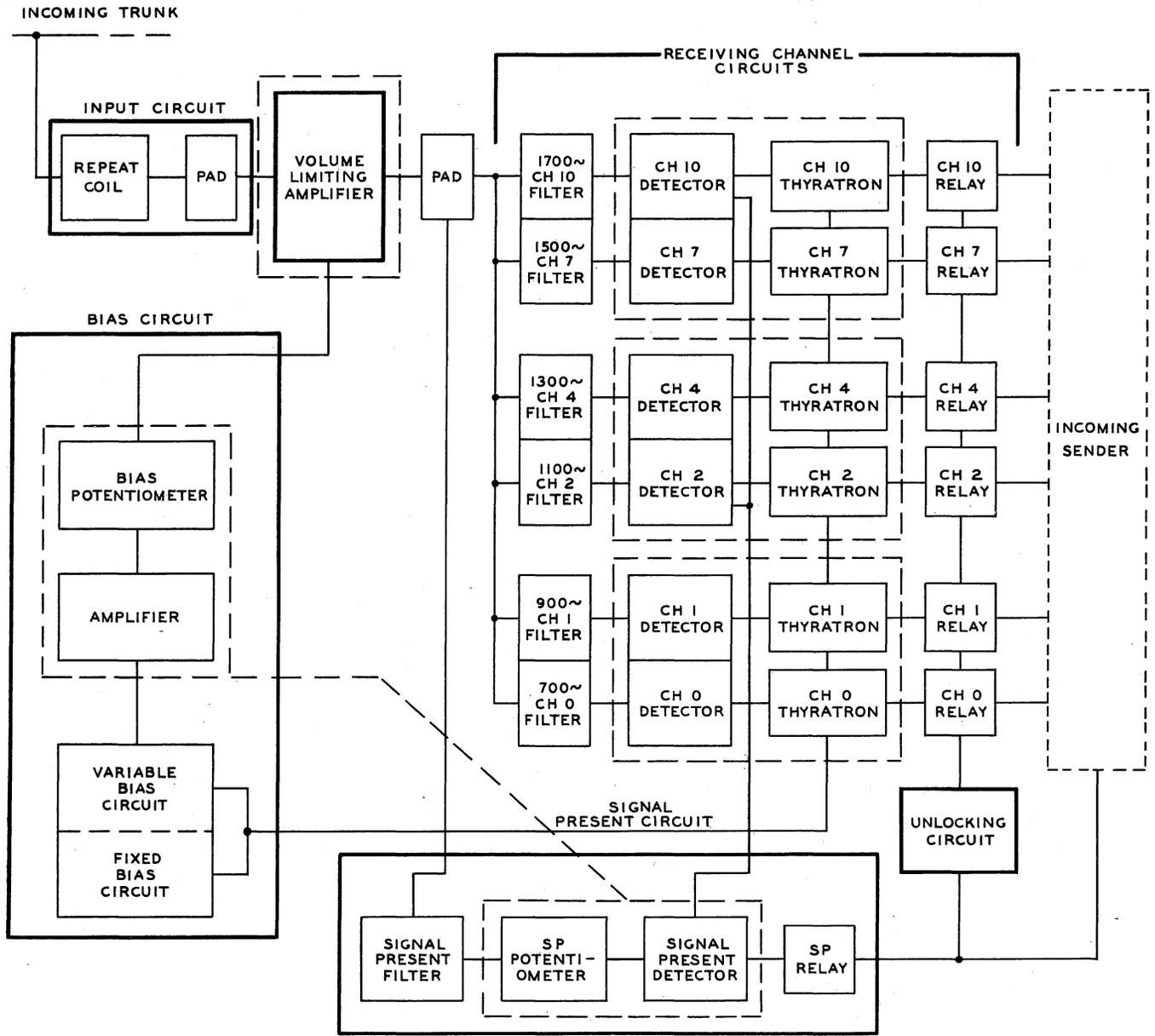
Bay Arrangements

2.34 Receivers may be segregated on separate bays of relay racks or they may be mounted with their associated sender, register, test, or monitoring equipment. When segregated, twelve receivers, two associated 115-volt ac supply units, and the required test frequency supply equipment are mounted on a standard 11' 6" relay rack bay, as shown in Fig. 6.

3. METHOD OF OPERATION ON A TYPICAL CALL

A. General

3.01 This section describes how an operator, using an MF keyset, establishes a call through a crossbar office. The principles of operation apply equally well to calls set up by an MF sender.



NOTE: - - - INDICATES PLUG-IN GROUP

Fig. 9 - MF Receiver Plan

B. Start of Pulsing With KP Pulse

3.02 When an operator handles a call which can be completed through a crossbar office, the first action is to connect a cord circuit to the trunk with the TALK key operated and operate a KP (key pulsing) button of the keyset. (See Fig. 1.)

3.03 The operation of the KP key causes transfer of the cord circuit from the operator's telephone set to the position keyset, lights a positional KP lamp, and prepares the keyset circuit to send the KP signal over the trunk as soon as the distant end signals that it is ready to receive pulses.

3.04 Connection of the cord to the trunk gives a CONNECT supervision signal to the distant end which returns OFF HOOK supervision to delay pulsing until a sender is found. When the sender at the distant end is found and connected to the trunk through a sender link, the supervision is changed to ON HOOK and interpreted as a START PULSING signal at the calling end. This causes the KP pulse signal to go out on the trunk automatically and lights the positional SENDER lamp.

3.05 Receipt of the KP signal at the distant end prepares the MF receiver associated with the sender to accept the digits that are to follow.

C. Digit Pulsing

3.06 The operator may begin keying the digits of the called number as soon as the SENDER lamp is lighted. This is done by pressing one button at a time for each digit.

3.07 The receiver converts the incoming pulses into appropriate dc signals to the sender.

D. End of Pulsing With ST Pulse

3.08 Following the last digit of the series keyed by the operator, the ST key is pressed to indicate the end of pulsing. At the switchboard end, operation of the ST key disconnects the keyset from the cord, re-connects the telephone set under control of the TALK key, and extinguishes the KP and SENDER lamps.

3.09 Whether or not the ST signal, consisting of frequencies coded 7 and 10, serves any useful purpose, depends upon the register arrangement provided in the sender or other circuit with which the receiver is associated. In some cases, the traffic is such that all calls involve the same number of digits, and the sender or other circuit proceeds as soon as the full compliment of digits have been received. In other cases, the number of digits varies from call to call and it is necessary to indicate when all that are needed have been registered. The ST signal serves this purpose,

and although it is superfluous in the former case, it is always transmitted in order to avoid operating complications.

3.10 Receipt of the ST signal tells the receiver to restore to normal.

3.11 If the operator presses two buttons simultaneously, or if the KP key is pressed again after the SENDER lamp lights, usually the distant end returns reorder flashes and the operator must release the connection and start the call over again.

4. MAINTENANCE FEATURESA. Current Supply and Distribution Circuit

4.01 As pointed out previously, two or more groups of oscillators are provided to supply transmitting equipment such as keysets, senders, and pulse converters. When a supply is required only for test circuits, one group of oscillators is provided.

4.02 Each oscillator is equipped with a pair of bridging output jacks, as shown in Fig. 3. These jacks make the oscillators available for output voltage and frequency measurements and output voltage alarm tests. They also provide for emergency patching of the output to other than the normally associated load circuits.

4.03 Each group of oscillators has a set of distributing jacks connected across the output supply leads from the transfer and alarm circuit. These jacks can be used for test access to the distributing leads. Also, in case of damage to the transfer and alarm circuit, the distributing jacks can be patched to the corresponding oscillator output jacks. This connects the output of the oscillators directly to the distributing leads and frees the transfer and alarm circuit for maintenance.

4.04 A test circuit consisting of jacks, resistances, a potentiometer, and a key is provided for checking the voltage alarm feature and the output of the oscillator. This equipment is located on the transfer and alarm equipment panel shown in Fig. 3.

4.05 A 3-way network, equipped with jacks for connecting to a head receiver and to two oscillators, is provided for making beat frequency comparisons between two oscillators of the same frequency or between a single oscillator and a variable frequency test oscillator.

4.06 When two groups of oscillators are used, a transfer and alarm circuit is provided to indicate various alarm conditions and to permit the circuits normally served by either group of oscillators to be transferred to the other group. The transfer is made automatically when one or more oscillators in a group fails to provide signaling voltage at the proper level. The transfer also can be made manually in order to free one oscillator group for clearing trouble or making tests.

4.07 The keys, lamps, and jacks associated with the transfer and alarm circuit are shown in Fig. 3. The lamps indicate the following:

- (a) A ground on an output lead and whether it is associated with the odd or even group of oscillators.
- (b) A voltage failure in the odd or even group of oscillators.
- (c) A transfer of circuits from one group of oscillators to the other.
- (d) A battery failure in the transfer circuit.
- (e) Cancellation of a transfer of circuits from the odd or even group of oscillators.

4.08 Jacks are provided to give access to the windings of double-wound relays used for detecting battery failures in the transfer circuit.

4.09 A feature is provided for locating a false ground on one of the leads used to stop the senders from pulsing while a transfer is being made.

B. Receiving Circuit

"Mfr. Disc." Receiving Circuit

4.10 The original MF receiving circuit equipment occupies the space of ten 1-3/4" mounting plates, and all apparatus is wired in place.

4.11 Five test jacks are provided for testing and adjusting 11 polar relays.

4.12 A single frequency test tone, usually 900 cycles, is provided from the sender test circuit for adjusting the volume limiter and the sensitivity of the signal present circuit.

4.13 All operation tests of the receivers are applied by a test circuit, usually a sender or register test circuit, designed to test the circuits with which the receivers are associated.

Standard Receiving Circuit

4.14 An improved MF receiving circuit was developed to obtain a substantial reduction in initial cost and in unit size. It occupies the space of only five 2" mounting plates. Its characteristics eliminate the need for input pads, reduce the number of polar relays from 11 to 3, and utilize much less expensive vacuum tubes, requiring considerably less heater power by operating on 60 cycles ac. (See Fig. 7.) The new receiver uses +130-volt plate supply instead of 48-volt central office battery.

4.15 One jack is provided on the receiving unit for patching the adjusting tones to the input of the receiving unit. Pin jacks are provided for checking the adjustments.

4.16 Three test jacks are provided for testing the three polar relays.

4.17 A pin jack is provided for access to the N lead, used for short-circuiting a resistance, thus reducing the negative grid bias of the channel thyratrons to a point that will indicate whether the limiter is approaching the point of failure.

4.18 Five plugged-in subassemblies are provided for each receiver. One is used for the volume-limiting amplifier unit, one for the signal present detector and bias amplifier unit, and three interchangeable subassemblies for the channels. These subassemblies will be an aid to maintenance, since a subassembly in trouble can be replaced by a new subassembly while the trouble is being cleared.

4.19 For adjustment of the receivers, a pad circuit is provided which is arranged to deliver three different levels of tone to be used for adjusting the volume limiter and the signal present features of the receiver.

4.20 When current supply and distribution equipment is provided in the same building with the receivers, the pad equipment together with associated jacks is located on the current supply bay, and the tone is produced by a combination of two frequencies.

4.21 When a current supply and distributing equipment is not provided in the same building, which may be the case when the receiver is used with service observing or key monitoring equipment, the pad circuit or equivalent, designed for making the adjustments with an available 1000-cycle supply, will be provided with the receiver equipment.

4.22 A filament supply and transfer circuit is provided to supply alternating current for the regular filament supply, to automatically transfer the filaments to the office 48-volt dc supply when the ac voltage falls 10 percent below normal, and to automatically transfer back to the ac supply when the voltage has returned to 95 percent of normal. Included is a means for detecting a trouble ground or battery in the filament circuit, and provisions which prevent a transfer from the ac supply to the dc supply as long as there is a trouble ground or battery condition in the filament circuit. An audible and visual alarm is provided for each of these conditions.

4.23 All operation tests are applied by the office test facilities, usually a sender or register test circuit, designed to test the circuits with which the receivers are associated.