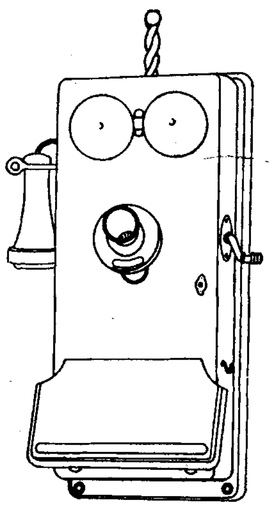
R.H. Brown

FUNDAMENTALS OF TELEPHONY

LESSON NO. 1

Issued March, 1962



Western Electric Company
INCORPORATED

Equipment Engineering — Area "B"   **Engineering Personnel Relations**

5/1/63 Instructor – [illegible] MM 65-5[illegible]
Call [illegible] when set. Room 40[illegible]
in Bldg. 24-4 Wed's 10-12 ([illegible])

Western Electric Company, Inc.
Equipment Engineering - Area "B"
Engineering Personnel Relations

For Training Purposes Only

Lesson No. 1

FUNDAMENTALS OF TELEPHONY

This Lesson covers the basic theory of the Telephone and Telephone Switching, together with the general features of the various Switching Systems. Comparisons are drawn between the various Dial Systems and the Manual Switching System to assist in understanding the various Switching Machines.

Information contained herein is to be used only for training purposes.

CONTENTS

Issued March, 1962

Bibliography

Bell System Publications

Western Electric Company, Inc.
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Lesson No. 1

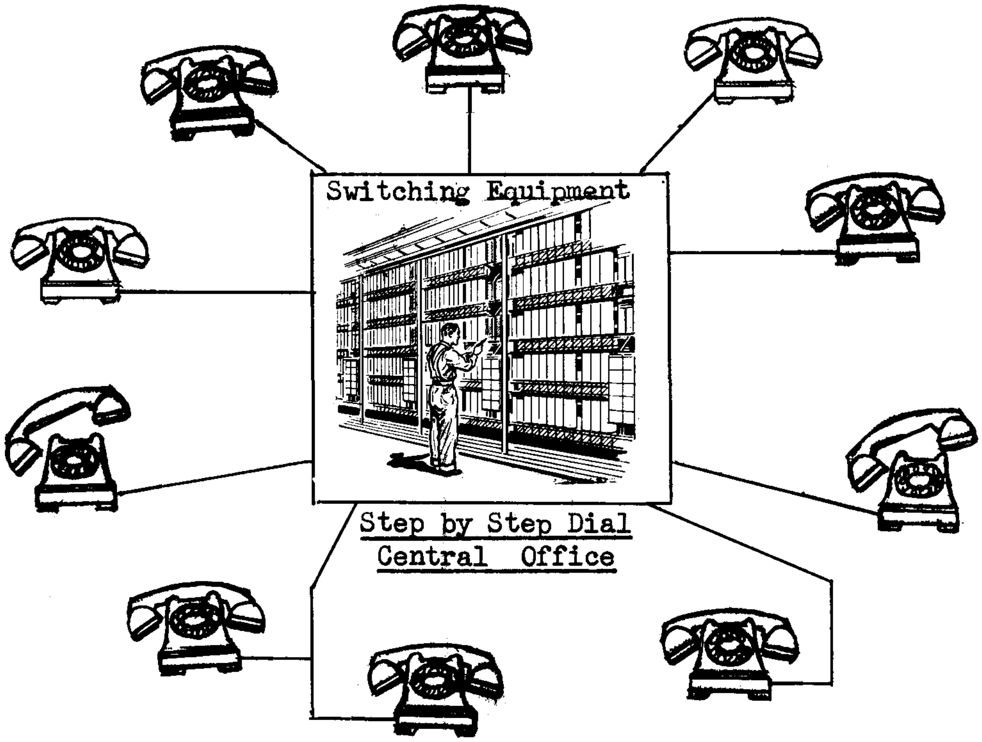
FUNDAMENTALS OF TELEPHONY

Section 1

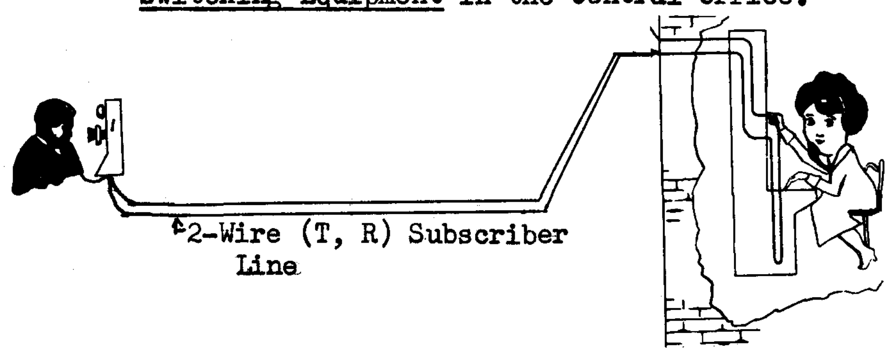
Principles of Telephone Switching

CONTENTS

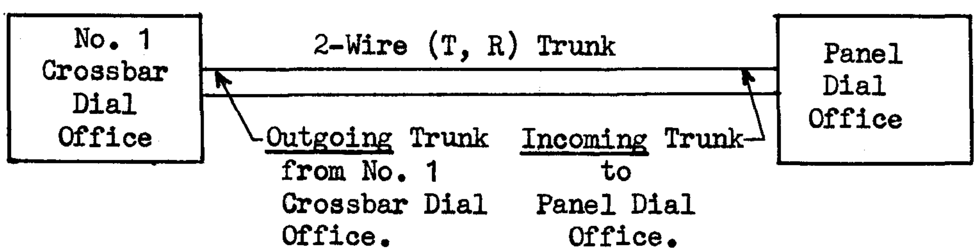
Function - The function of any Telephone Switching System is to connect together temporarily the Lines of any two Subscribers so they may talk.



Subscriber Line - A 2-wire Path between a Subset (Telephone) and the Switching Equipment in the Central Office.



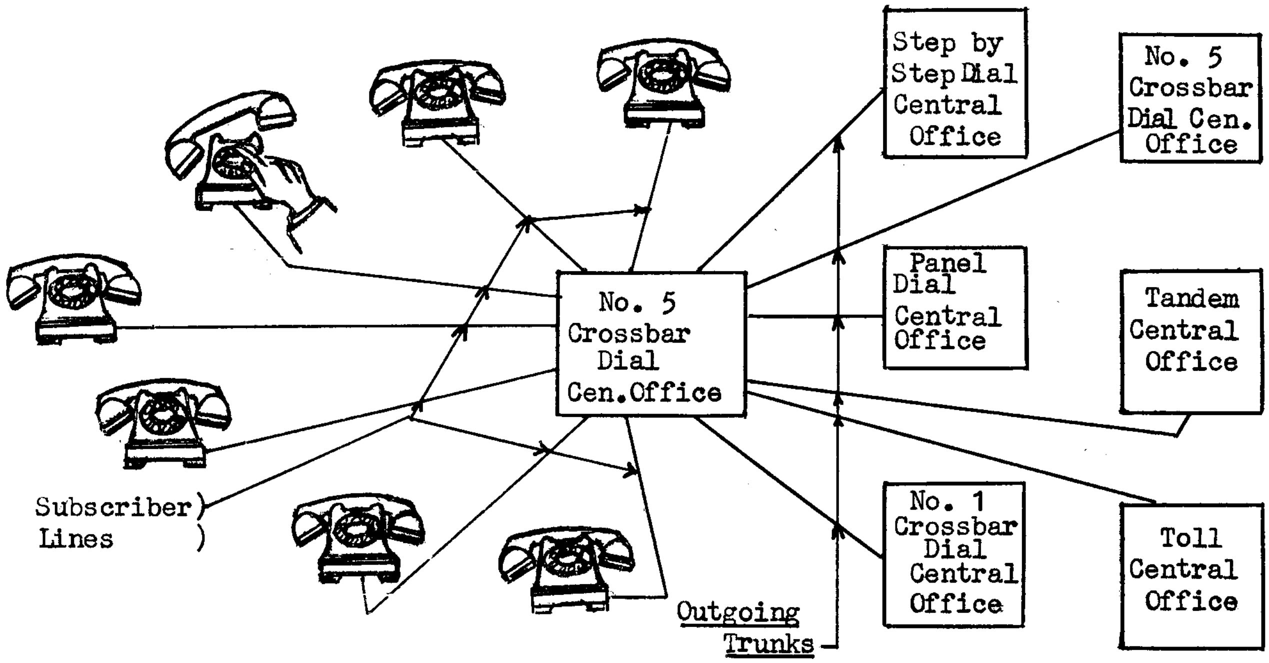
Trunk - A 2-wire Path (T, R) between two Central Offices.



2 appearances of a line are jack & lamp.

Requirements of a Telephone Switching System

1) Originating Calls - Each Subscriber Line must have access through the Switching Equipment to all other Subscriber Lines terminating in that Central Office, as well as to all Outgoing Trunks to other Central Offices.



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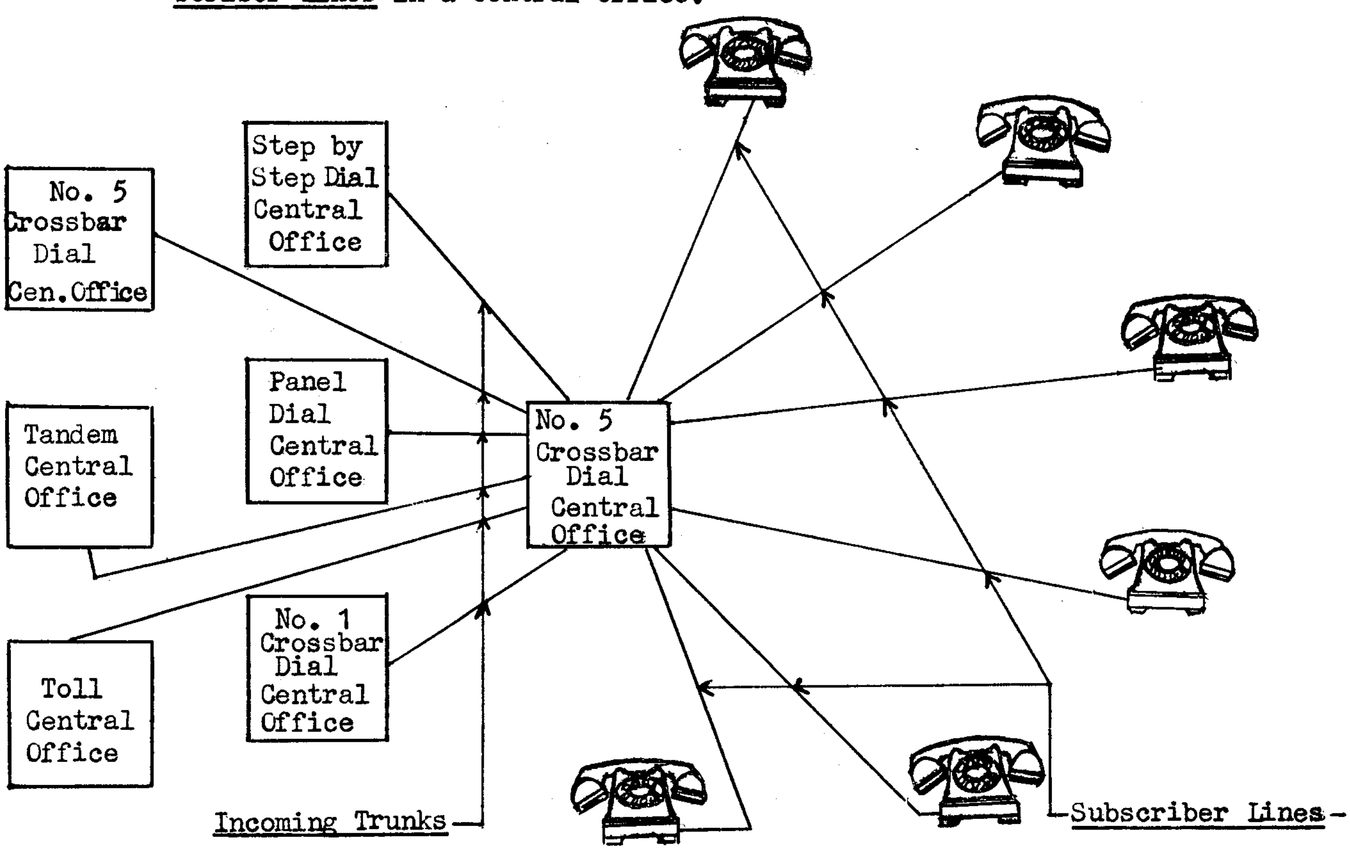
2) Terminating Calls - Each Incoming Trunk must have access to all Subscriber Lines in a Central Office.



Tandem Office - A Central Office used as an intermediate Switching Point for traffic between other Central Offices.

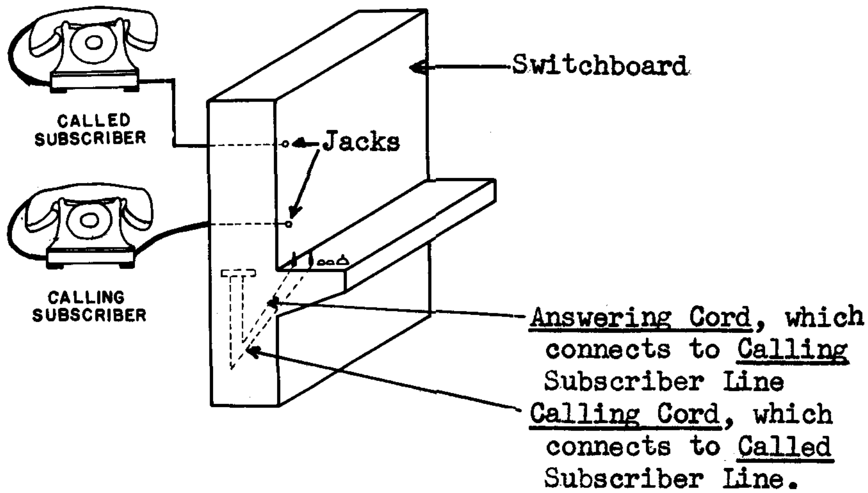
Toll Office - A Central Office for completing Calls to destinations outside the Local Service Area of the Calling Station.

Telephone Switching Systems

1) Manual
2) Dial
   a) Direct Dial Control
   b) Common Control

Manual Switching System

1) Subscriber Lines are cabled to Jacks mounted on a Switchboard.
2) Operators connect Subscriber Lines together manually by inserting Plugs on the ends of Cords into Jacks.

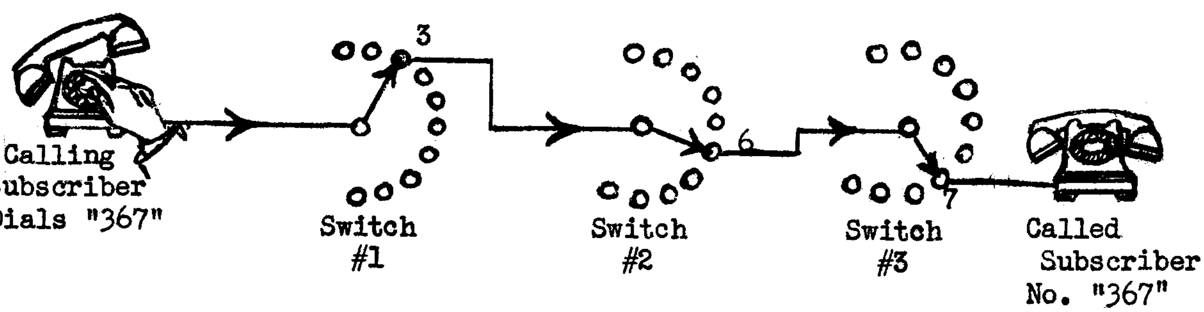


Dial Switching Systems

1) Subscriber Lines cable to electro-mechanical switches, instead of Jacks.

2) The Calling Subscriber operates a Dial, which transmits electrically the Called Telephone Number to the Switching Equipment in the Central Office.

3) Direct Dial Control - Switches respond directly to Dial Pulses as the Calling Subscriber dials the digits of the Called Telephone Number.

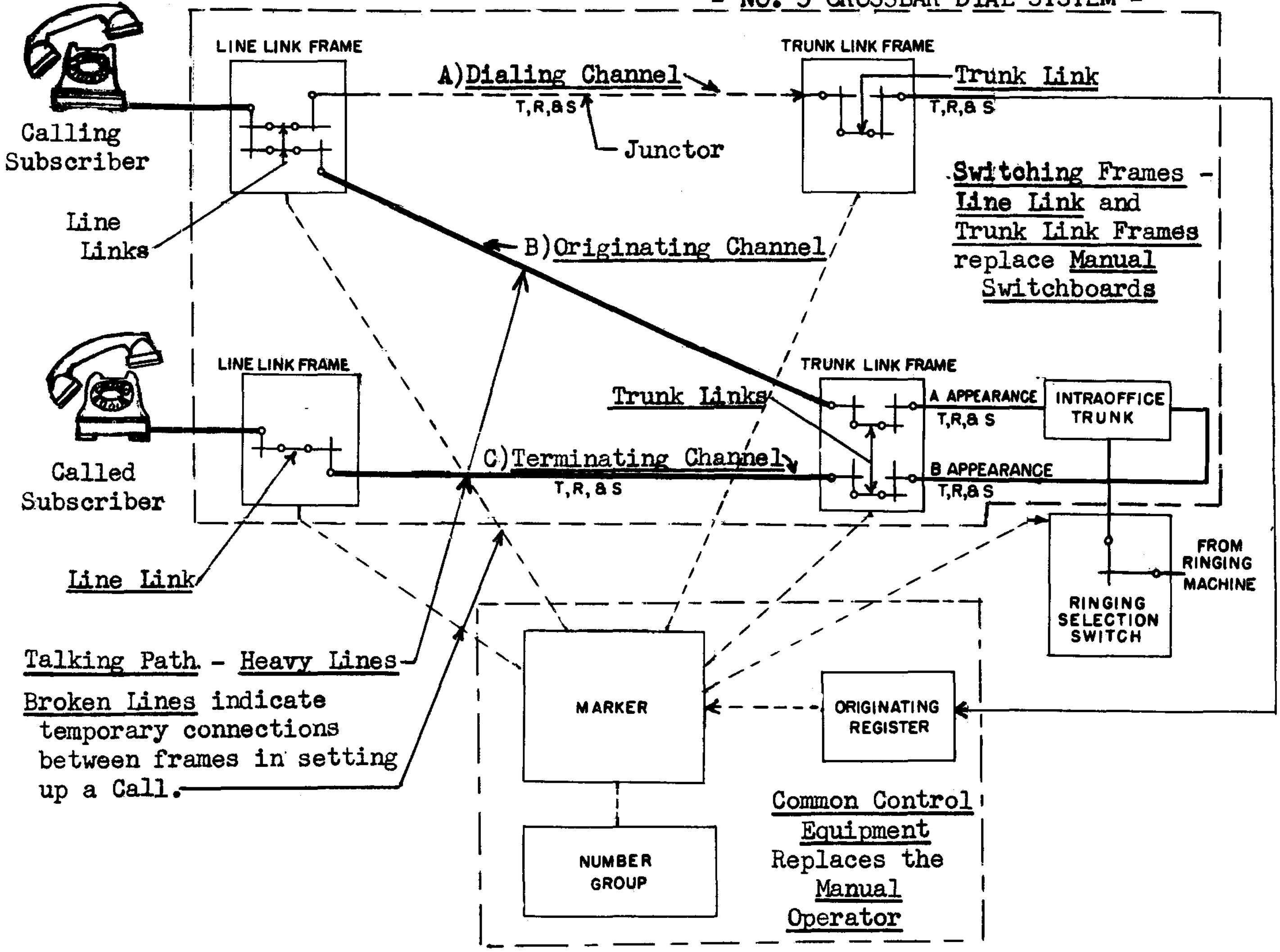


4) The Step-by-Step Dial Switching System is a Direct Dial Control System.

5) Common Control Switching Systems - The dialed digits of the Called Telephone Number are registered in the Common Control Equipment, which uses the stored information to:

1) Select an Idle Talking Path, through the Switching Frames, between the Calling and Called Subscribers.
2) Close through the Talking Path.
3) Then the Common Control Equipment releases, to be used in setting up other Calls.

- NO. 5 CROSSBAR DIAL SYSTEM -



A) Dialing Channel - Between the Calling Subset and the Originating Register - made up of:
1) Line Link,
2) Junctor,
3) Trunk Link.

B) Originating Channel - Between the Calling Subset and the Intraoffice Trunk - made up of:
1) Line Link,
2) Junctor,
3) Trunk Link.

C) Terminating Channel - Between the Intraoffice Trunk and the Called Subset - made up of:
1) Trunk Link,
2) Junctor,
3) Line Link.

(B and C) - Talking Path

4) Common Control Switching Systems:
a) Panel Dial
b) No. 1 Crossbar Dial
c) No. 5 Crossbar Dial
d) Crossbar Tandem
e) Crossbar Toll.

Western Electric Company, Inc.
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FUNDAMENTALS OF TELEPHONY

Section 2

Early Developments in Dial Switching Systems

CONTENTS

+Table I — List of United States Patents on Automatic Telephone Exchanges Issued During the Years 1879-1900, Inclusive.*

Number	Date Issued	Patentee	Application Date
222,458	Dec. 9, 1879	Connolly & McTighe	Sept. 10, 1879
223,201	Dec. 30, 1879	Westinghouse, G. Jr.	Oct. 11, 1879
223,202	Dec. 30, 1879	Westinghouse, G. Jr.	Oct. 13, 1879
224,565	Feb. 17, 1880	Westinghouse, G. Jr.	Oct. 27, 1879
237,222	Feb. 1, 1881	Westinghouse, G. Jr.	Feb. 7, 1880
248,138	Oct. 11, 1881	Buell, C. E.	June 15, 1881
255,766	Apr. 4, 1882	Buell, C. E.	Dec. 12, 1881
262,645	Aug. 15, 1882	Connolly & McTighe	Aug. 29, 1881
262,646	Aug. 15, 1882	Connolly, M. D.	Nov. 29, 1881
262,647	Aug. 15, 1882	Connolly, M. D.	Nov. 8, 1881
263,862	Sept. 5, 1882	Connolly, M. D.	Oct. 29, 1881
269,130	Dec. 12, 1882	Snell, F. H.	Sept. 6, 1882
281,613	July 17, 1883	Cardwell, G. A.	July 7, 1882
282,791	Aug. 7, 1883	Snell, F. H.	Feb. 28, 1883
283,806	Aug. 28, 1883	O'Donel, I. M.	June 5, 1880
290,730	Dec. 25, 1883	Bartelous, J. V. M.	June 15, 1282
295,356	Mar. 18, 1884	Connolly, T. A.	Apr. 10, 1883
310,282	Jan. 6, 1885	Jackson & Cole	Mar. 5, 1884
335,708	Feb. 9, 1886	Lockwood, T. D.	Sept. 26, 1885
349,975	Sept. 28, 1886	Bickford, J. H.	Nov. 25, 1885
349,976	Sept. 28, 1886	Bickford, J. H.	Jan. 18, 1886
367,219	July 26, 1887	McCoy, J. A.	Jan. 29, 1887
372,378	Nov. 1, 1887	Lockwood, T. D.	Apr. 11, 1887
381,938	May 1, 1888	McCoy, J. A.	July 6, 1887
408,327	Aug. 6, 1889	Smith, J. R.	Feb. 16, 1888
435,295	Aug. 26, 1890	Ford, W. H.	Dec. 31, 1889
442,734	Dec. 16, 1890	Smith & Childs	Sept. 27, 1889
447,918	Mar. 10, 1891	Strowger, A. B.	Mar. 12, 1889
457,477	Aug. 11, 1891	Hayes & Sears	Feb. 3, 1891
486,909	Nov. 29, 1892	Strowger, A. B.	Feb. 19, 1892
498,236	May 30, 1893	Clark, E. A.	Apr. 5, 1892
498,289	May 30, 1893	McCaskey, A. S.	July 29, 1892
498,291	May 30, 1893	McCaskey, A. S.	Aug. 25, 1892
499,748	June 20, 1893	McClaren, A. E.	June 13, 1892
510,195	Dec. 5, 1893	Serdinko, J.	Apr. 22, 1893
511,873	Jan. 2, 1894	Callender, R.	Apr. 24, 1893
511,874	Jan. 2, 1894	Callender, R.	May 12, 1893
511,875	Jan. 2, 1894	Callender, R.	Aug. 13, 1892
515,108	Feb. 20, 1894	Callender, R.	Nov. 2, 1893
515,109	Feb. 20, 1894	Callender, R.	Nov. 2, 1893
515,110	Feb. 20, 1894	Callender, R.	Nov. 2, 1893
520,246	May 22, 1894	Simoneau, L. E.	July 11, 1893
528,590	Nov. 6, 1894	Childs, W.	May 12, 1891
528,591	Nov. 6, 1894	Childs, W.	May 27, 1890
530,324	Dec. 4, 1894	Callender, R.	Dec. 18, 1893
533,893	Feb. 12, 1895	Hey & Parsons	Mar. 30, 1893
535,806	Mar. 12, 1895	Nissl, F.	Feb. 17, 1894
537,603	Apr. 16, 1895	Decker, W.	May 14, 1894
538,975	May 7, 1895	McDonough, J. W.	May 21, 1891
540,168	May 28, 1895	Keith, Lundquist & Erickson	Nov. 7, 1894
543,160	July 23, 1895	Shibata, W. Y.	Oct. 11, 1894
543,708	July 30, 1895	Shibata, W. Y.	Nov. 24, 1893
546,725	Sept. 24, 1895	†Berditschewsky et al.	Mar. 27, 1895
547,755	Oct. 8, 1895	Hutchins, G. K.	May 6, 1893
550,728	Dec. 3, 1895	Smith, J. G.	Feb. 18, 1893
550,729	Dec. 3, 1895	Smith, J. G.	Feb. 20, 1893
551,391	Dec. 17, 1895	Lounsbury, W. F.	Apr. 23, 1895
554,125	Feb. 4, 1896	Houts, W. A.	Dec. 24, 1894
556,007	Mar. 10, 1896	Freudenberg, M.	Jan. 10, 1896
561,377	June 2, 1896	Dean, G. Q. & J. Jr.	Aug. 3, 1895
562,064	June 16, 1896	†S. Berditschewsky	Mar. 23, 1896
570,840	Nov. 3, 1896	Brooks, M.	Jan. 26, 1895
573,859	Dec. 29, 1896	Callender, R.	Mar. 19, 1896
573,884	Dec. 29, 1896	Keith, A. E.	Sept. 16, 1893
574,245	Dec. 29, 1896	Houts & Nilson	Aug. 25, 1896
574,707	Jan. 5, 1897	Bowman, L. G.	July 18, 1896
582,578	May 11, 1897	Clark, Ellacott & Johnson	Sept. 28, 1893
584,384	June 15, 1897	Macklin, A. B.	Aug. 7, 1896
586,529	July 13, 1897	Davis, W. W.	Sept. 5, 1896
587,435	Aug. 3, 1897	Freudenberg, M.	Oct. 22, 1896
588,511	Aug. 17, 1897	Van Wagenen, A.	Apr. 30, 1896
589,798	Sept. 7, 1897	Strowger & Keith	Feb. 19, 1896
591,201	Oct. 5, 1897	Strowger, Lundquist & Erickson	July 17, 1895
597,062	Jan. 11, 1898	Keith & Erickson	Aug. 20, 1896
604,373	May 24, 1898	Decker, W.	Mar. 25, 1895
604,434	May 24, 1898	Stillwell & Barneck	Nov. 10, 1896
606,764	July 5, 1898	Lundquist, F. A.	May 19, 1897
611,974	Oct. 4, 1898	Nilson, L. G.	Mar. 9, 1896
612,681	Oct. 13, 1898	Snow, H. P.	Nov. 1, 1897
616,714	Dec. 27, 1898	Lundquist & Erickson	Mar. 28, 1893
624,666	May 9, 1899	Lundquist, F. A.	Sept. 20, 1897
626,983	June 13, 1899	Decker, W.	Aug. 3, 1896
632,759	Sept. 12, 1899	Slater, J. C.	May 23, 1898
638,249	Dec. 5, 1899	Keith & Erickson	Dec. 16, 1895
639,186	Dec. 12, 1899	Seligmann-Lui, G.	May 27, 1898

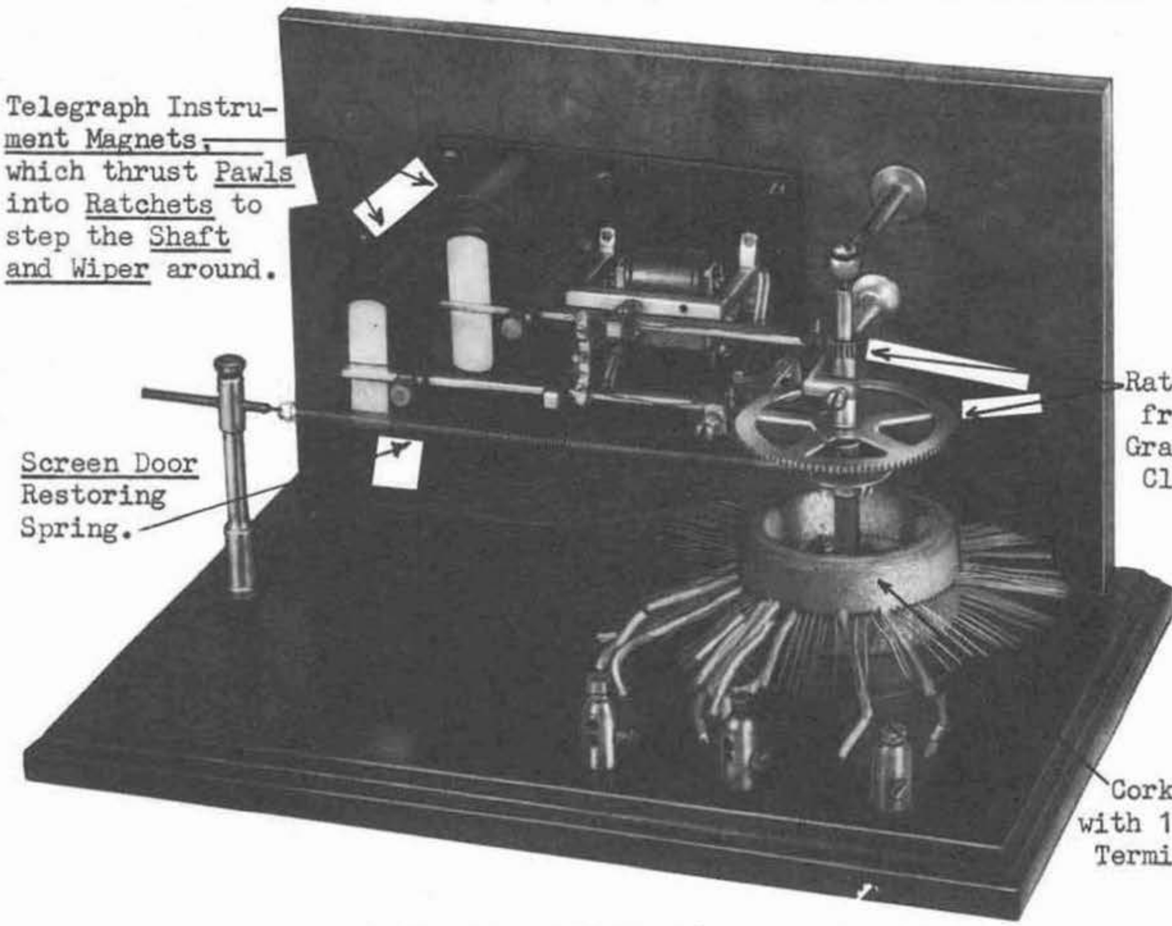
* Excludes village, house and factory systems. † Called "Apostoloff." Note:—No automatic telephone exchange patents were issued during the year 1900.

+ Taken from the Bell Laboratories Record January, 1953.

STEP BY STEP DIAL

During the Jesse James Era, Almon B. Strowger of Kansas City found the undertaking business rather slow. Upon investigation, he discovered the local telephone operator was his competitor's daughter; therefore he developed the Step by Step Dial Switching System so that he might enjoy a more equitable share of that business.

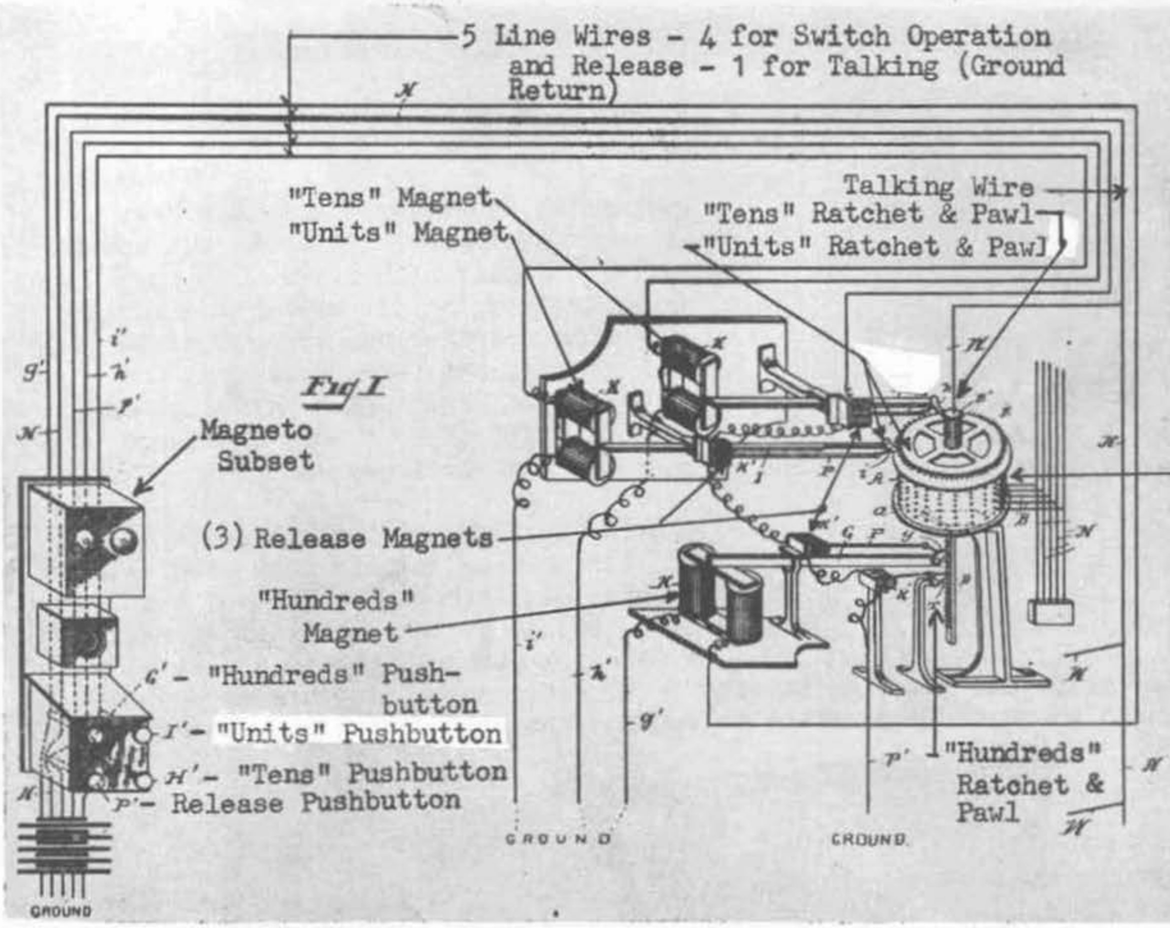
One day in 1889, during his spare time, Mr. Strowger sat at his desk carefully placing pins around the edge of a collar box. He had an idea that, by arranging a metal finger or wiper on a centrally located shaft and rotating it with an electromagnet, he could develop a mechanism which could complete telephone connections without human aid.



An Experimental Strowger Switch - 1891

Mr. Strowger came to Chicago with his idea and an experimental switch. A company was formed known as the, "Strowger Automatic Telephone Exchange;" later reorganized as the Automatic Electric Company.

THE STROWGER PATENT #447,918, Issued March 10, 1891



To call No. 315, the Calling Subscriber depressed the "Hundreds" Pushbutton (G') three (3) times, lifting the Shaft and Wiper three (3) notches, and bringing the Wiper opposite the third horizontal row of terminals. He then depressed the "Tens" Pushbutton (H') once, which caused the "Tens" Ratchet and Pawl Assembly to step the Wiper horizontally to Terminal or Contact No. 310. Depressing the "Units" Pushbutton (I') five (5) times forced the Pawl into the 100-tooth Ratchet five (5) times, moving the Wiper to Contact No. 315. The Calling Subscriber next cranked his Magneto, applying Ringing Current to the Called Subscriber Line to signal the Called Subscriber. After the conversation was completed, the Calling Subscriber depressed the Release Pushbutton (P'), energizing the Release Magnets and thereby restoring the Switch Shaft and Wiper to normal.

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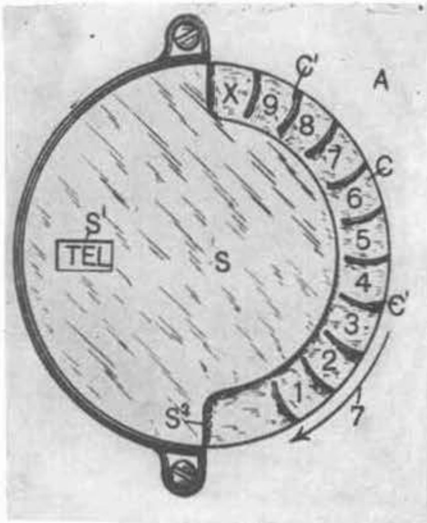
The First Strowger Automatic Telephone Exchange

Installed at La Porte, Indiana.
Cutover November 3, 1892.

5 Line Wires.
Pushbuttons for "Dialing" and Release.
Hand-Cranked Magneto for Ringing.
About 75 Subscribers.
Flat Rubber Disc Type Switch, with Rotary movement only, and one circular Row of Terminals.

The "Finger-Wheel" Dial Replaces the "Pushbuttons"



Finger-Wheel Dial Developed by
Strowger Engineers:
A. E. Keith,
John Erickson,
Charles J. Erickson
Patent #597,062, issued
August 20, 1896.
Finger Slots replaced
by Finger Holes in
Later Subscriber Dials.

Push-Button Dialing resulted in a high percentage of dialing errors and "Wrong Numbers," which made Subscribers very unhappy and unnecessarily wore out the Equipment.

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Western Electric Company Meets the Competition by Developing its Own Version of the Dial

Makeup of Dial

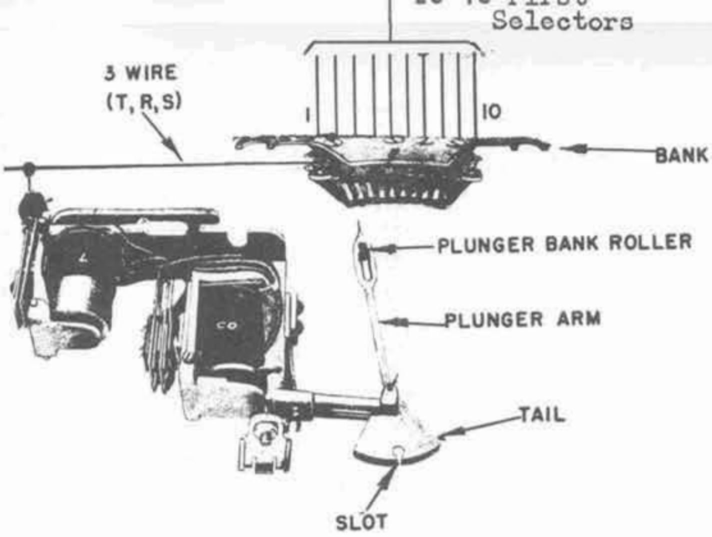
100 Holes drilled in an Iron Ring.
Any one Subscriber in the group of 100 could be selected by a single "pull" of the Dial.
Dialing was done by means of a Spring-Loaded Crank.

To Dial Subscriber #89

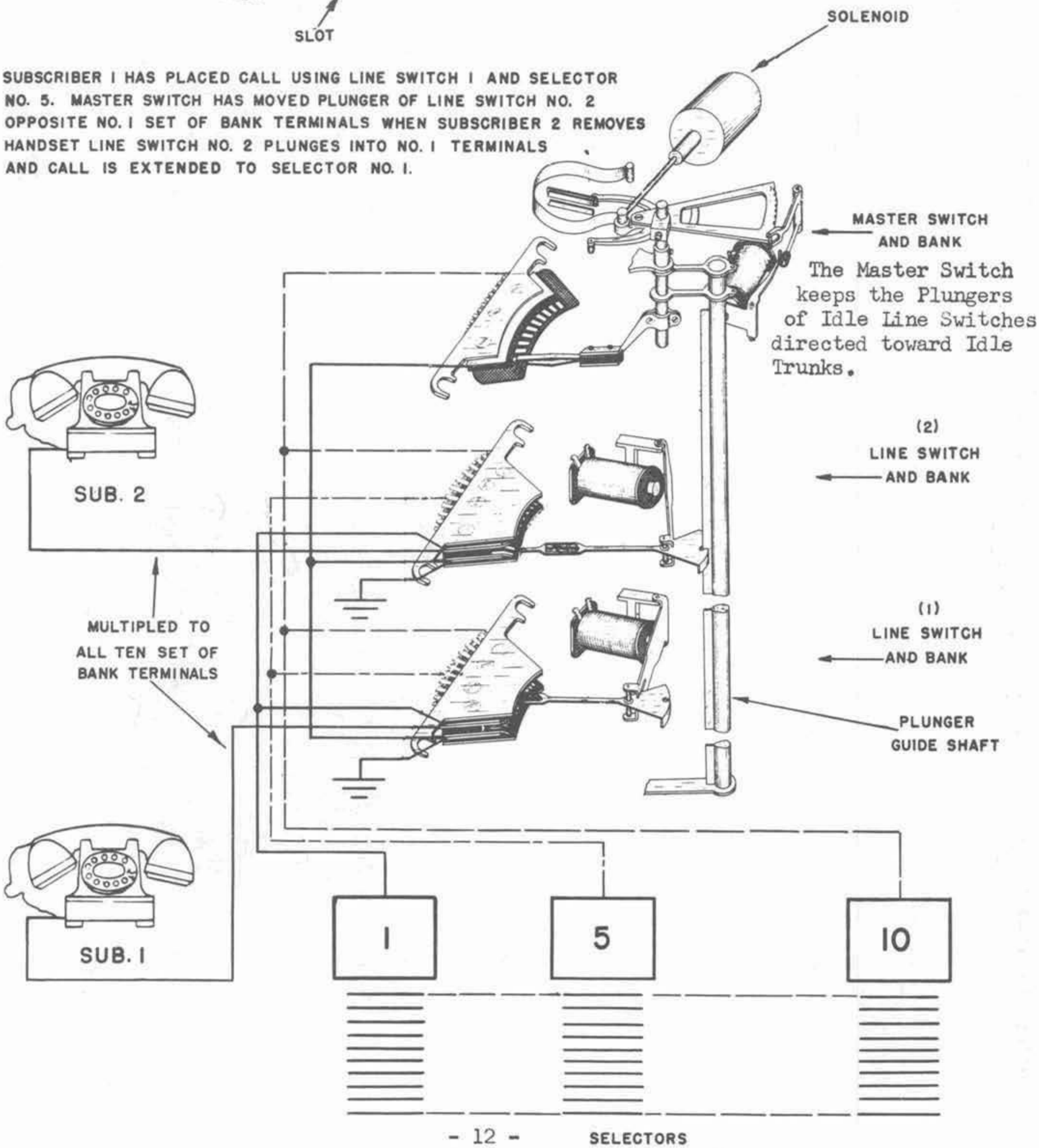
Insert the Peg on the end of the Chain in hole No. 89.
Pull the Dial Crank around to rest against the Peg and then release.
As the Dial Crank restores to normal, 89 pulses control the switching equipment in the Central Office to cut through to Subscriber No. 89.
A Pushbutton was furnished for Ringing the Called Station.

This type of Subscriber Dial was abandoned as the number of Telephone Subscribers increased over 100.

THE KEITH LINE SWITCH - 1907



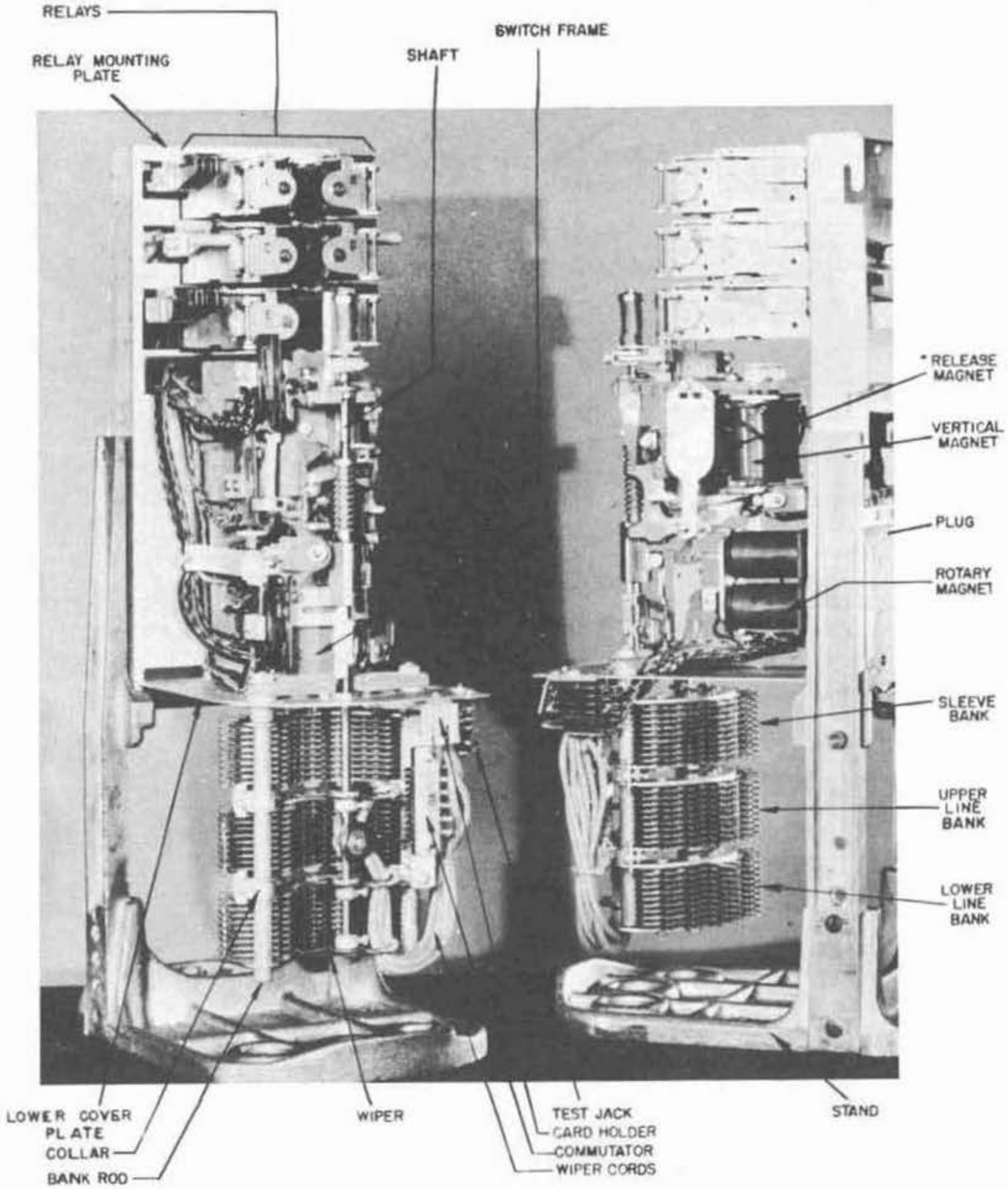
The expensive Switch used for each Subscriber Line in early Strowger Exchanges was replaced by a smaller and more economical Plunger Type Line Switch, developed by A. E. Keith, and first used in 1907. Thus each Subscriber Line terminated in one of these Line Switches, which operated to connect that Line to an Idle First Selector Switch when the Calling Subscriber removed his Handset.



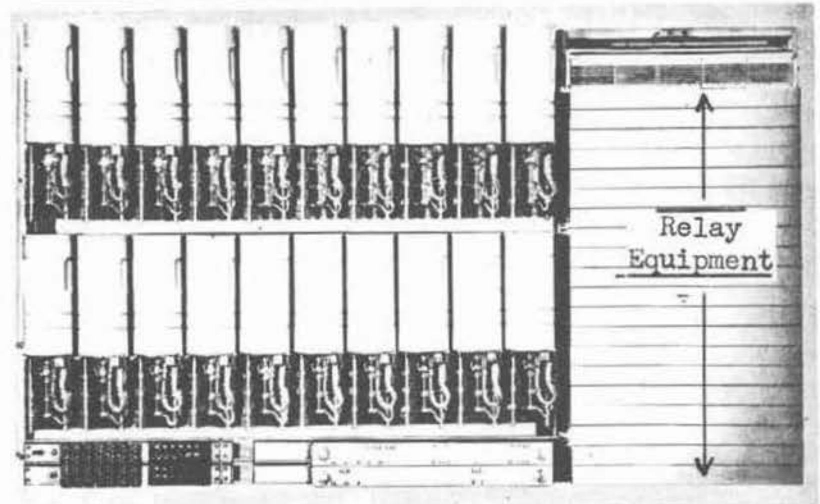
THE LINE FINDER SWITCH - 1927

The Line Finder Switch, serving 200 Lines, was developed, using the standard switch mechanism (the same as used in Selector and Connector Switches), to replace the Keith Line Switch required for each Line.

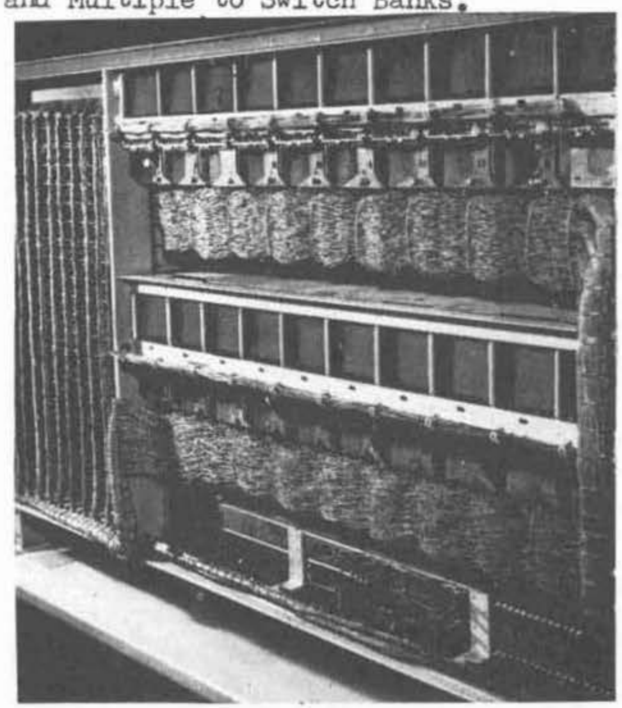
1927 - Line Finder Switches first installed in Brazil, Ind.



A Line Finder Unit, normally 20 Line Finder Switches, serves a Line Group of 200 Lines. Three (3) Units mount one above the other on a Line Finder Frame.



Below - Rear View of Line Finder Unit. Note Local Cable and Multiple to Switch Banks.

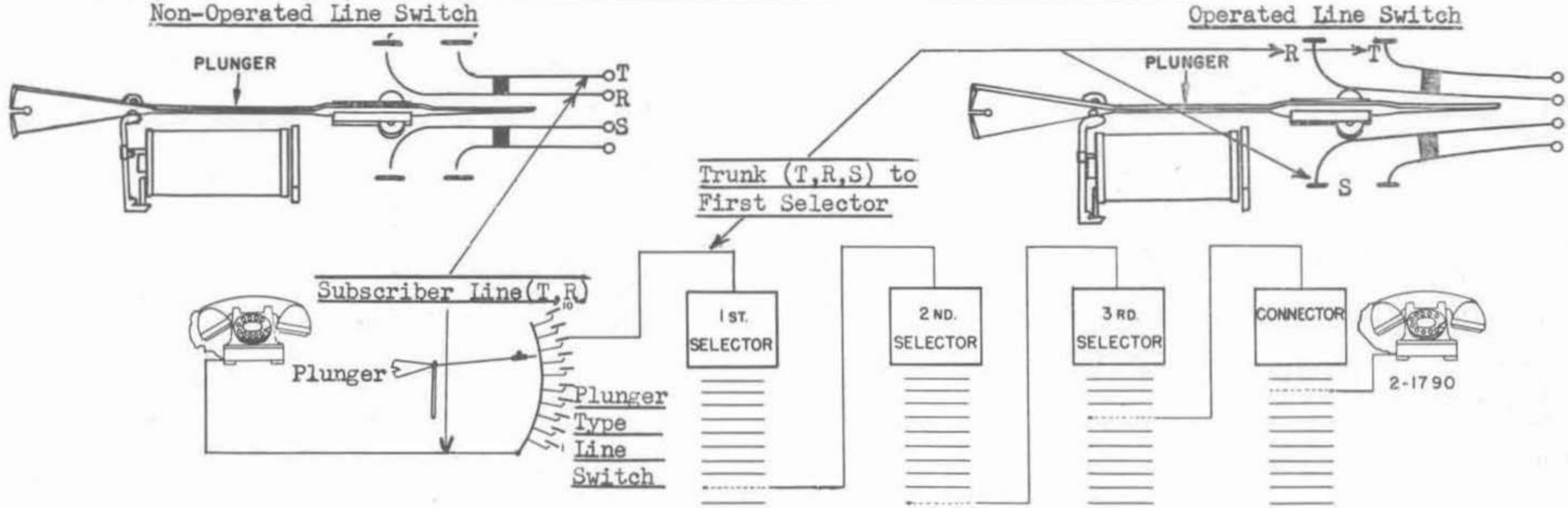


Comparison of KEITH LINE SWITCH and LINE FINDER SWITCH Operation

KEITH LINE SWITCH

1 Switch for Each Subscriber Line

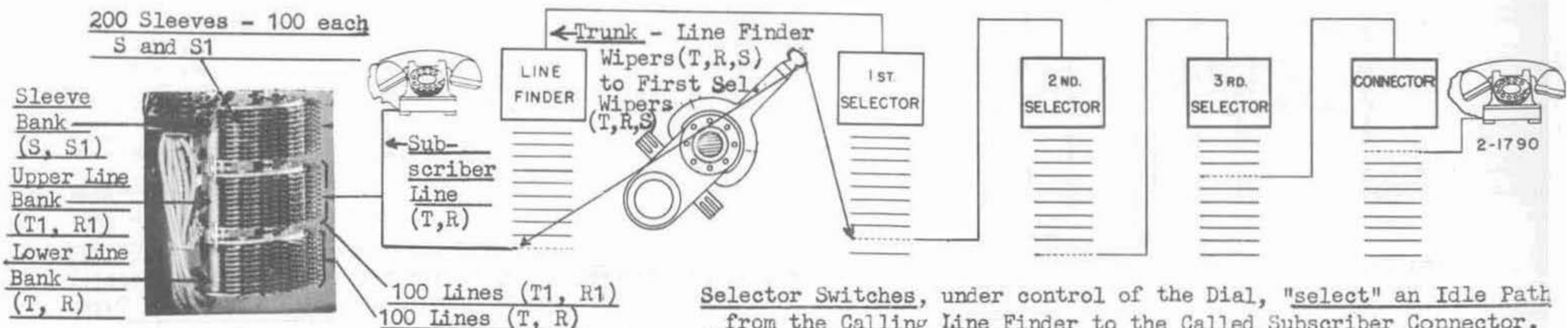
The Keith Line Switch connects the Calling Subscriber Line to an Idle First Selector.



LINE FINDER SWITCH

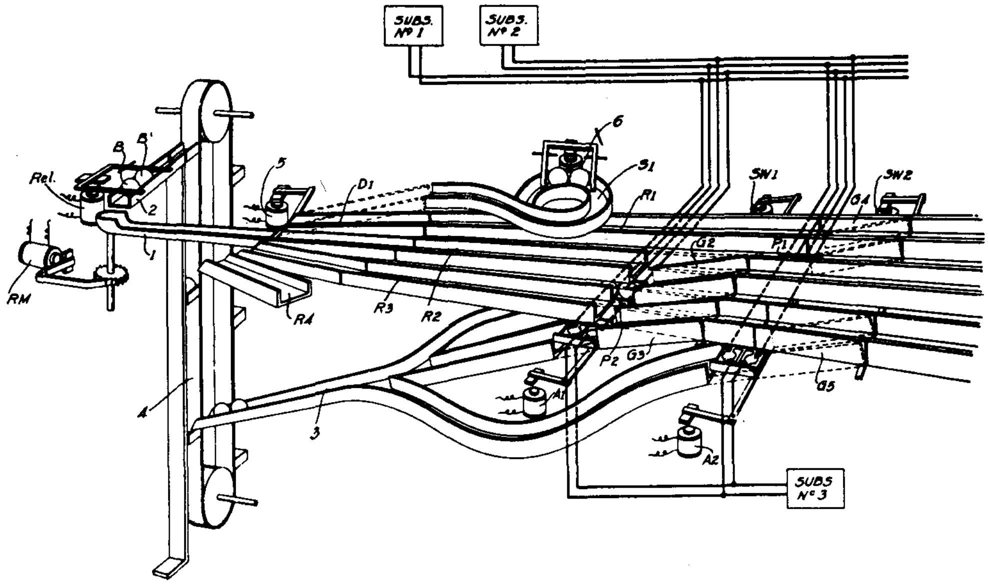
Normally 20 Switches for a Line Group of 200 Lines (198 Subscriber & 2 Test Lines)

The Line Finder Switch "finds" the Calling Subscriber Line, wired to a set of Line Bank Terminals (T, R). Switch Wipers (T, R, S) cabled to a First Selector Switch.



Selector Switches, under control of the Dial, "select" an Idle Path from the Calling Line Finder to the Called Subscriber Connector. The Connector Switch, under control of the Dial, "finds" the Called Subscriber Line.

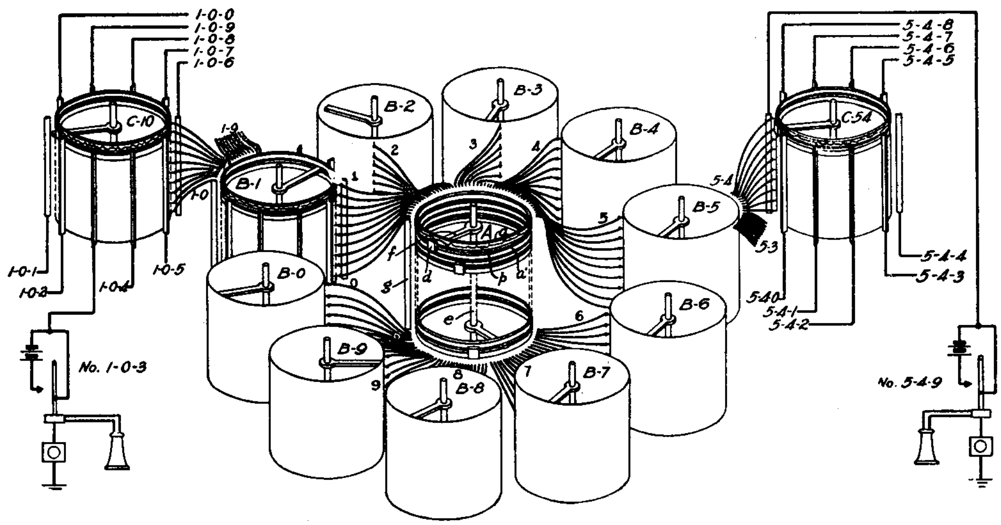
Patent #511, 874
Issued Jan. 2, 1894
Never Used Commercially
System Capacity - 10 Subscriber Lines



Operation:

1) Subscriber No. 1 wishes to Call Subscriber No. 2. He transmits two (2) impulses to the Central Office.
2) Rotary Magnet RM steps Switch Track 1 into alignment with inclined Runway R2.
3) Switching Magnet SW1 operates to depress Gate G2. The Path is now prepared for the desired connection.
4) Release Magnet Rel operates, releasing two steel balls B and B' from Storage Track 2
5) The two steel balls B and B' roll down Storage Track 2, out onto Switching Track 1, to Runway R2 (See No. 2), to depressed Gate G2 (See No. 3).
6) The two balls B and B' roll down Gate G2 and come to rest on the contacts of Cross-Connecting Plate P2 (Note detail of Cross-Connecting Plate for G5 - two pairs of contact members bridged by the two steel balls.), thereby establishing a Talking Path between the two Subscriber Lines, Nos. 1 and 2.
7) When the Subscribers finish talking, the Calling Subscriber "rings off," operating Magnet A1:
   a) Tilting Contact Plate P2 so that
   b) The two steel balls B and B' drop onto Return Runway R3 and roll down to Elevator Belt 4.
   c) Elevator Belt 4 returns the two balls B and B' to Storage Track 2, ready for establishing other connections.
8) A Storage Track is associated with each Runway R1, R2, etc., onto which the two balls may be deflected (Only Storage Track S1 has been shown.) if the Called Subscriber Line is busy:
   a) If Subscriber No. 1 is busy and another call originates for his line, Deflecting Gate D1, operated by Magnet 5, will deflect the two balls released for the second call to Track S1, where they will be held as long as Subscriber No. 1 Line is busy.
   b) When Subscriber No. 1 Line becomes Idle:
      1') Magnet 6 operates
      2') The two balls released from Track S1 roll out onto Runway R1 to set up the second Talking Path to Subscriber No. 1 Line.

THE J. W. McDONOUGH SWITCHING SYSTEM
Patent #538,975
Issued May 7, 1895
Never Used Commercially
System Capacity - 1,000 Subscriber Lines



System Makeup: 1 Central Switch "A"
10 Group Switches "B"
100 Terminating Switches "C"

Switch Makeup: 10 Pairs of Rings (horizontal) per Switch. One Ring of each pair bears a Phonographic Recording.
1 Contact Carriage per pair of Rings (10 Carriages per Switch) equipped with a Magnet, Levers, Catches and a Phonographic Transmitter. Carriage Contacts slide over outer surfaces of Rings.
1 Shaft per Switch mounted at the switch axis and rotated continuously by an electric motor.
10 Radial Arms per Switch (1 Arm per pair of Rings) to push the Carriage Assemblies around.
100 Gates or Vertical Bars (10 Groups of) 10 each) for each "A" and "B" Switch) -
10 Gates for each "C" Switch)
(Carriage Contacts "make" (with the Gates as the (Radial Arms push the (Carriages around.

Inter-Switch Wiring:
10 Gates of each "A" Switch Group (Total 100 Gates) wired to 10 pairs of Rings on each of the 10 "B" Switches.
10 Gates of each "B" Switch Group (10 Groups per "B" Switch, 10 "B" Switches, Total 1,000 Gates) wired to the 10 pairs of Rings on a "C" Switch (Total 100 "C" Switches.).
10 Gates of each "C" Switch wired to 10 Subscriber Lines (Total 1,000 Subscriber Lines).

Operation:

A) Phonographic announcements inform the Calling Subscriber as to the progress of his call. This arrangement corresponds to the Revertive Pulsing used in the Panel and No. 1 Crossbar Dial Systems.

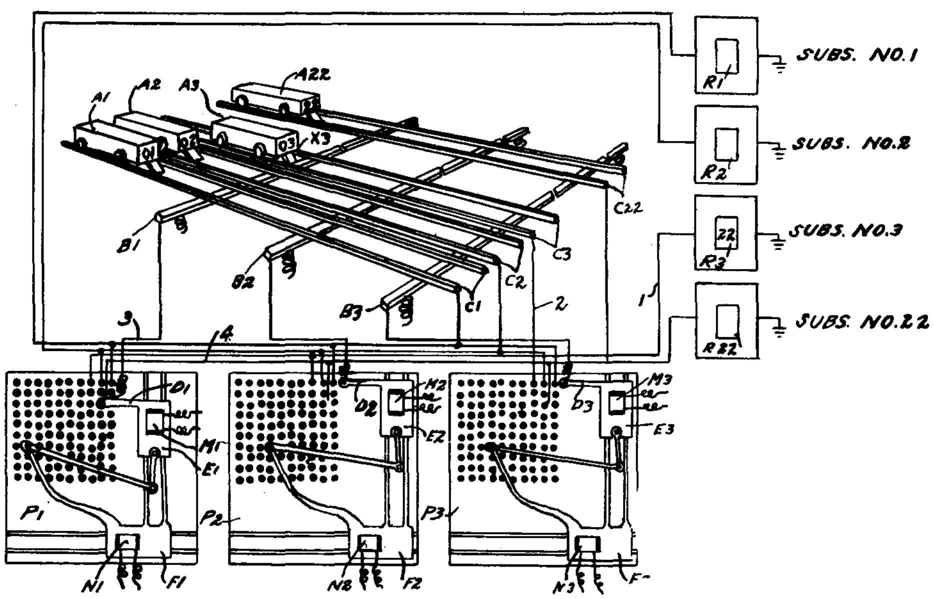
B) Subscriber No. 103 Calls Subscriber No. 549:

1) Subscriber No. 103 removes his Handset and listens to the signals, "101, 102, etc."

2) When the Calling Subscriber hears his own number, "103," he depresses a Pushbutton which stops the Carriage of his "C" Switch, connecting his Line to a pair of Rings on Switch "B1."
3) As the "B1" Switch Carriages rotate, signals "10, 11, 12, etc.," are transmitted.
4) Upon hearing "10," the Calling Subscriber again depresses his Pushbutton, stopping the "B1" Switch Carriages, and connecting his Line to an "A" Switch Gate (Vertical).
5) As the "A" Switch operates, the Subscriber hears the numbers of the Gates past which the Carriages move. Upon hearing "5," he depresses his Pushbutton, stopping Switch "A" Carriages, and cutting his Line through to a "B5" Switch Gate.
6) As Switch "B5" operates, the Calling Subscriber hears, "50, 51, 52, 53, etc.," and upon hearing "54," he again depresses his Pushbutton, causing the "B5" Switch Carriages to stop and cut through to a "C54" Switch Gate.
7) As Switch "C54" operates, the Subscriber hears, "540, 541, 542, 543, etc." When he hears "549," he depresses his Pushbutton once more, stopping Switch "C54" and cutting through to the Called Subscriber Line wired to "C54" Switch Gate No. 549.

THE MOISE FREUDENBERG SWITCHING SYSTEM

Patent #556,007
Issued March 10, 1896
Never Used Commercially
System Capacity - 100 Subscriber Line



A) General System Features: The Central Office Equipment of this system resembles a large railroad terminal freight yard. The cars required to switch the calls would be about the size of those for a O-gauge tinplate toy electric train.

1) A metal Car or Wagon (A1, A2, A3, etc.), operating on an insulated metal Track, is required for each Subscriber Line.
2) Beneath the Tracks (C1, C2, etc.), and at right angles to them, is a number of metal Beams (B1, B2, B3, etc.).

3) Each Beam (B1, B2, B3, etc.) is wired to the movable Contact Member (D1, D2, D3, etc.) of an "X-Y" Coordinate Plate Switch (P1, P2, etc.).
4) Corresponding stationary Terminals of each Plate Switch are multipled together. A Subscriber Line is wired to each Multiple.
5) Each Plate Switch has an F1 ("X") Carriage driven horizontally along a Track, plus a second E1 ("Y") Carriage, moving at right angles to the first.
6) Contact Member D1 of Plate Switch P1 (also D2, D3, etc. of other Plate Switches) is supported by the E1 Carriage.
7) Links and Magnets M1 (horizontal or "X" drive) and N1 (vertical or "Y" drive) drive D1 over the entire Contact Field of P1 Plate Switch. A visible Register at the Calling Substation records the progress of the D1 Contact Member over the coordinate Contact Field.

B) Operation: Subscriber No. 3 Calls Subscriber No. 22:

1) Car or Wagon A3 is released electrically by the Calling Subscriber, No. 3, to hunt for an Idle B Beam.
2) A Projection X3 on the underside of Wagon A3 hits the first Idle B Beam (B1 in the diagram), and makes an electrical connection with it, swinging the B1 Beam downward, out of reach of any other Subscriber Wagon.
3) Plate Switch P1 is now connected to the Calling Subscriber, No. 3.
4) This initiates the operation of Plate Switch P1. Magnets M1 and N1 sweep the movable Contact Member D1 horizontally and vertically over the Contact Field.
5) The number of each Terminal ("1, 2, 3, 4, 5, etc.") over which the D1 movable Contact Member sweeps is recorded on the Calling Substation Register R3.
6) As soon as the desired Subscriber Number, "22," appears on Register R3, the Calling Subscriber releases a Pushbutton, which stops the D1 movable Contact Member on Terminal No. 22 of Plate Switch P1.
7) The Talking Circuit set up extends from Ground, through Subset No. 3, Wires 1 and 2, Track C3, Projection X3, Beam B1, Wire 3, Contact Member D1, Terminal No. 22 Plate Switch P1, Wire 4, through Subset No. 22 to Ground.

THE WESTERN ELECTRIC ROTARY SWITCHING SYSTEM

Developed About 1905
Dial Pulses Control Selections Indirectly
Used Only In Europe
System Capacity - 10,000 Subscriber Lines

A) Rotary Switching System Features:
1) Power-Driven Equipment - Horizontal and Vertical Driveshafts provide power for operating the Switches - A 2 H.P. Electric Motor is required for a 10,000-Line installation.
2) Switches have Rotary Motion only.
3) Switch Banks (To which Lines or Trunks are cabled) - Semi-Circular in shape - 200 Sets of Terminals, 20 Sets per Level, 10 Levels.
4) 10 Sets of Brushes per Switch - Only 1-Set "tripped" to "wipe" over the Terminals of 1-Level.
5) Selections controlled by Register Switches, positioned by pulses received from the Subscriber Dial. As the Selector or Final Brushes "wipe" over one Terminal after another, a Pulse is sent back (Revertive Pulsing) to the Register Switch for each Terminal contacted. When the Register Switch reaches normal, the Circuit is opened and the Brushes stop on the last set of Terminals.

6) Switches Used:

   a) Line Switch - "Finds" the Calling Subscriber Line.

   b) Selector Switch - Finds an Idle Trunk, under control of the Register Switch, from the Line Switch to the Final Switch serving the Called Subscriber Line.

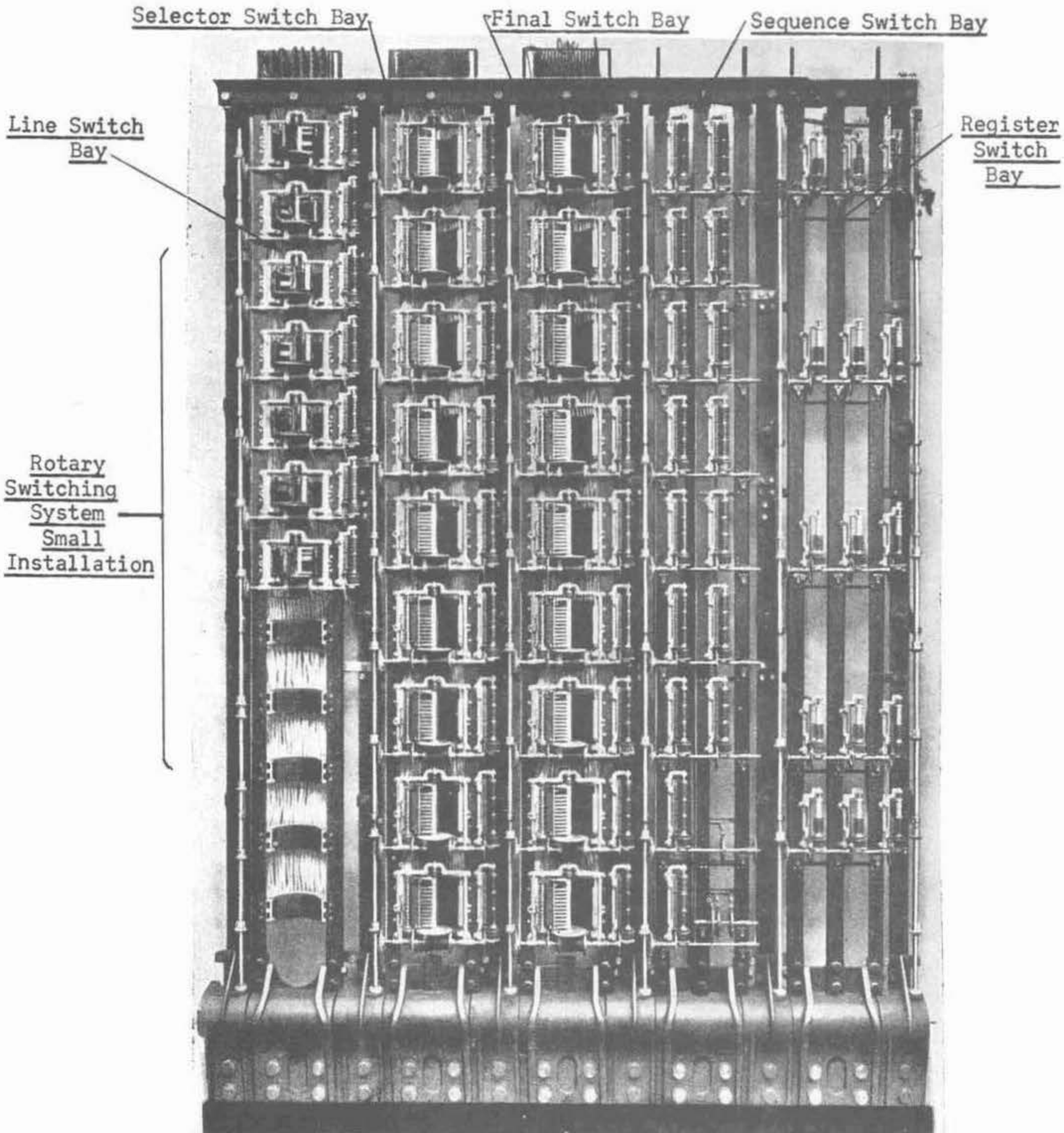
   c) Final Switch - Under control of the Register Switch, finds the Called Subscriber Line.

   d) Register Switch:

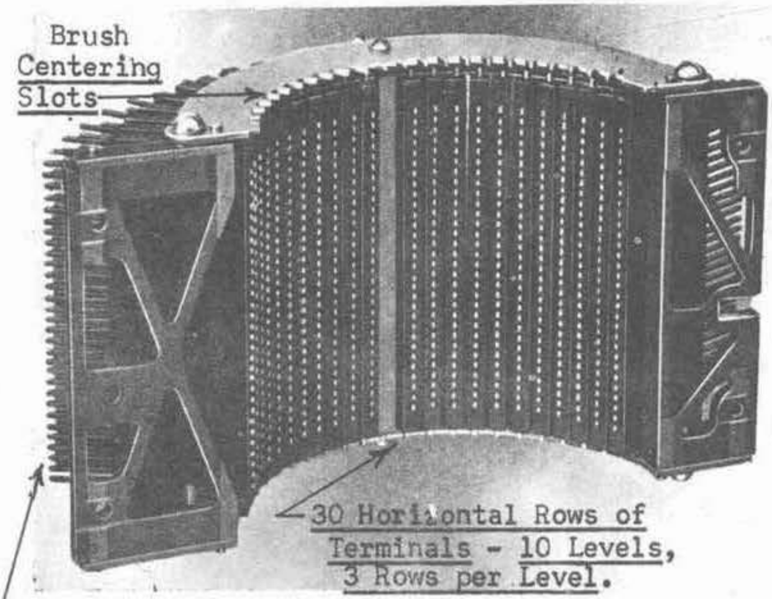
      1') Stores the Digits dialed by the Calling Subscriber.

      2') "Translates" or Converts the Dial Pulses received on a Decimal Basis (1-out-of-10) to a series of Pulses necessary to make Selections on the basis of 1 out of 20 (20 Sets of Terminals per Level).

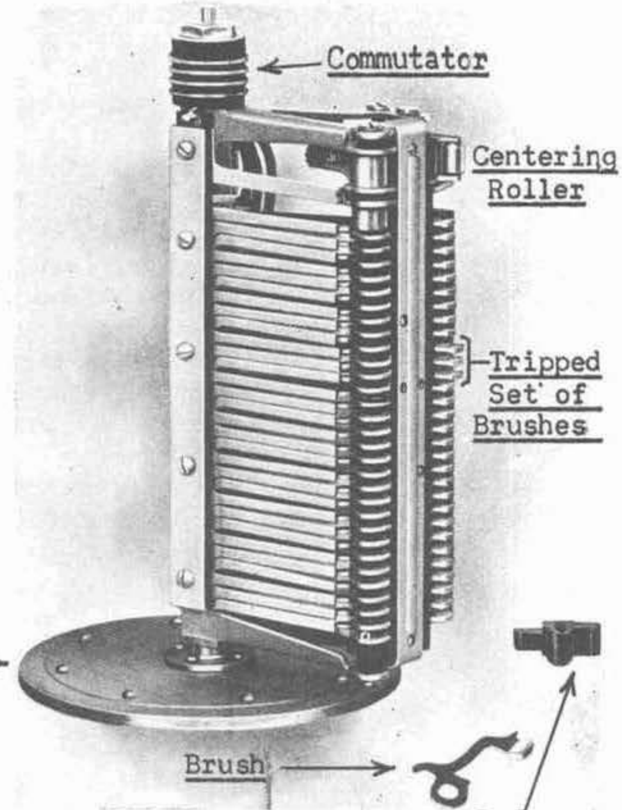
      3') Controls the operation of the Selector and Final Switches on a "Revertive Pulsing" basis.



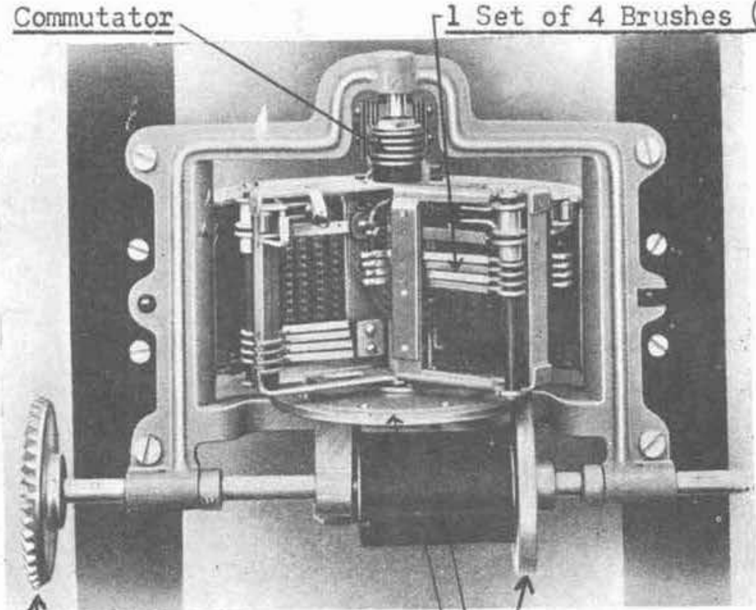
Rotary System Selector Bank



Rotary System
Selector Brush Carriage and Brush

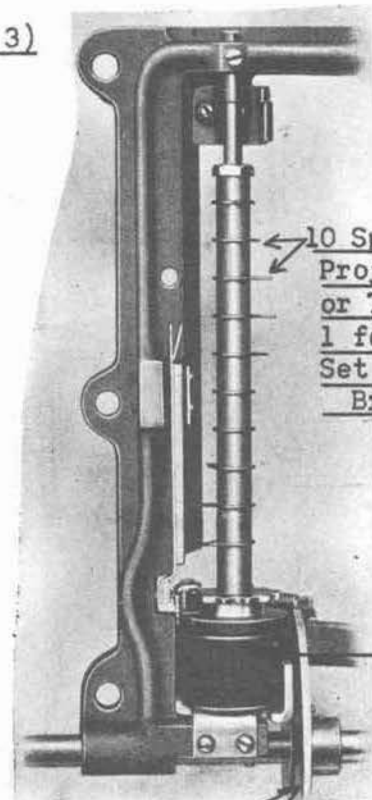


Rotary System Line Switch

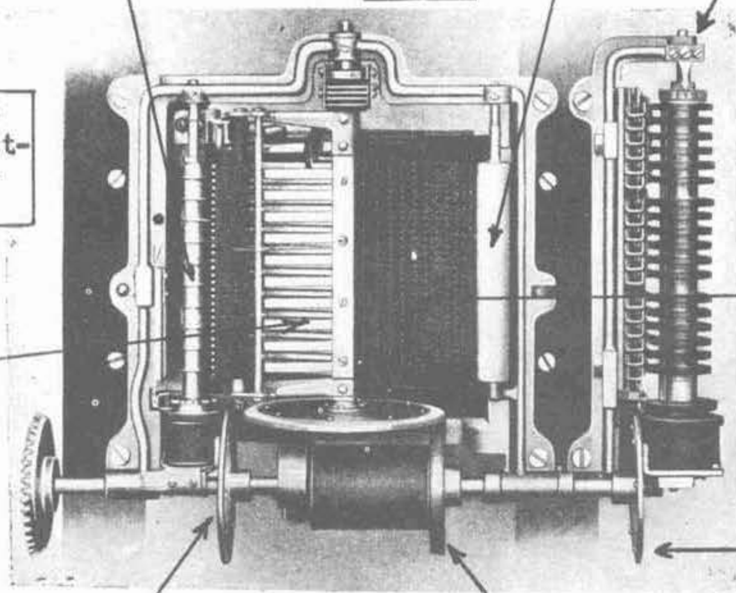


60 Subscriber Line Terminals per Bank
20 Terminals per Row (Horizontal)
4 Horizontal Rows of Terminals per Level of 20 Lines.

Selector Brush Chooser
Releases a Brush Latch, "Tripping" One Set of Brushes.

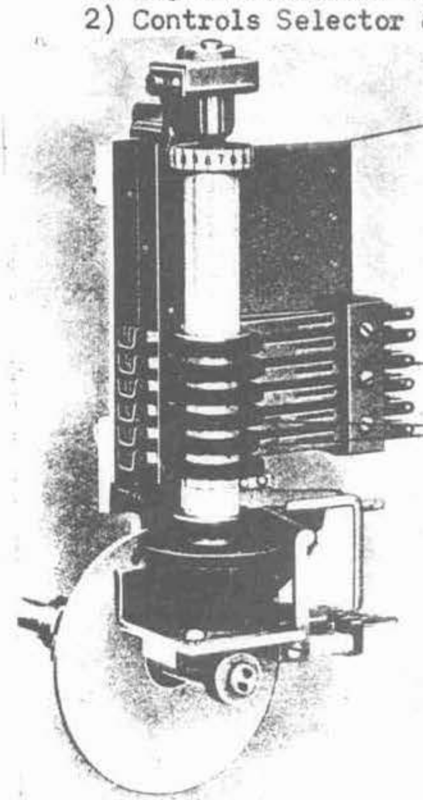


The Rotary System SELECTOR SWITCH



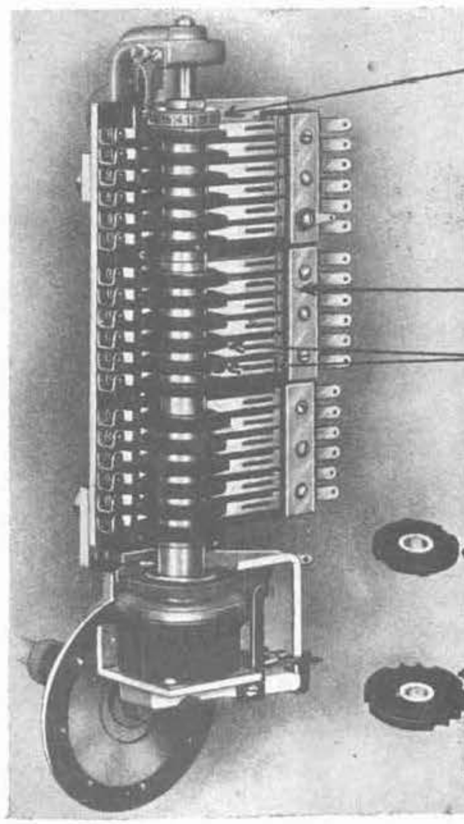
The Final Switch is similar in construction to the Selector Switch.

Register Switch
1) Registers Dialed Digits.
2) Controls Selector & Final Switch Operation.



The Register controls Selector and Final Switch operation (On a Revertive Pulse basis) as it restores to normal, after being advanced by Dial Pulses to the position representing the Digit Dialed.

Sequence Switch
(Power-Driven Relay)



As the Sequence Switch rotates only in one direction, it always opens and closes the circuits wired to its contacts in the same order or "sequence."

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FUNDAMENTALS OF TELEPHONY

Section 3

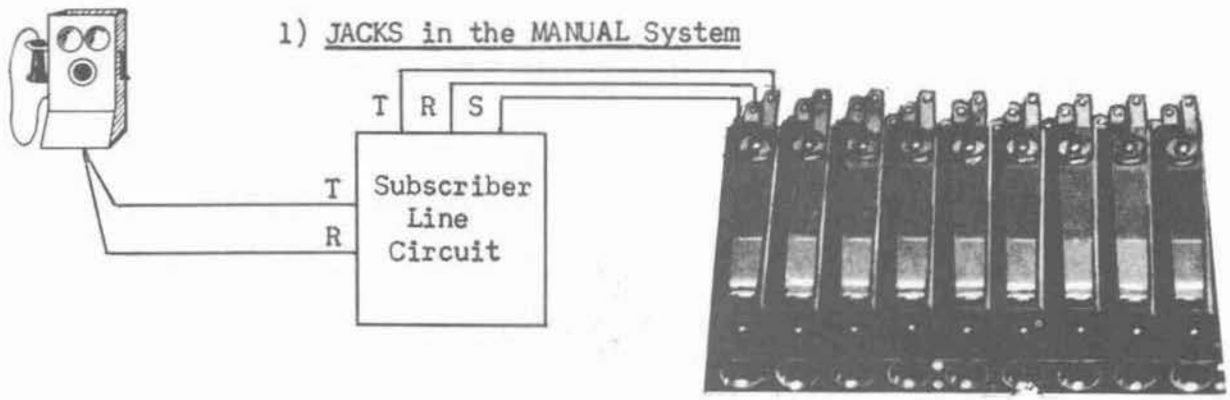
General Comparison of Switching Systems

CONTENTS

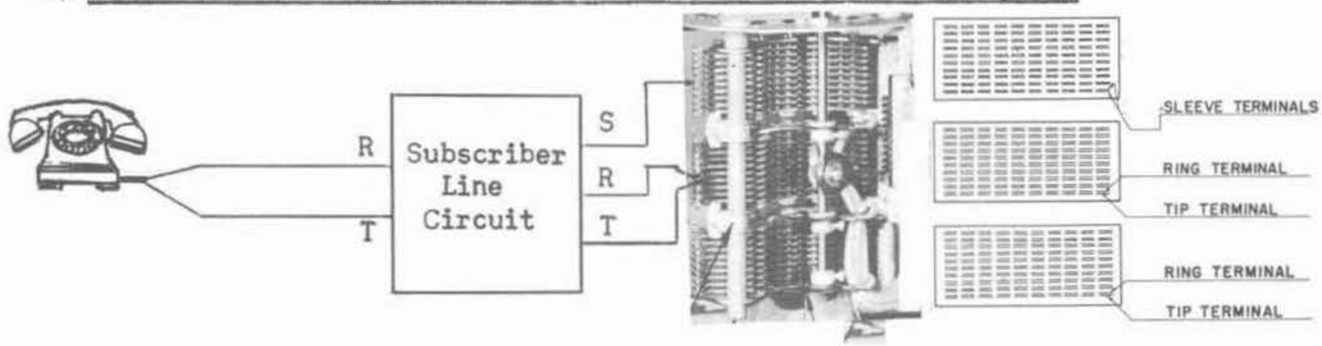
GENERAL COMPARISON OF SWITCHING SYSTEMS

A) Subscriber Lines Cable to:

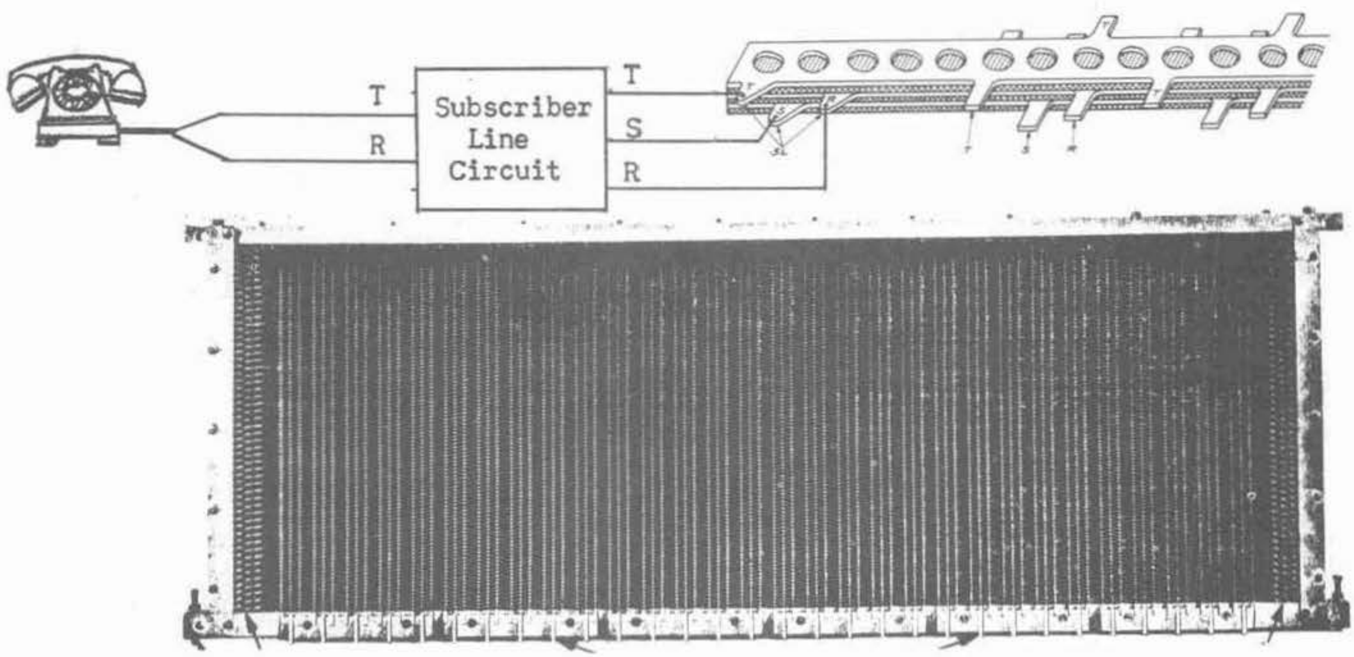
1) JACKS in the MANUAL System



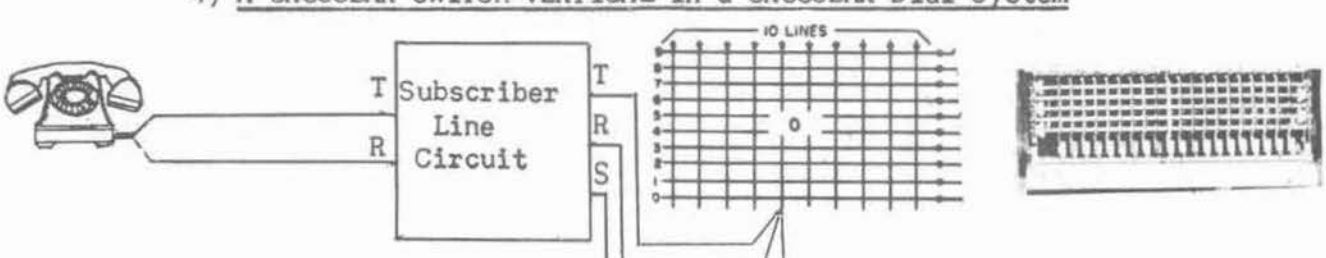
2) A SET OF SWITCH BANK TERMINALS in the STEP BY STEP Dial System



3) A SET OF MULTIPLE BANK STRIPS in the PANEL Dial System

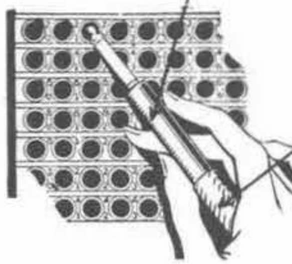


4) A CROSSBAR SWITCH VERTICAL in a CROSSBAR Dial System

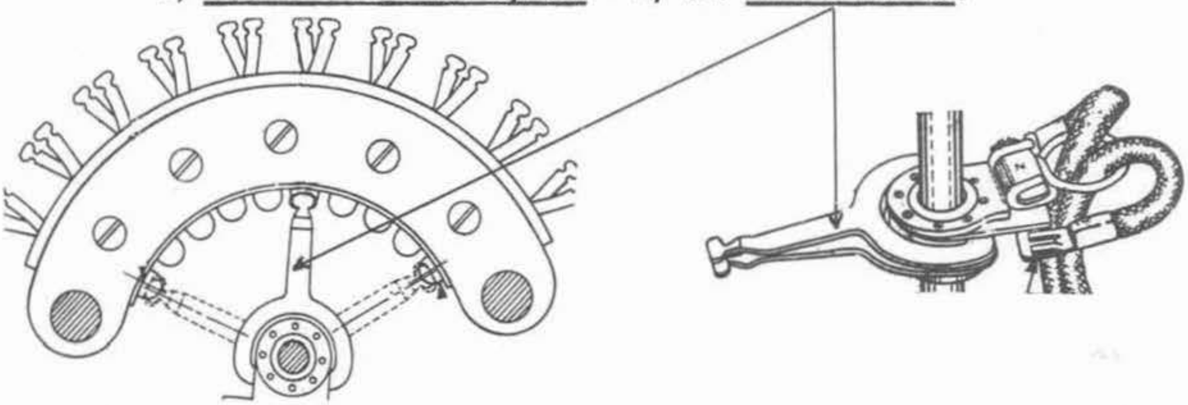


B) A CONNECTION is MADE in a:

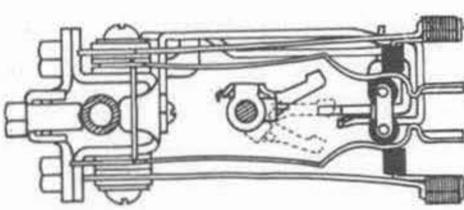
1) MANUAL System - By a PLUG on the end of a CORD.

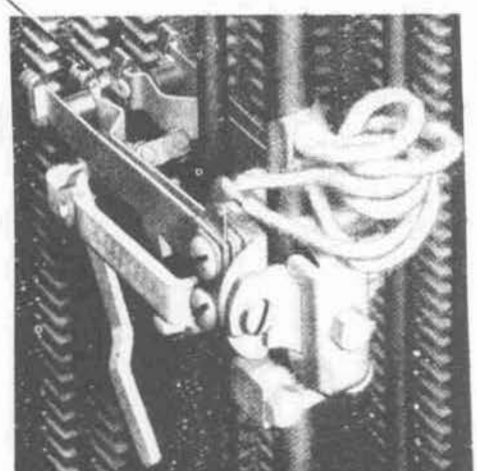


2) STEP BY STEP Dial System - By the SWITCH WIPERS.

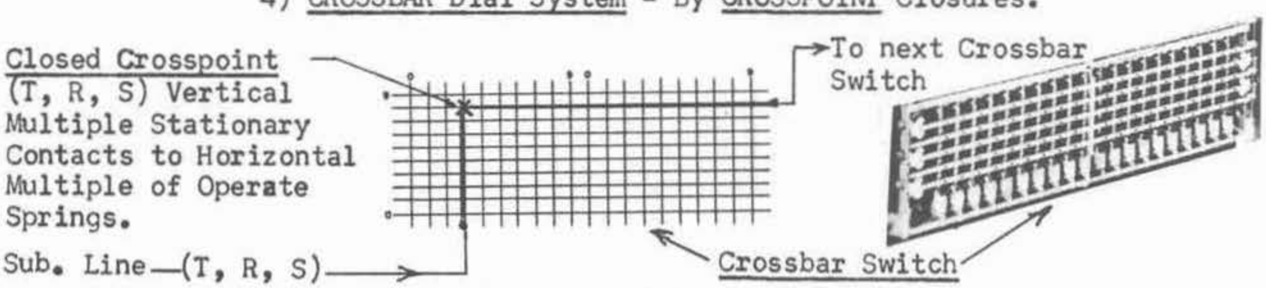


3) PANEL Dial System - By the MULTIPLE BRUSH SHOES.



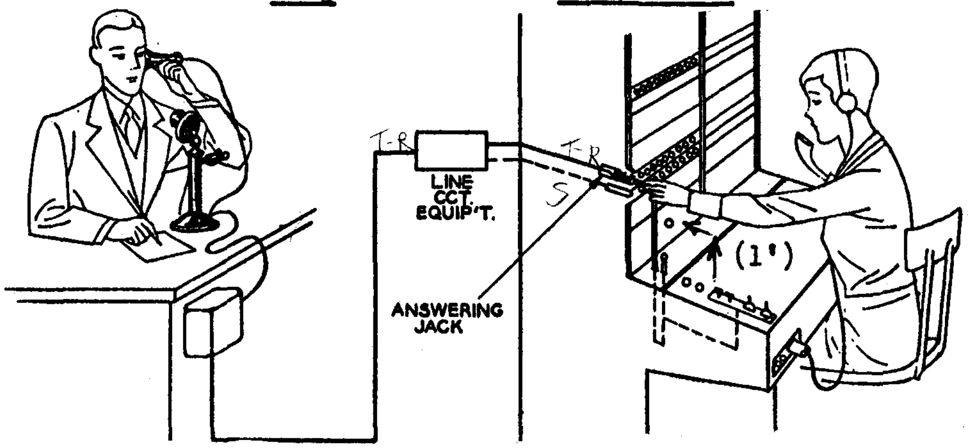


4) CROSSBAR Dial System - By CROSSPOINT Closures.

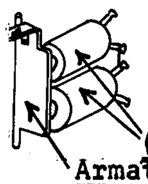


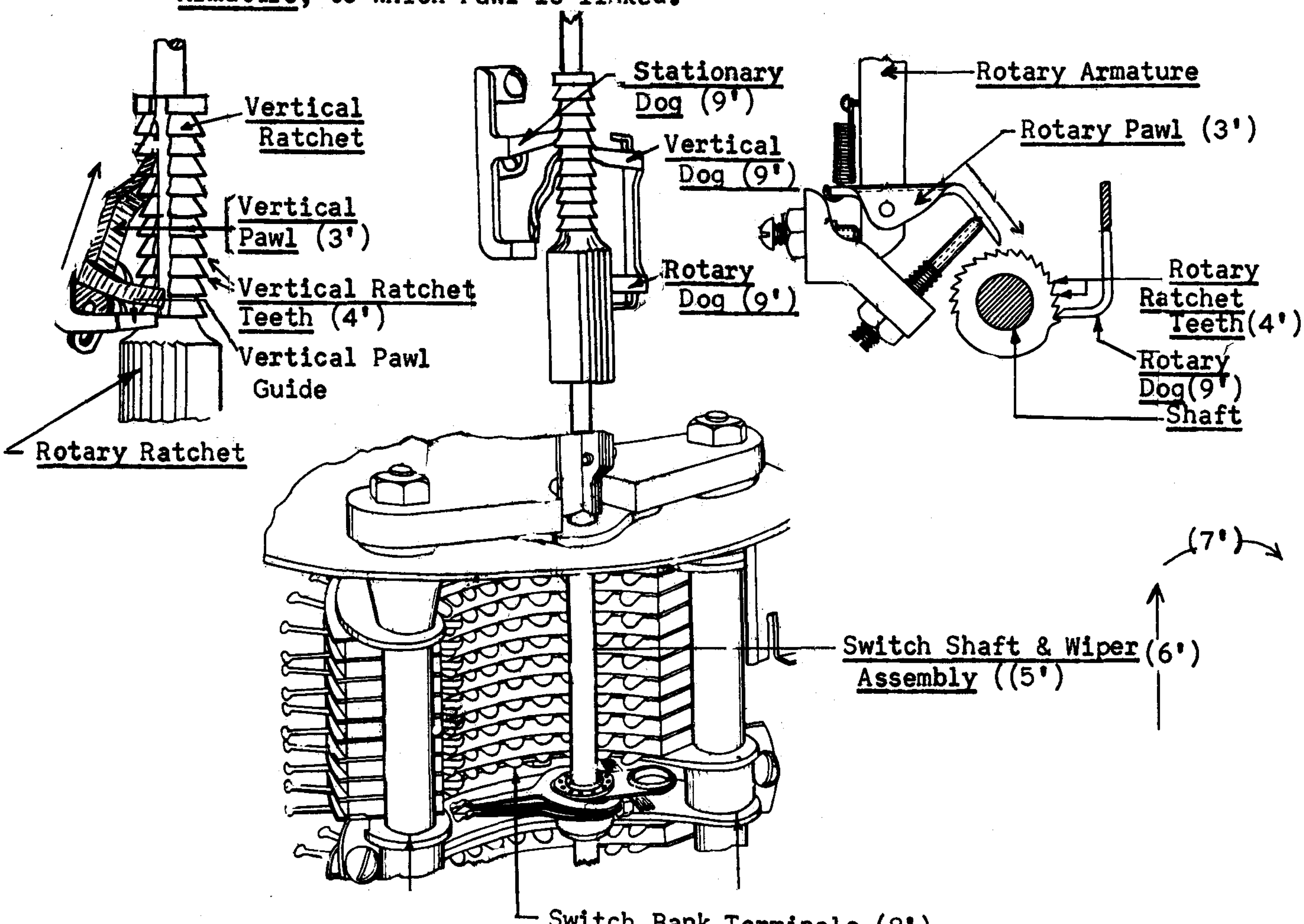
C) Method of MAKING A CONNECTION in a:

1) MANUAL System - The Operator picks up an Idle Cord and inserts the Plug of that Cord into a Jack.



2) STEP BY STEP Dial System - The Operator's Hand and Arm Movements (1') are replaced by a Stepping Magnet (2') thrusting a Pawl (3') into a Ratchet Tooth (4'), stepping the Shaft and Wipers (5'), first Vertically (6'), then Horizontally (7') or in a Rotary Direction to the desired Set of Switch Bank Terminals (8'). Each Step is held by a Dog (9').





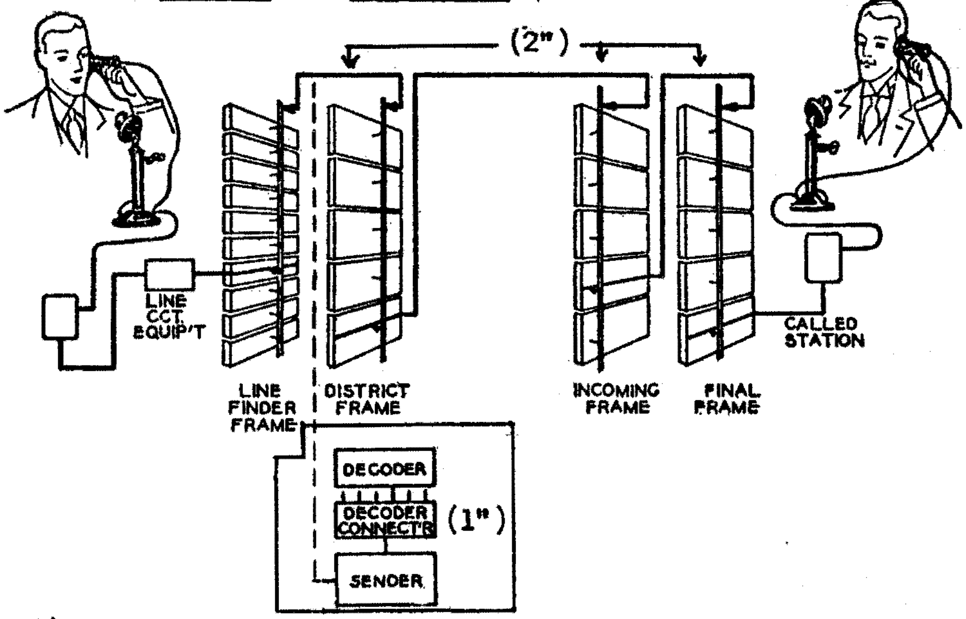
C) Method of MAKING A CONNECTION in a:

3) PANEL Dial System:

A') The Common Control Equipment (1"), which replaces the Manual Operator:

1') Registers the Digits Dialed, and

2') Sets Up the Connection (2") to the Called Subscriber Line.



B') The Operator's Hand and Arm Movements are replaced by:

1') An Electrically-Operated Clutch (3"), which

2') Forces a Rack (4") against a Rotating Cork Roll (5").

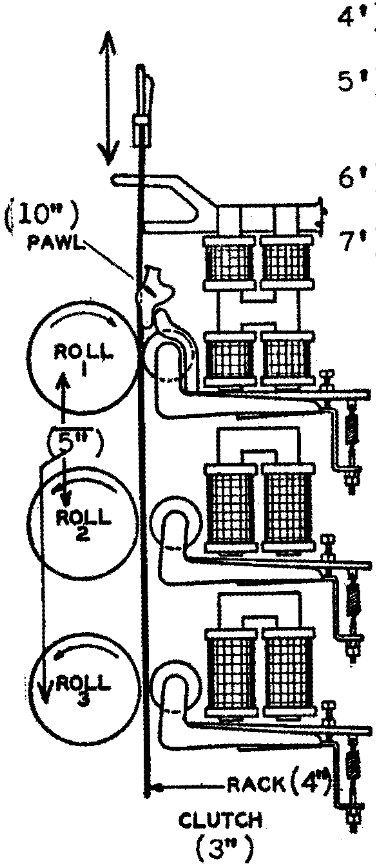
3') Friction drives the Multiple Brush Rod (6") Vertically.

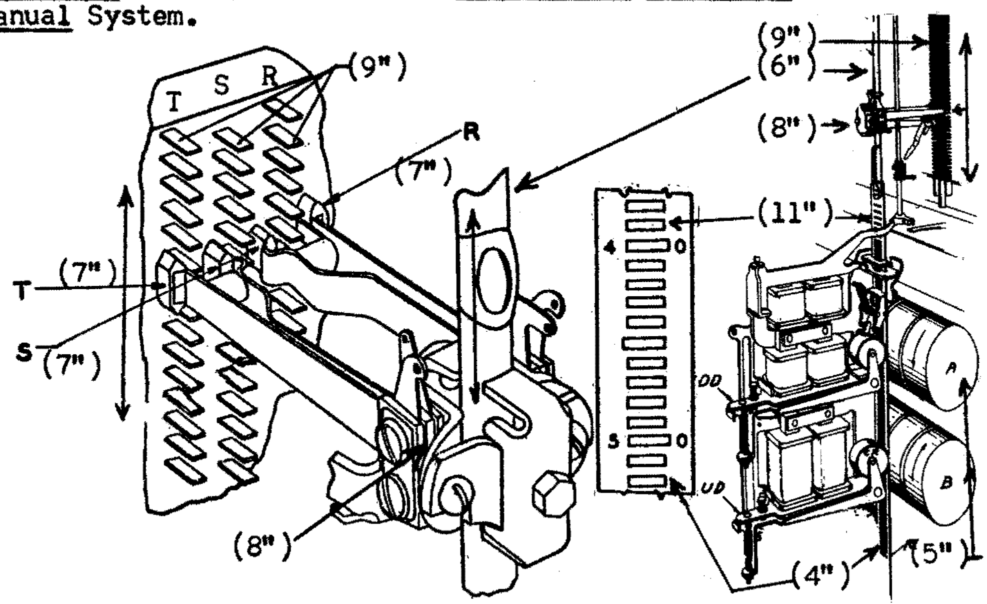
4') The Shoes (7") of a "Tripped" Multiple Brush (8") "wipe" over Multiple Bank Terminals (9").

5') The Clutch is released by the Common Control Equipment when the Multiple Brush Shoes make contact with the desired Set of Multiple Bank Terminals.

6') A Pawl (10") drops into a Rack Slot (11") to hold the Multiple Brush Rod in position.

7') The Multiple Brush Shoes in contact with the Multiple Bank Terminals correspond to the Plug inserted in a Jack of the Manual System.





C) Method of MAKING A CONNECTION in a:

4) CROSSBAR Dial System (Method of Switching a No. 1 Crossbar Call shown below.):

A') SWITCHING FRAMES, on which the Talking Path is built up, replace the Manual SWITCHBOARDS.

B') COMMON CONTROL FRAMES, which replace the Manual OPERATORS:

1') Register the Digits Dialed.

2') Set up a Talking Path (1") to the Called Subscriber Line. Only Line Link and District Link Frames shown below.

C') In Handling a Call, the COMMON CONTROL EQUIPMENT:

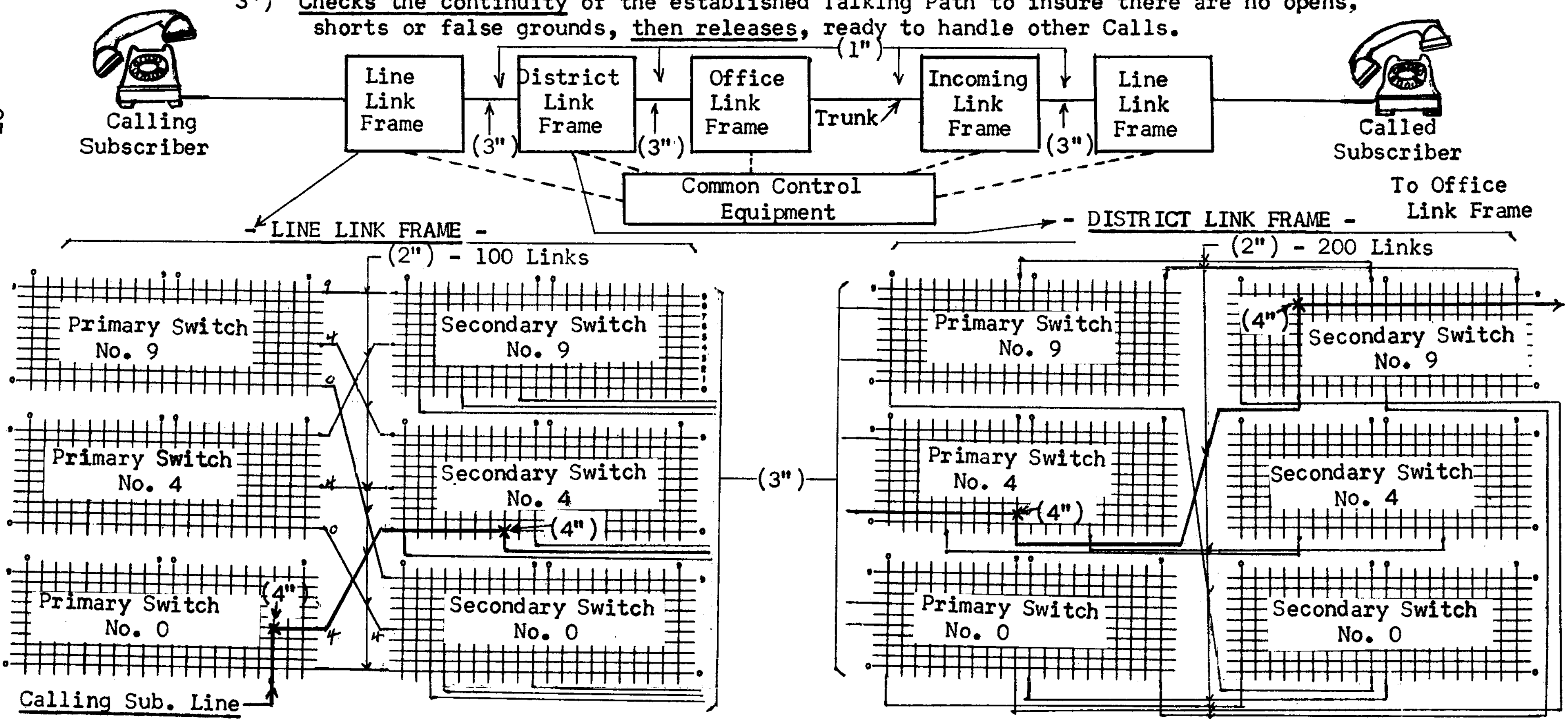
1') Selects an Idle combination of Paths through the various Switching Frames.

a') A Path between two Crossbar Switches on the same Frame is a LINK (2").

b') A Path between two Crossbar Switches on different Frames is a JUNCTOR (3").

2') Closes the necessary Crossbar Switch CROSSPOINTS (4") on the various Switching Frames to cut through a Talking Path between the Calling and Called Subscribers.

3') Checks the continuity of the established Talking Path to insure there are no opens, shorts or false grounds, then releases, ready to handle other Calls.



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FUNDAMENTALS OF TELEPHONY

Section 4

Subscriber Station Equipment

CONTENTS

SUBSCRIBER STATION EQUIPMENT

Subscriber Station or "Substation" - A Subset (Subscriber Set) installed and in service for telephone communication.

Substation Equipment - 1) Subscriber Set or "Subset" - An instrument designed for originating and receiving Telephone Calls.

2) Substation Protector - Mounts:

a) Protector Blocks (Lightning Arresters) - High voltage protection.

b) Fuses (7 Ampere, Tubular) or Lead Spacers - Excess current protection.

1) SUBSET

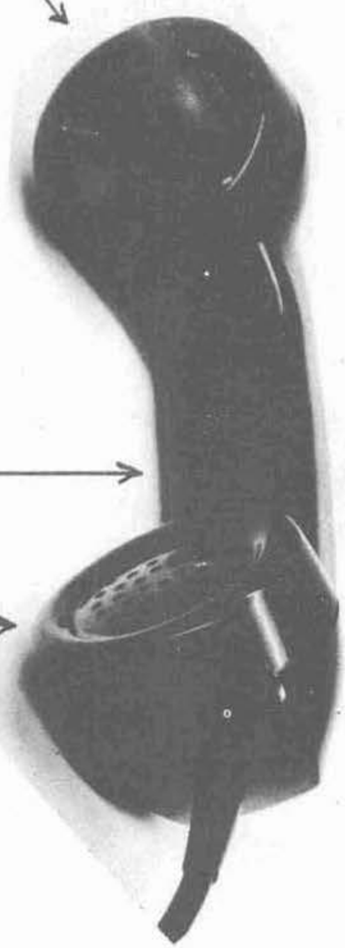
500-TYPE SUBSET
Front View

1) SUBSET

Ringer Volume Adjustment

500-TYPE SUBSET
Bottom View

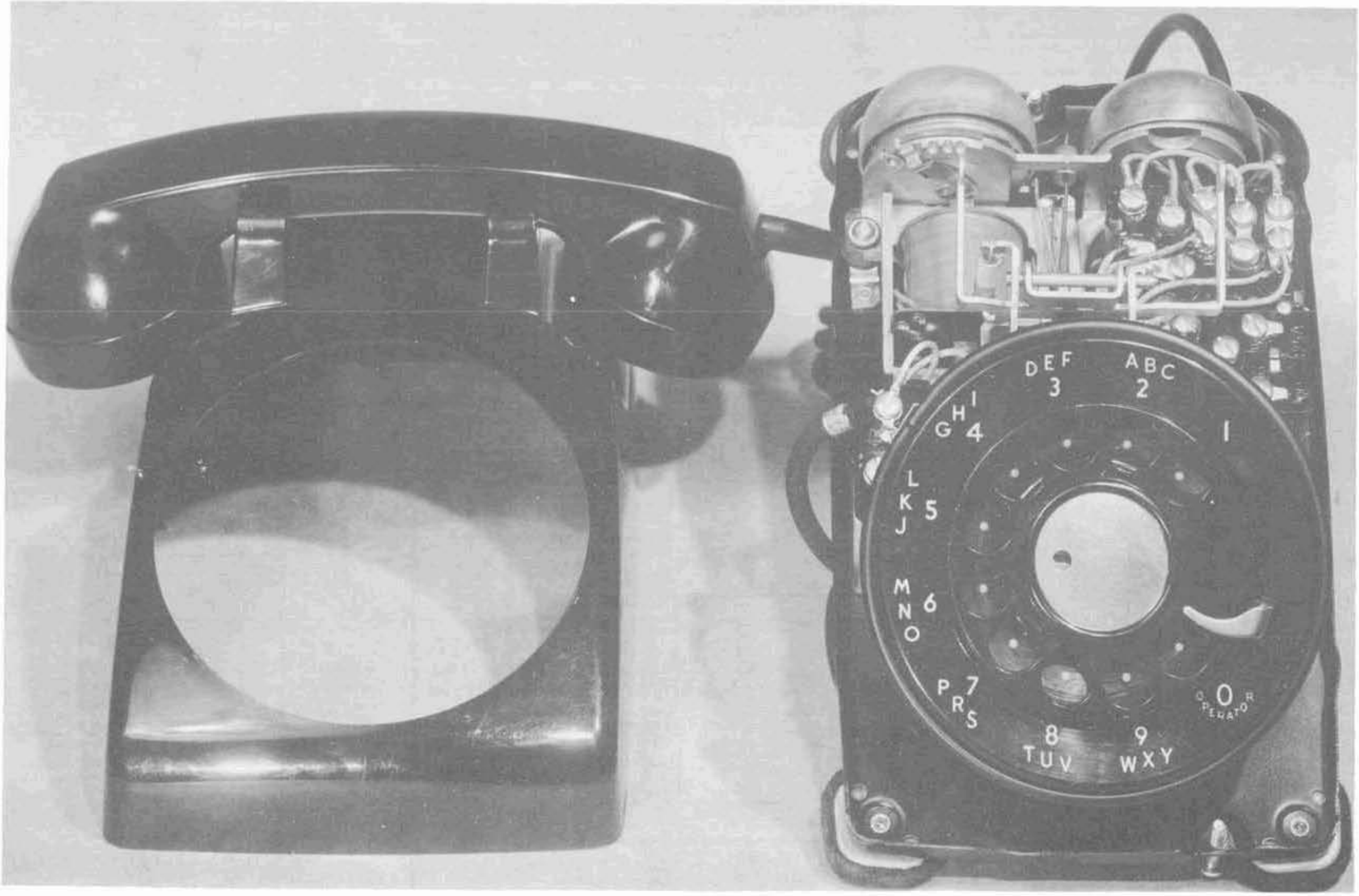
E2) Receiver Unit



E) 12-Oz. Handset

E1) Transmitter Unit

1) SUBSET



← Line Cord (Neoprene)
← C) Ringer
← D) Network
← A) Switch-hook
← B) Sub. Dial (7-Type)

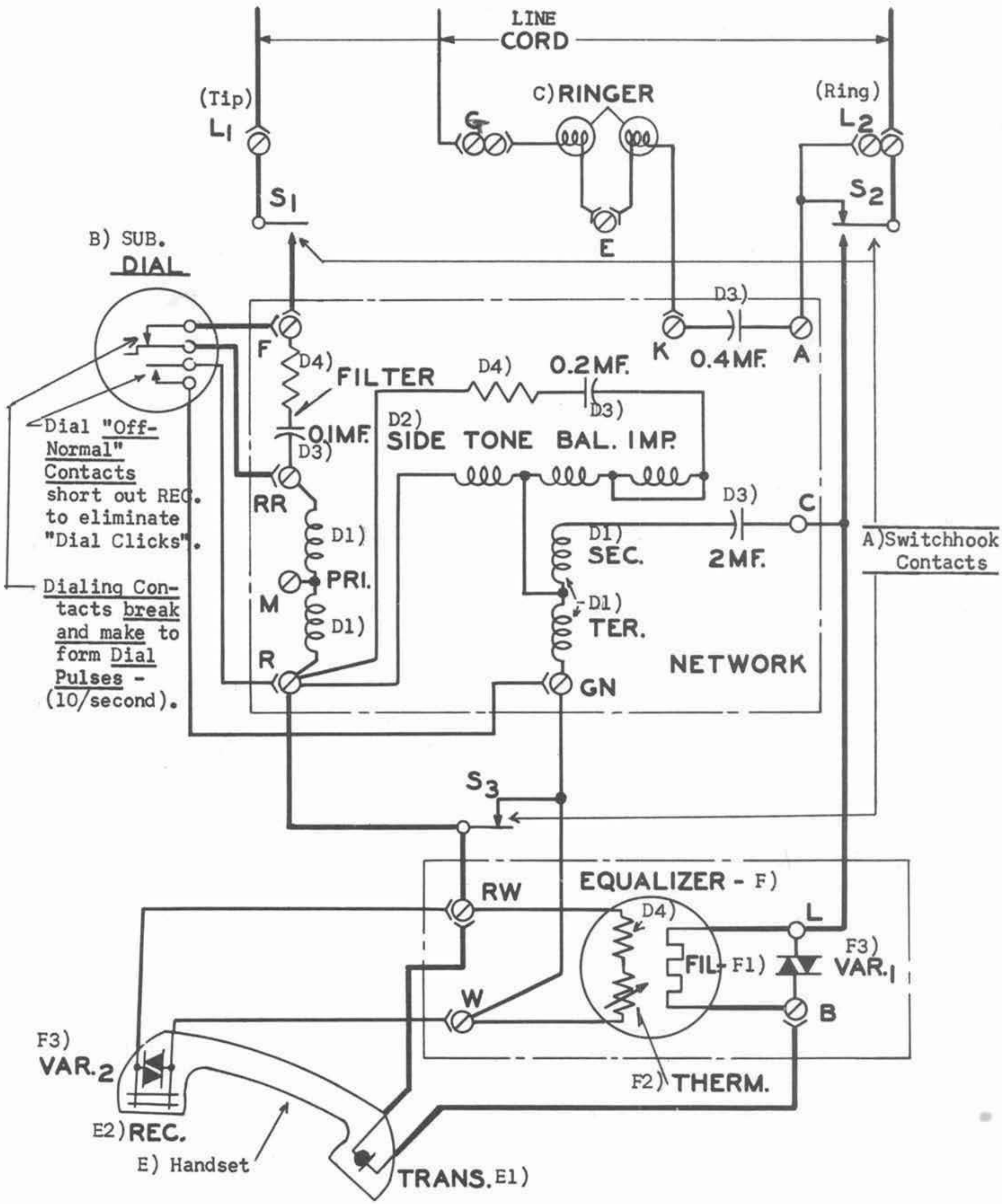
Housing

Handset Cord (Neoprene)

F) Equalizer

500-TYPE SUBSET
With Housing Removed

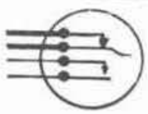
1) SUBSET


LINE CORD
(Tip) L1
C) RINGER
(Ring) L2
G
S1
S2
E
B) SUB. DIAL
D3)
F
K
0.4MF.
A
D4)
FILTER
D4)
0.2MF.
D3)
0.1MF.
D3)
D2) SIDE TONE BAL. IMP.
Dial "Off-Normal" Contacts short out REC. to eliminate "Dial Clicks".
RR
D3)
C
D1)
D1) SEC.
2MF.
A)Switchhook Contacts
PRI.
M
D1)
D1)
TER.
Dialing Contacts break and make to form Dial Pulses - (10/second).
R
NETWORK
GN
S3
RW
EQUALIZER - F)
D4)
L
F3) VAR.1
FIL- F1)
W
B
F3) VAR.2
F2) THERM.
E2) REC.
E) Handset
TRANS. E1)

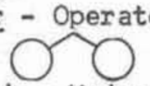
1) SUBSET - COMPONENTS

("A," "D2," "F3," etc., refer to Photo and Schematic on preceding pages.)

A) Switchhook - 1) Turns ON the Subset when the Subscriber removes the Handset from the Cradle.
2) Turns OFF the Subset when the Subscriber replaces Handset in the Cradle.



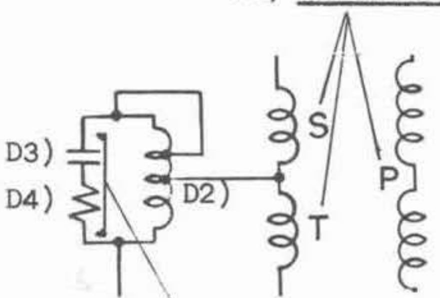
B) Subscriber Dial - Opens ("breaks") and closes ("makes") the Subscriber Loop (Line) to the Central Office 10 or more times per second to direct the Switching Equipment in setting up a Call. An apparatus blank mounts in place of the Subscriber Dial for Manual Service.



C) Ringer - Operated by 20-Cycle A-C Ringing Current from the Central Office Ringing Machine to signal the Called Subscriber.

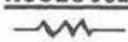
D) Network - Made up of:

D1) Induction Coil - A Telephone Transformer to strengthen the voice currents.



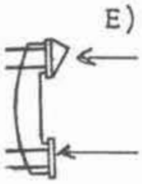
D2) Sidetone Balance Coil - Maintains a constant balance (flat response) over the voice-frequency range.
Sidetone - The reproduction by the Receiver of voice sounds and room noises actuating the Transmitter of the same Subset.

D3) Capacitors - A Capacitor is a device (two conductors separated by a Dielectric or insulator) which blocks d.c. (such as Talking Battery Supply), but transmits a.c. (20-Cycle Ringing Current).



D4) Resistors - A Resistor is a device for controlling the rate of current flow in a circuit

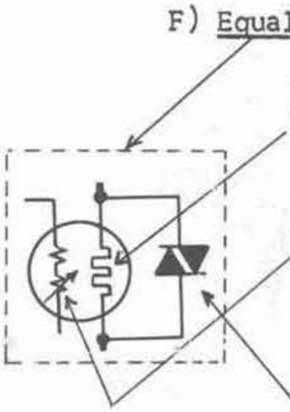
D5) Filter - A 50-Ohm Resistor in series with a 0.1 mf. Capacitor and the Induction Coil Windings to suppress radio receiver interference resulting from "breaks" and "makes" of the Dialing Contacts.



E) Handset - Includes the Transmitter and Receiver Units:

E1) Transmitter - A device which converts the mechanical energy (air pressure variations) of sound waves into electrical energy (varying electrical current - Talking Current.).

E2) Receiver - A device which converts electrical energy into the mechanical energy of reproduced sound waves.



F) Equalizer - A device for controlling reproduced voice volume or level, with variations in Subscriber Loop length, and with different Talking Battery Supplies.

F1) Ballast Lamp - A Current Regulator with a tungsten Filament, connected in series with the Transmitter Unit. The Filament resistance increases rapidly as temperature rises, to maintain a constant current.

F2) A Thermistor - A temperature-sensitive Resistor bridged around (shunting) the Receiver Unit, and connected in series with a loss-limiting Resistor. The Thermistor is heated by the Ballast Lamp Filament to introduce loss automatically, thereby avoiding excessive voice level on short Subscriber Loops.

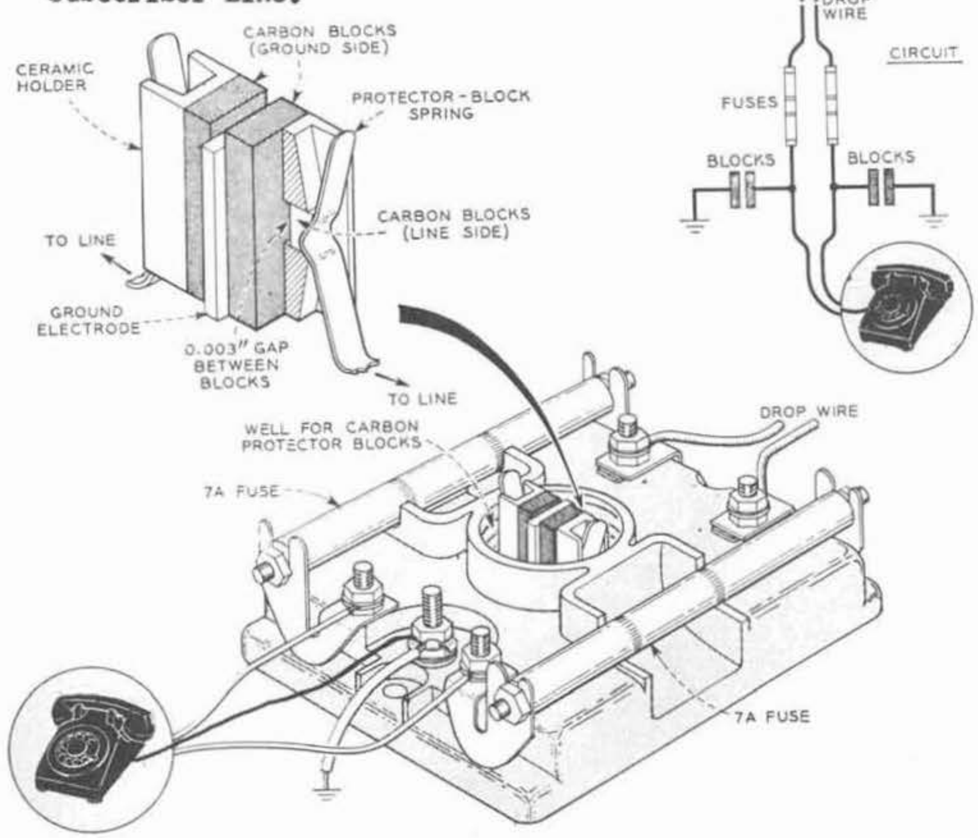
F3) A Varistor - A variable Resistor (Resistance decreases as impressed Voltage increases), shunting the Ballast Filament to limit current flow through it.

2) SUBSTATION PROTECTOR

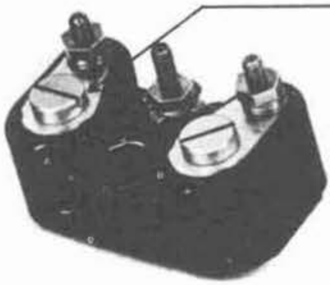
The Substation Protector is made up of:

a) Protector Block Assembly (Lightning Arresters) - One per Subscriber Line Wire - Operated by high-voltage on Subscriber Line.

b) Fuse - 7-Ampere Cartridge Type; Lead Alloy Spacers on 111A - One per Subscriber Line Wire - Operated by excess current flow through the Subscriber Line.

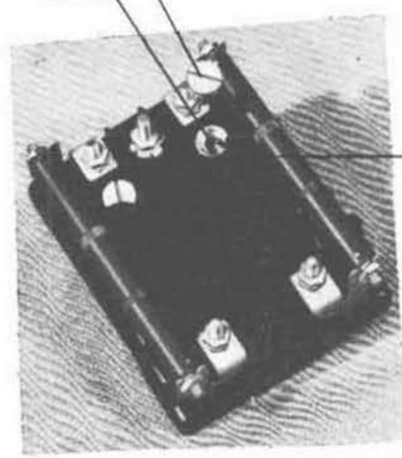


98A SUBSTATION PROTECTOR



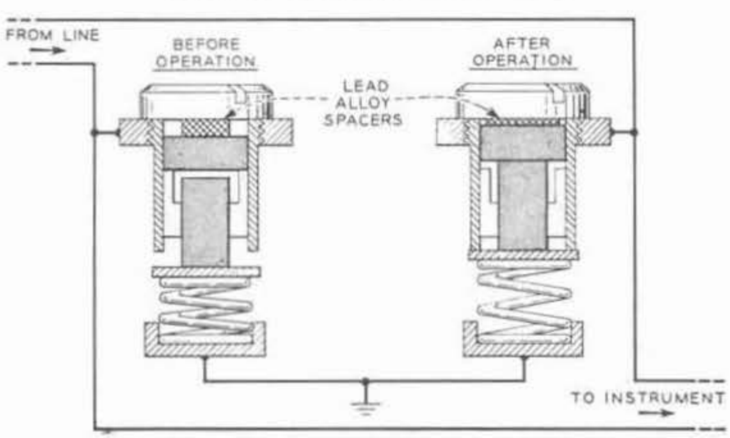
Mounted in Well
(Under Spring Tension) Well
Protector Blocks
Carbon Disc.
Carbon Rod in Porcelain Tube.

Cap Screw



Fuse

111A SUBSTATION PROTECTOR



106A SUBSTATION PROTECTOR

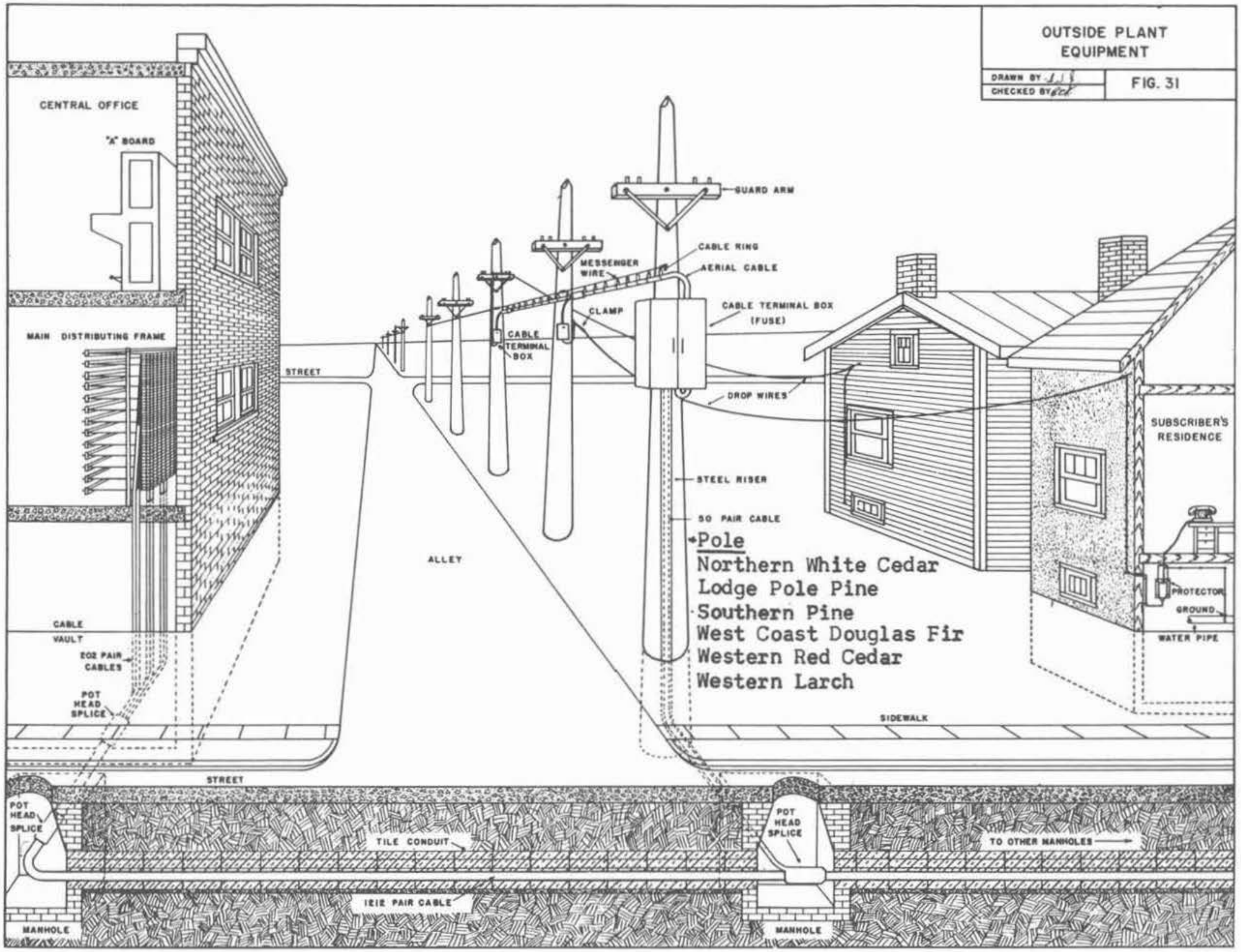
Lesson No. 1

FUNDAMENTALS OF TELEPHONY

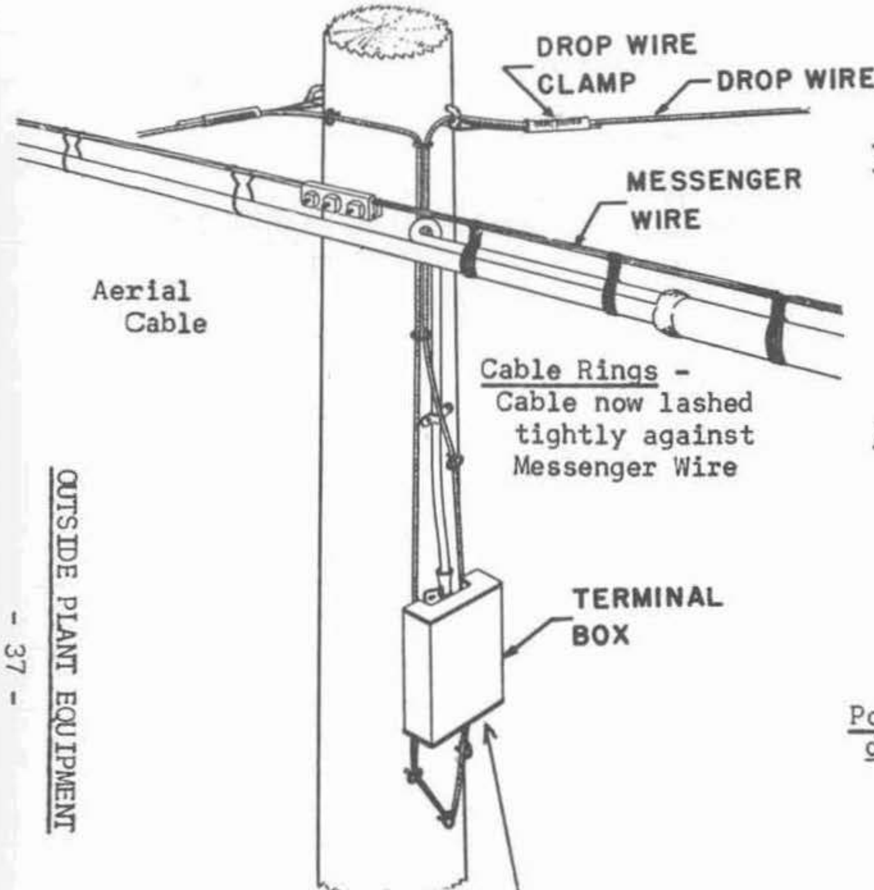
Section 5

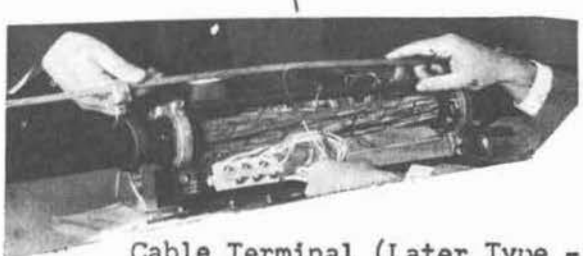
Outside Plant Equipment

CONTENTS

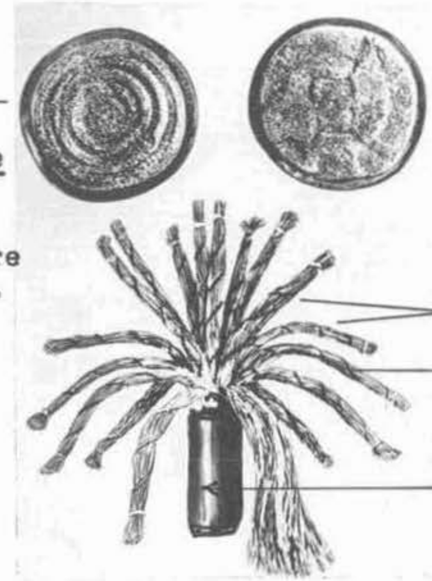


Outside Plant Equipment Required between the Central Office and a Substation





Cable Terminal (Later Type - Mounted on Cable instead of Pole.)

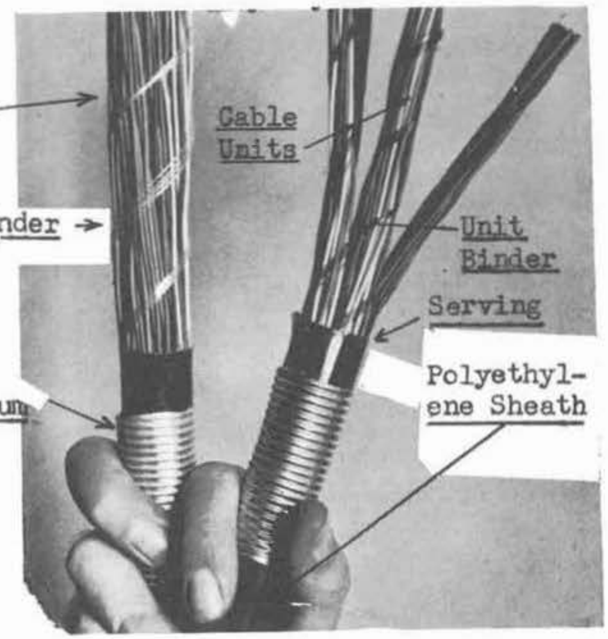
Concentric Cable —  —Unit Cable

Types of Exchange Cable
Lead Covered
Lepeth)
Alpeth)-From Core
Stalpeth) Outward.

Al - Aluminum
Le - Lead
St - Steel
Peth - Polyethylene.

Cable Units
Unit Binder
Lead Sheath

Exchange Cable

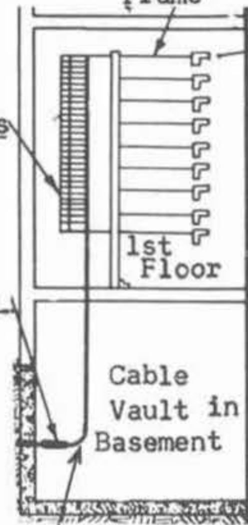


Polyethylene Conductor Insulation
Core Binder
Corrugated Steel or Aluminum Sheath
Polyethylene Sheath

Tile Conduit
Concrete Conduit also used.

Vertical Columns of Protector Mountings

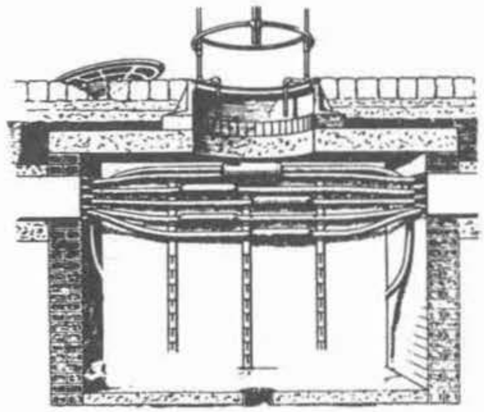
MDF - Main Distributing Frame



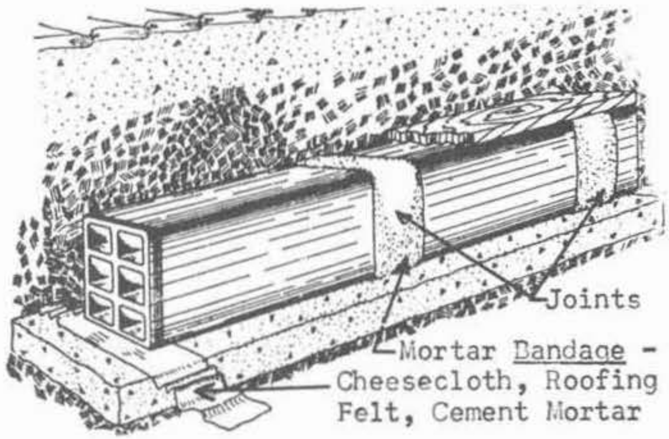
Horiz. Rows of Terminal Strips

Pothead Splice

Flameproof Insulated Cables extend Lines and Trunks to Main Distributing Frame



Typical Manhole
(6' X 4' Wide X 5' High)



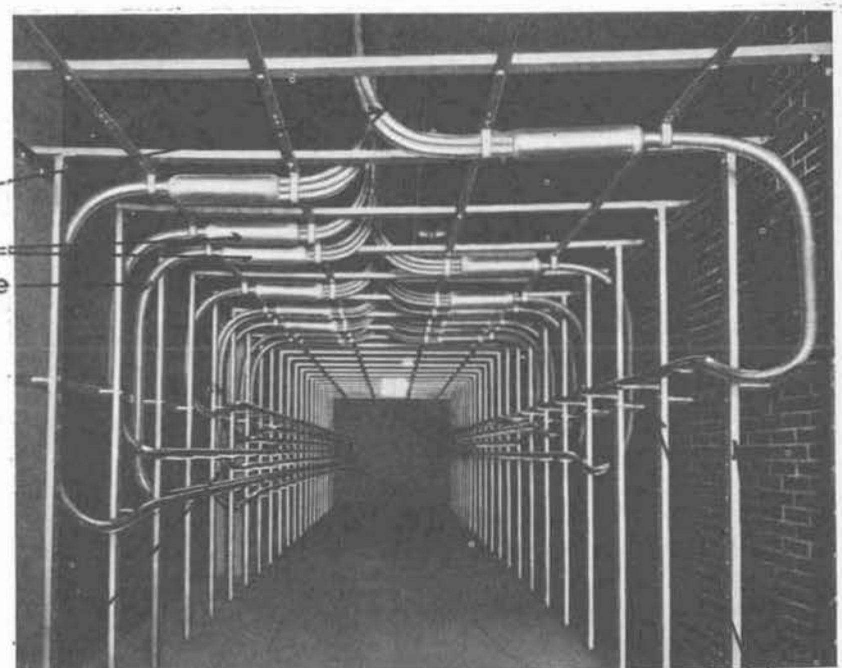
Joints

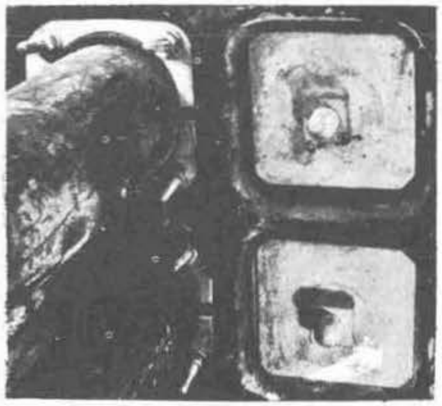
Mortar Bandage - Cheesecloth, Roofing Felt, Cement Mortar

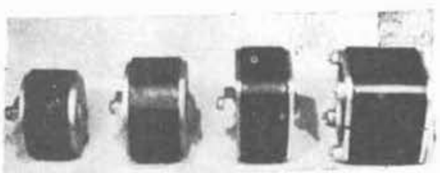
Method of Laying Conduit

Pothead Splices

End of Underground Cable







Rubber Duct Plugs Used in Manholes and Cable Vault to Seal Out Water and Gas.

Cable Pins support Cables

Central Office Cable Vault

Cable Rack

OUTSIDE PLANT EQUIPMENT

Western Electric Company, Inc.
Equipment Engineering - Area "B"
Engineering Personnel Relations

For Training Purposes Only

Lesson No. 1

FUNDAMENTALS OF TELEPHONY

Section 6

Central Office Distributing Frames and Cabling

CONTENTS

Auxiliary Framing Bars (Superstructure)

Threaded Rod

Switchboard Cable

Cable Rack

Rolling Ladder Track

VIDF - Vertical Rows of Terminal Strips

HIDF - Horizontal Rows of Terminal Strips

3-Wire Flameproof Jumpers (T, R, S) lie loosely on Shelves.

Rolling Ladder

Loudspeaking Telephone to Local Test Desk

IDF - Intermediate Distributing Frame

1) Not used in Crossbar Central Offices.
2) For re-locating Lines on Switching Equipment in Manual, Step by Step and Panel Offices.
3) 3-Wire Flameproof Jumpers from HIDF to VIDF.

VMDF - Protector Mountings

1) Protector Blocks
2) Heat Coils

HMDF - Horizontal Rows of Terminal Strips

2-Wire Flameproof Jumpers (T, R) lie loosely on Shelves

Mezzanine Platform

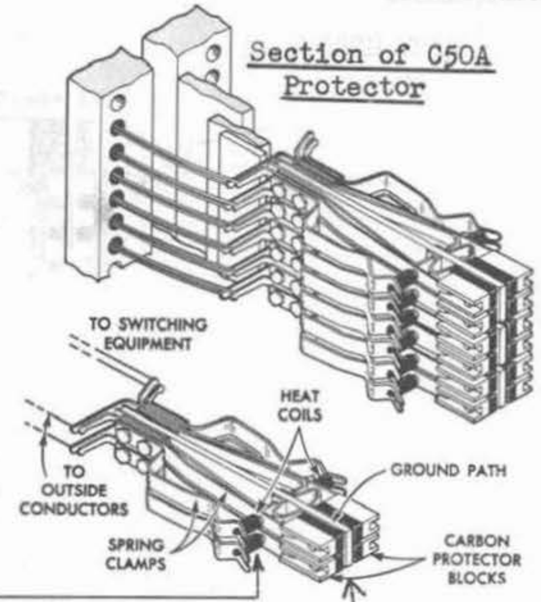
MDF - Main Distributing Frame

1) Outside Subscriber Lines and Trunks terminate on the VMDF.
2) Central Office Equipment cables to the HMDF.
3) 2-Wire Jumpers from VMDF to HMDF.
4) Switchboard Cable from HMDF to HIDF.

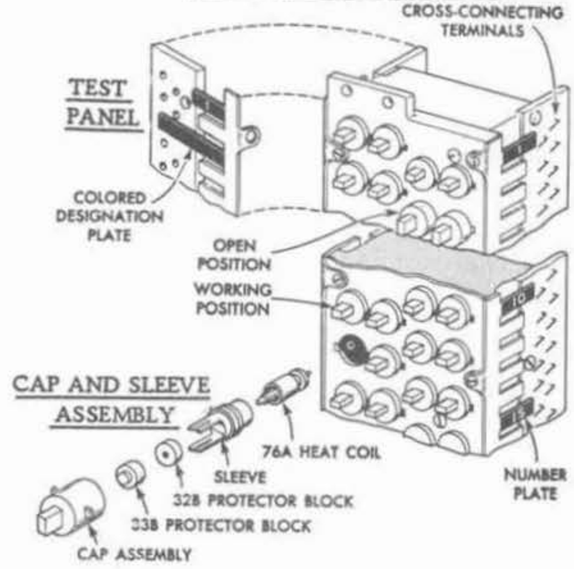
CENTRAL OFFICE DISTRIBUTING FRAMES

VMDF EQUIPMENT

Section of C50A Protector



New 300-Type Connectors



Protector Blocks - High-Voltage Protection

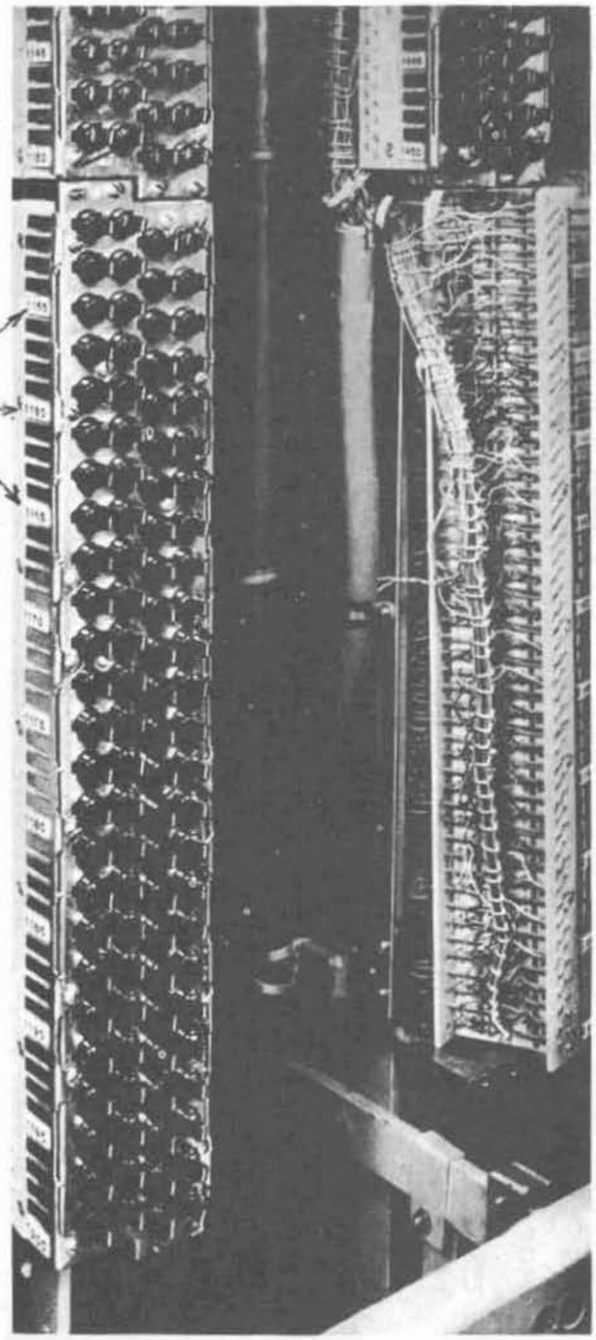
Heat Coils - Excess Current Protection

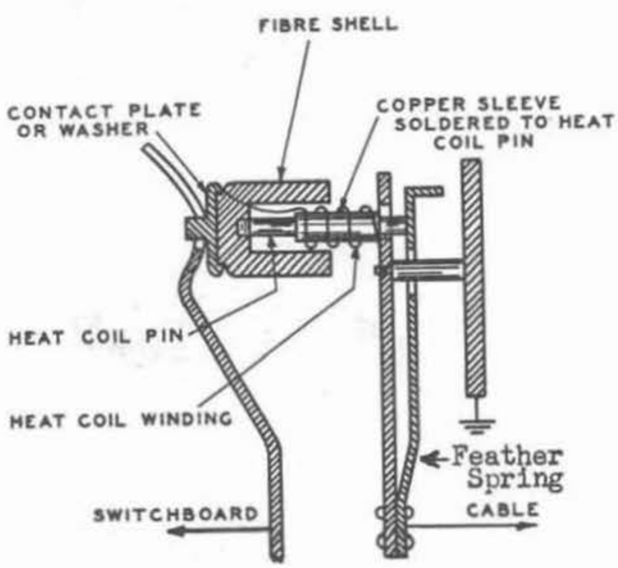
VMDF Vertical Column of C50A Protectors

2-Wire Jumpers (T, R) VMDF to HMDF

Number Plates
Cable Pair Numbers

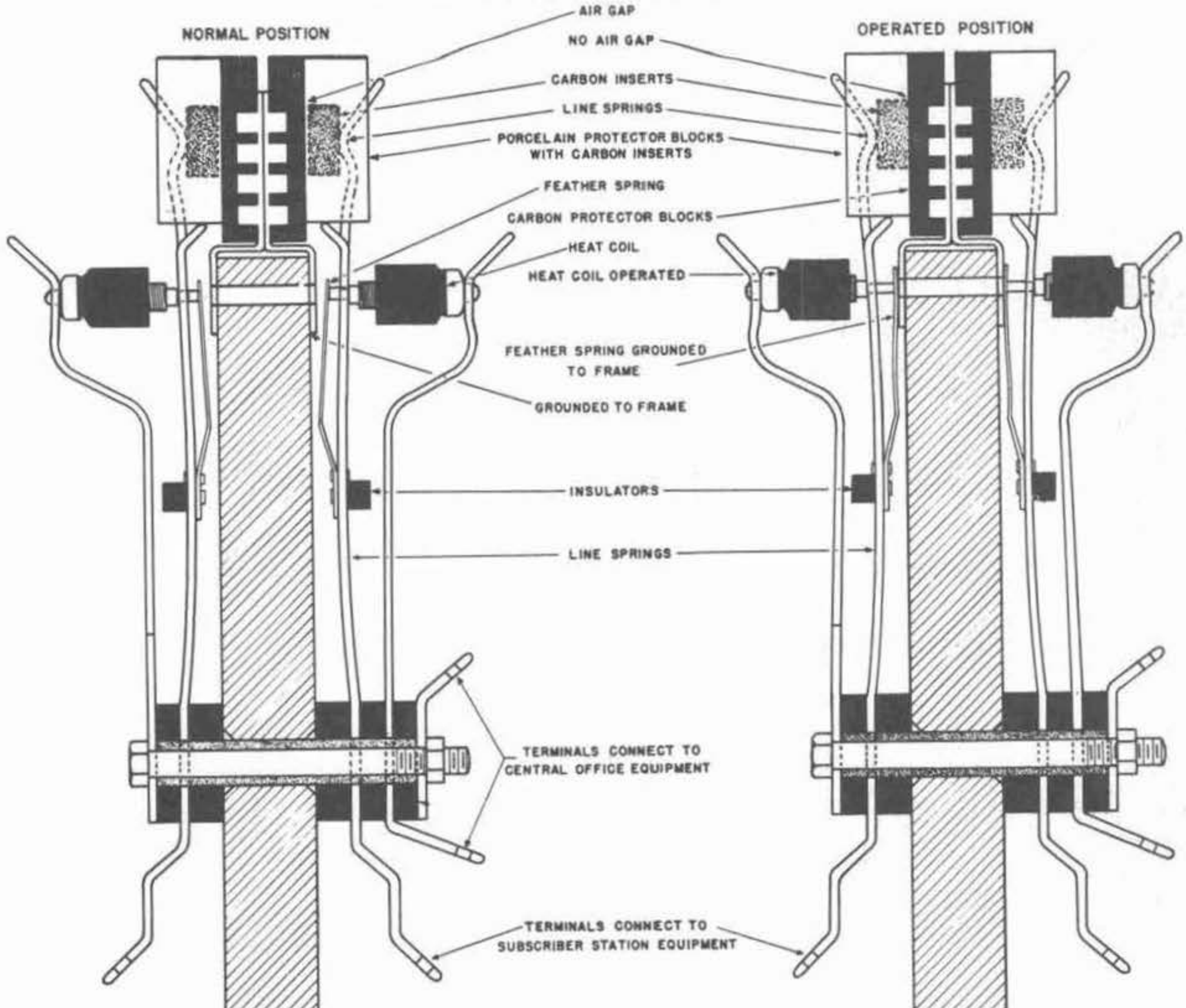
300-Type Connector Unit →



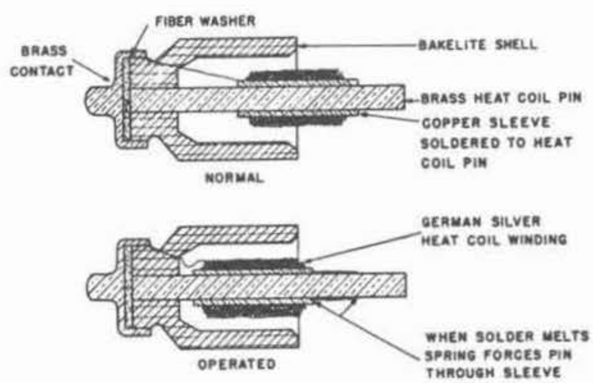


Cross-Section of Type 76A Heat Coil

Protector Blocks and Heat Coils

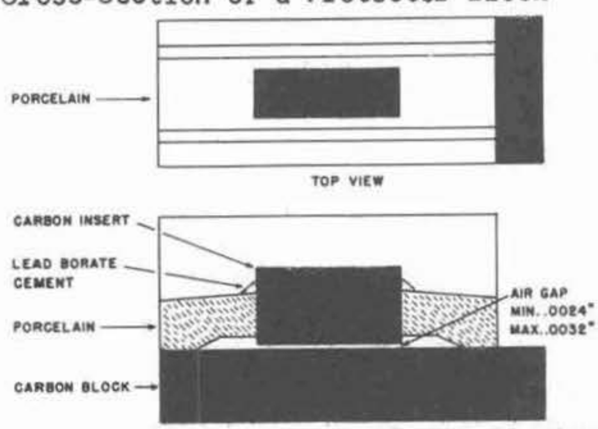


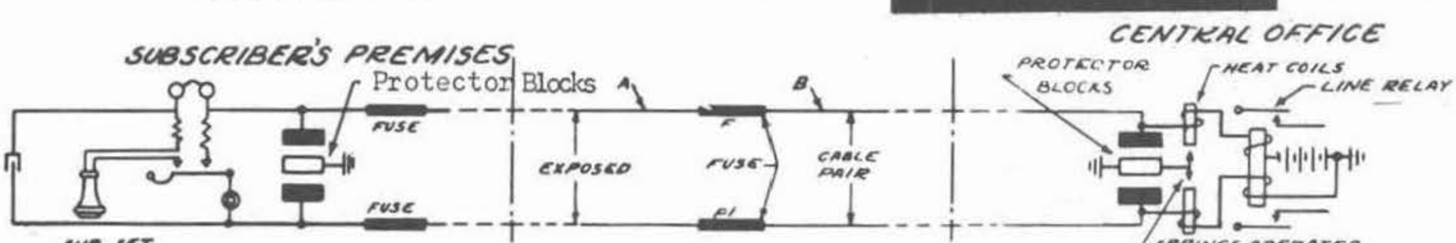
ASSEMBLED "B" TYPE PROTECTOR



CROSS SECTION OF A HEAT COIL

Cross-Section of a Protector Block



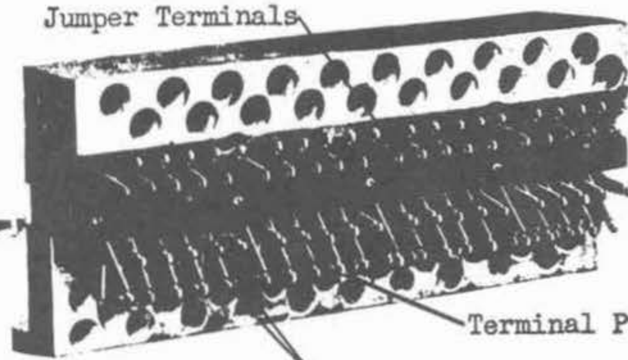


SCHEMATIC OF LINE CIRCUIT

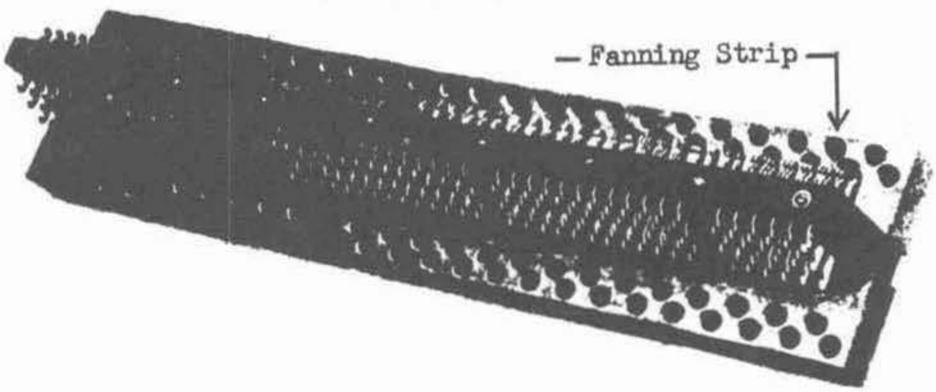
OTHER DISTRIBUTING FRAME EQUIPMENT

Terminal Strips - Mount on the HMDF, HIDF and VIDF, as well as on Switchboards, Units, Frames, etc., to facilitate necessary changes in wiring, assignments, cross-connections, etc.

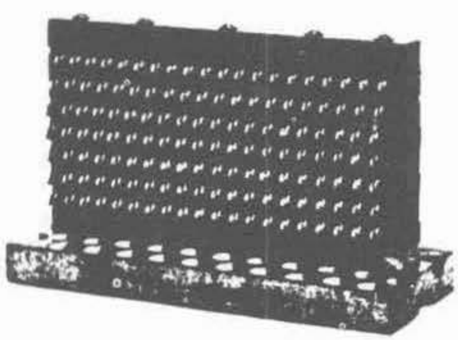
HMDF Terminal Strip
Terminal Punchings for hand-wrapped connections.



VIDF Terminal Strip



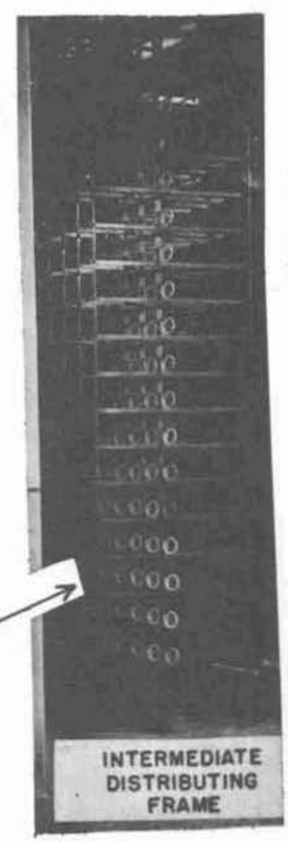
HIDF Terminal Strip



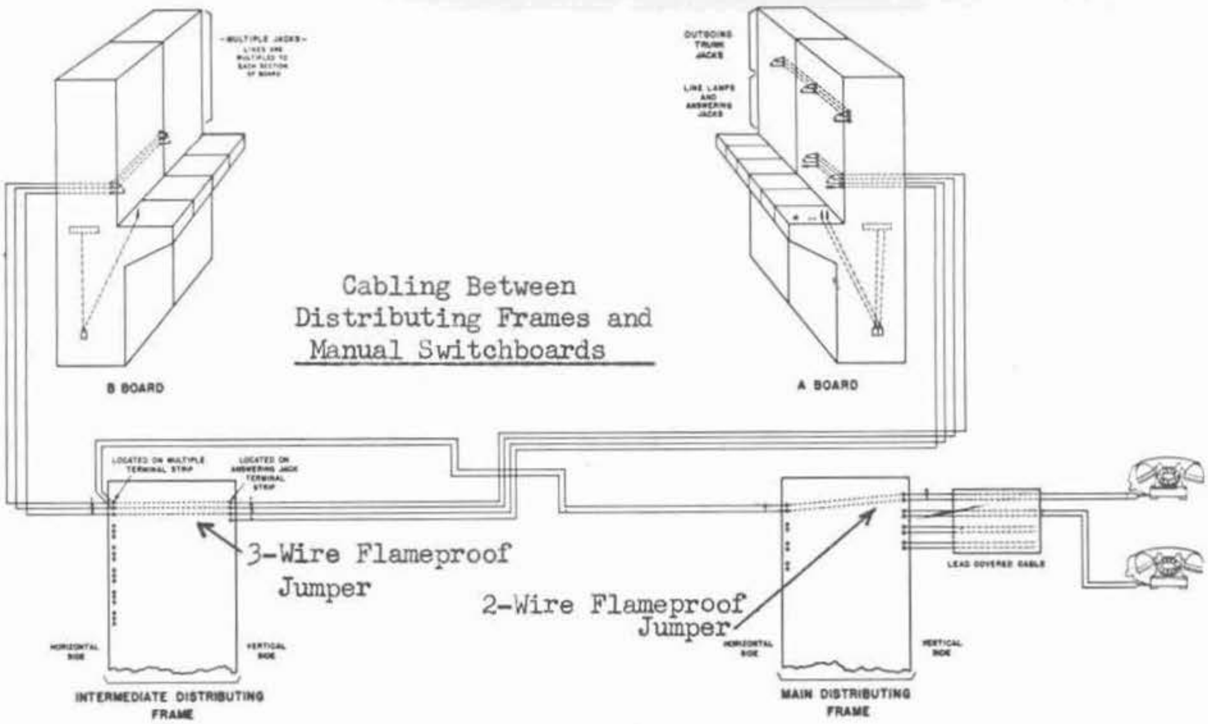
All of the above Terminal Strips are assembled by hand.
Newer Type Terminal Strips have the Punchings cast in a Resin Compound block, which is attached to a Wood Fanning Strip by means of self-tapping screws.
Many new Terminal Strips are arranged for Gun-Wrap Wiring.

\- - - - -

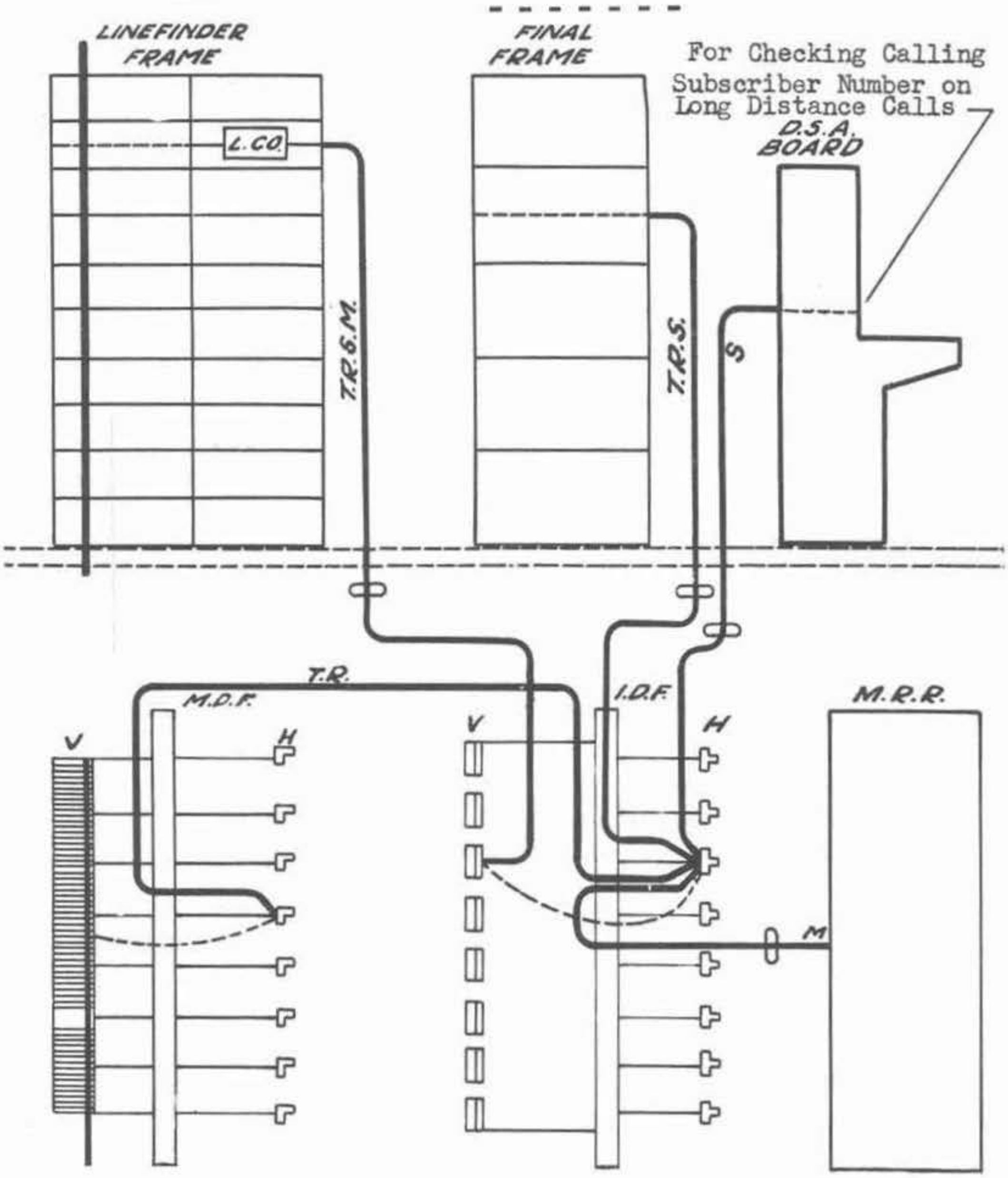
Distributing Rings
Mount on Verticals of Distributing Frames.
The Rings are finished with a viterous enamel paint, which acts as an insulator in case the Jumper insulation is defective. Rings prevent the Jumpers from becoming wedged in the Framework.



CENTRAL OFFICE CABLING



Cabling Between Distributing Frames and Manual Switchboards



Cabling Between Distributing Frames and Panel Dial Switching Frames

Panel Dial Call originates on a Line Finder Frame and terminates on a Final Selector Frame

Lesson No. 1

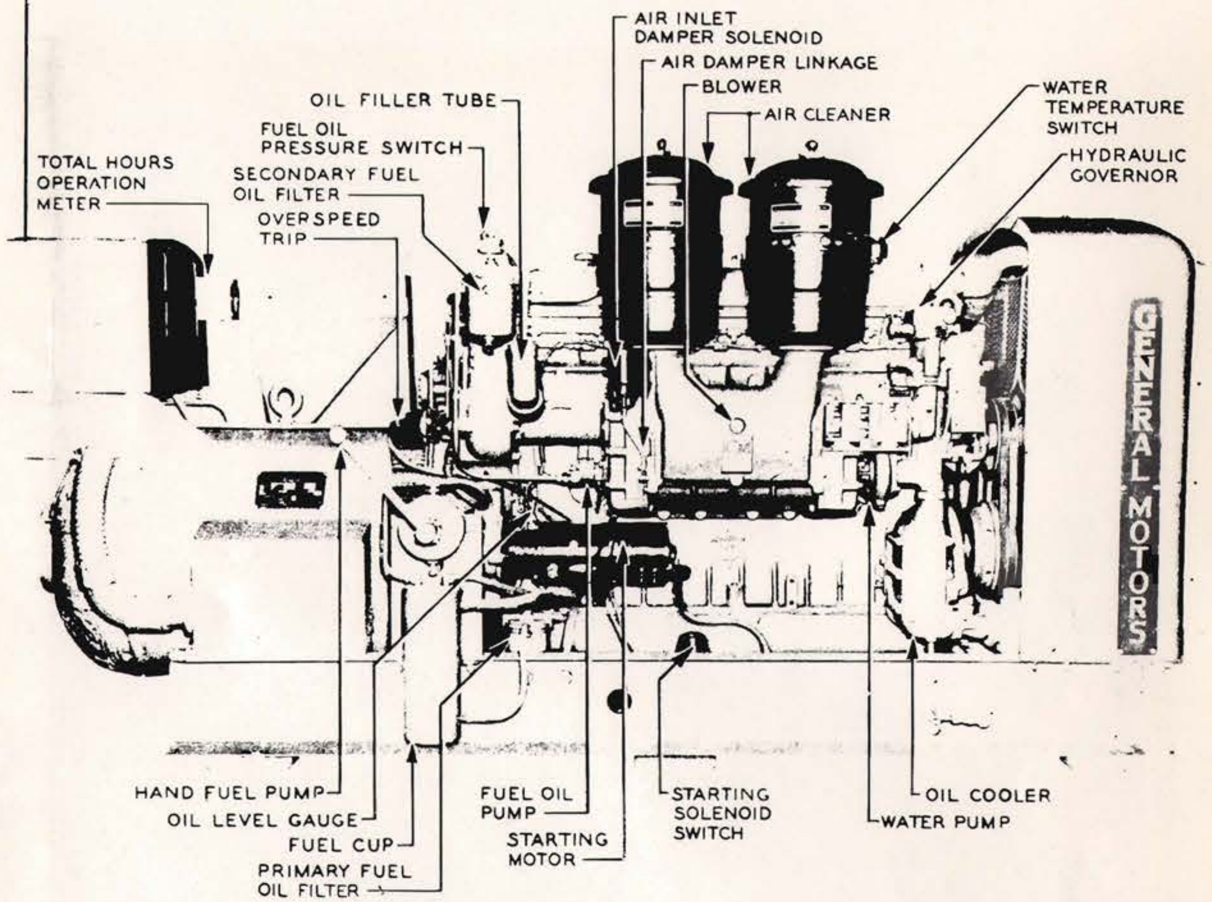
FUNDAMENTALS OF TELEPHONY

Section 7

CENTRAL OFFICE POWER PLANT

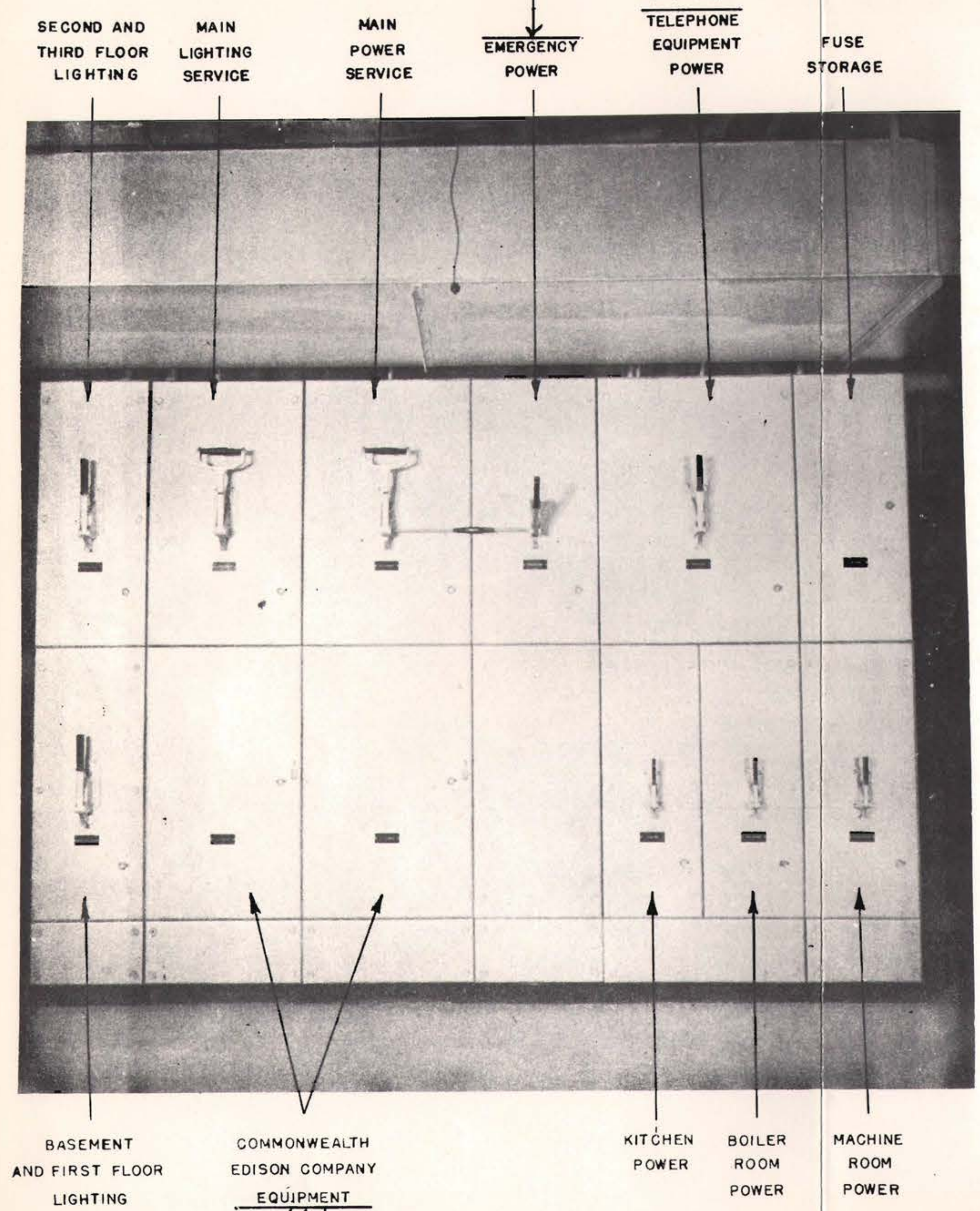
CONTENTS

200/230-v, 3-Phase, 60-Cycle A.C.

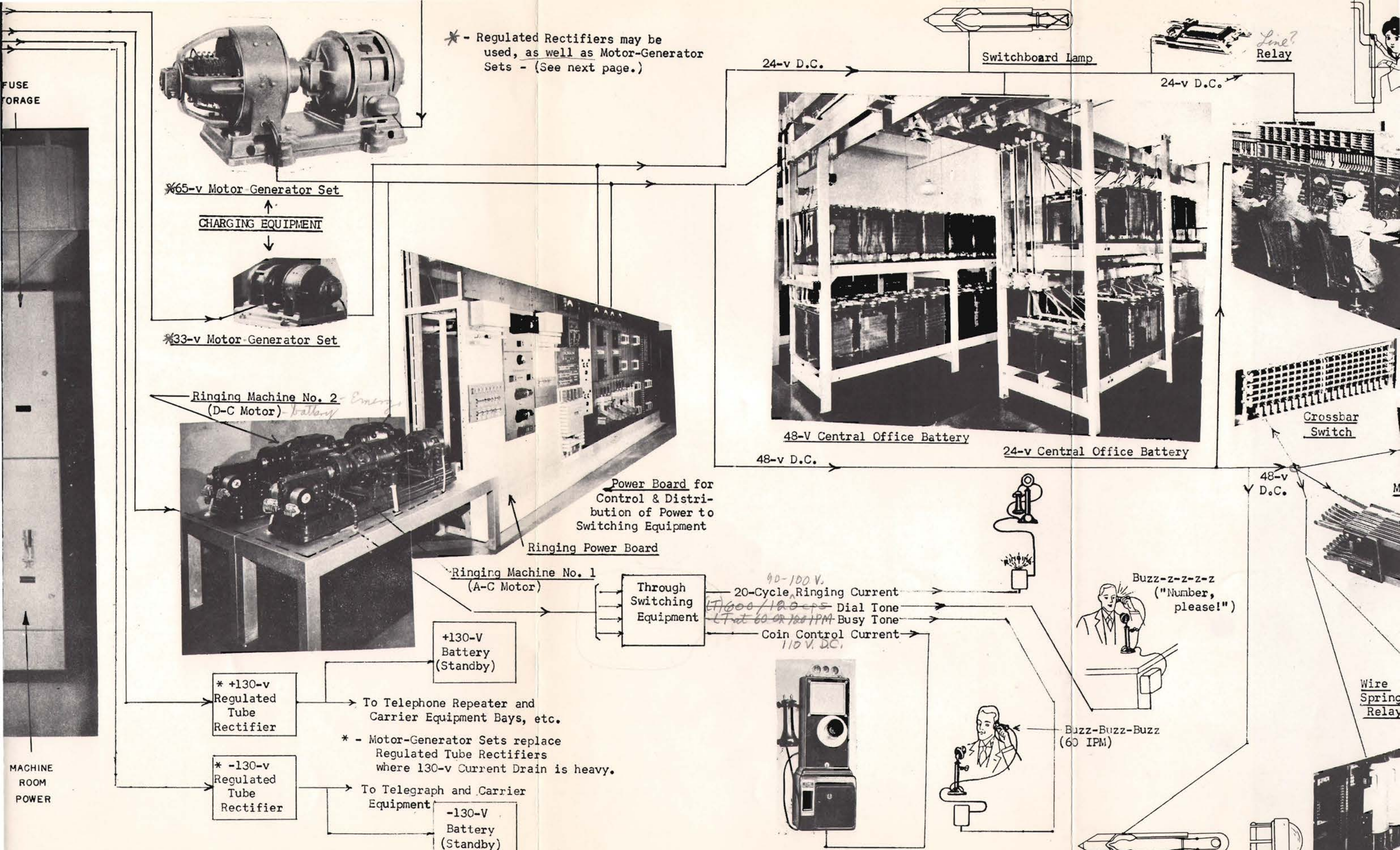


EMERGENCY POWER PLANT
200/230-v, 3 Phase, 60 Cycle A-C Diesel Engine Alternator

Public Service Company 200/230-v, 3 Phase, 60 Cycle A-C Power Mains

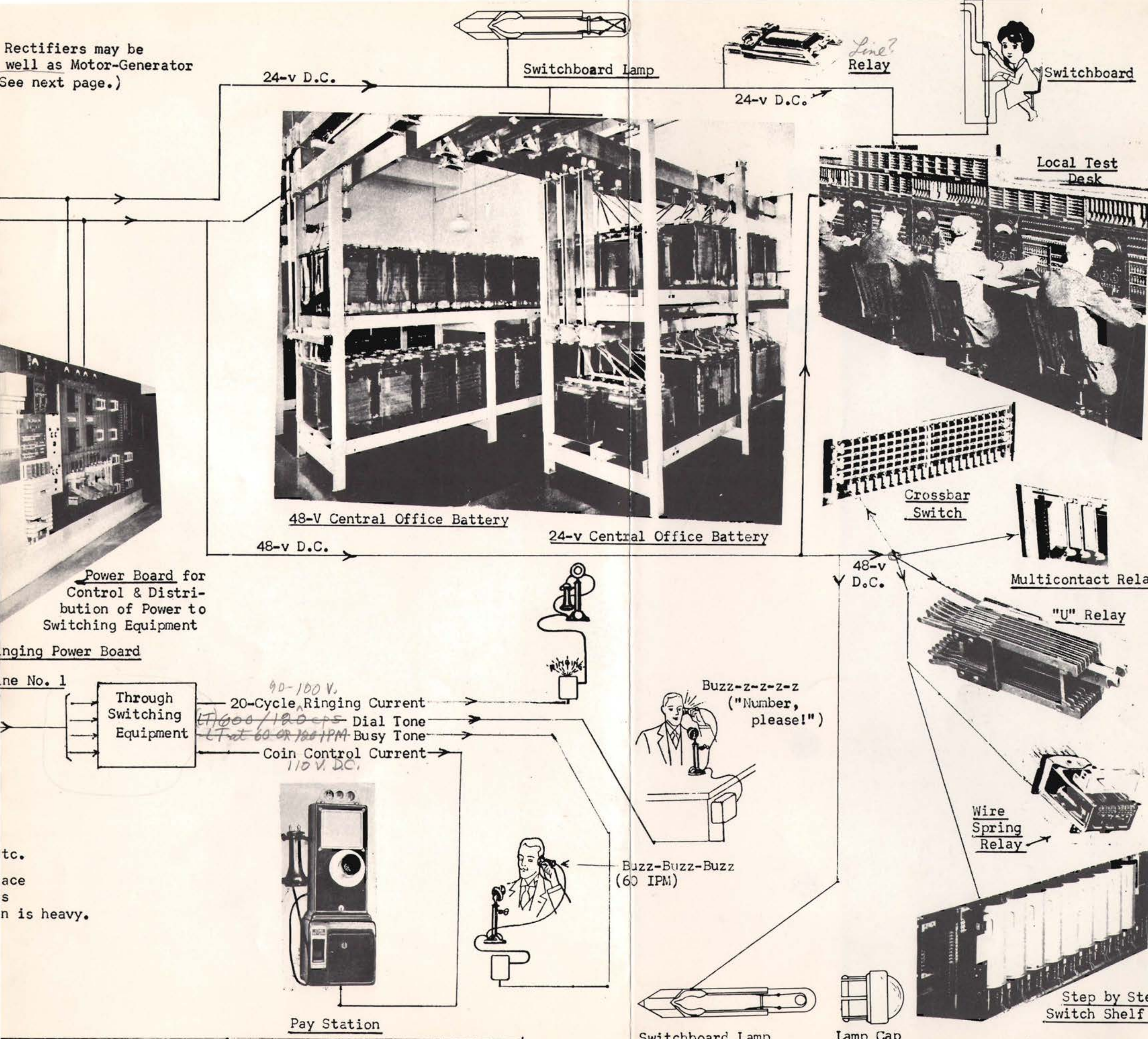


HOUSE SERVICE PANEL

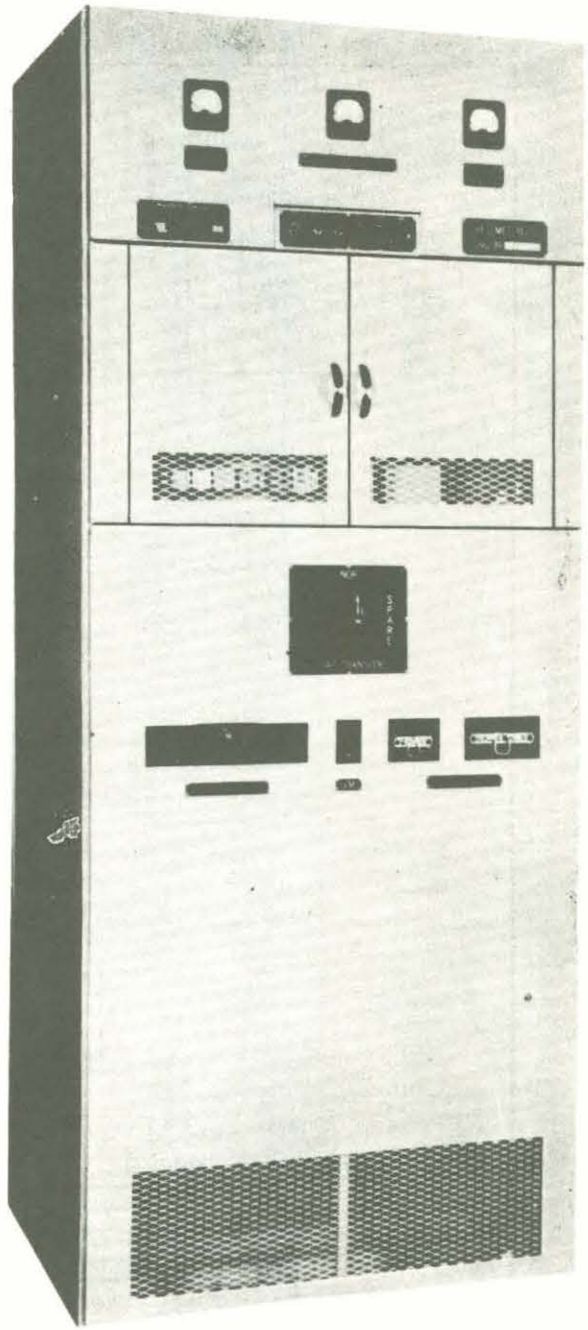


E CENTRAL OFFICE POWER PLANT -

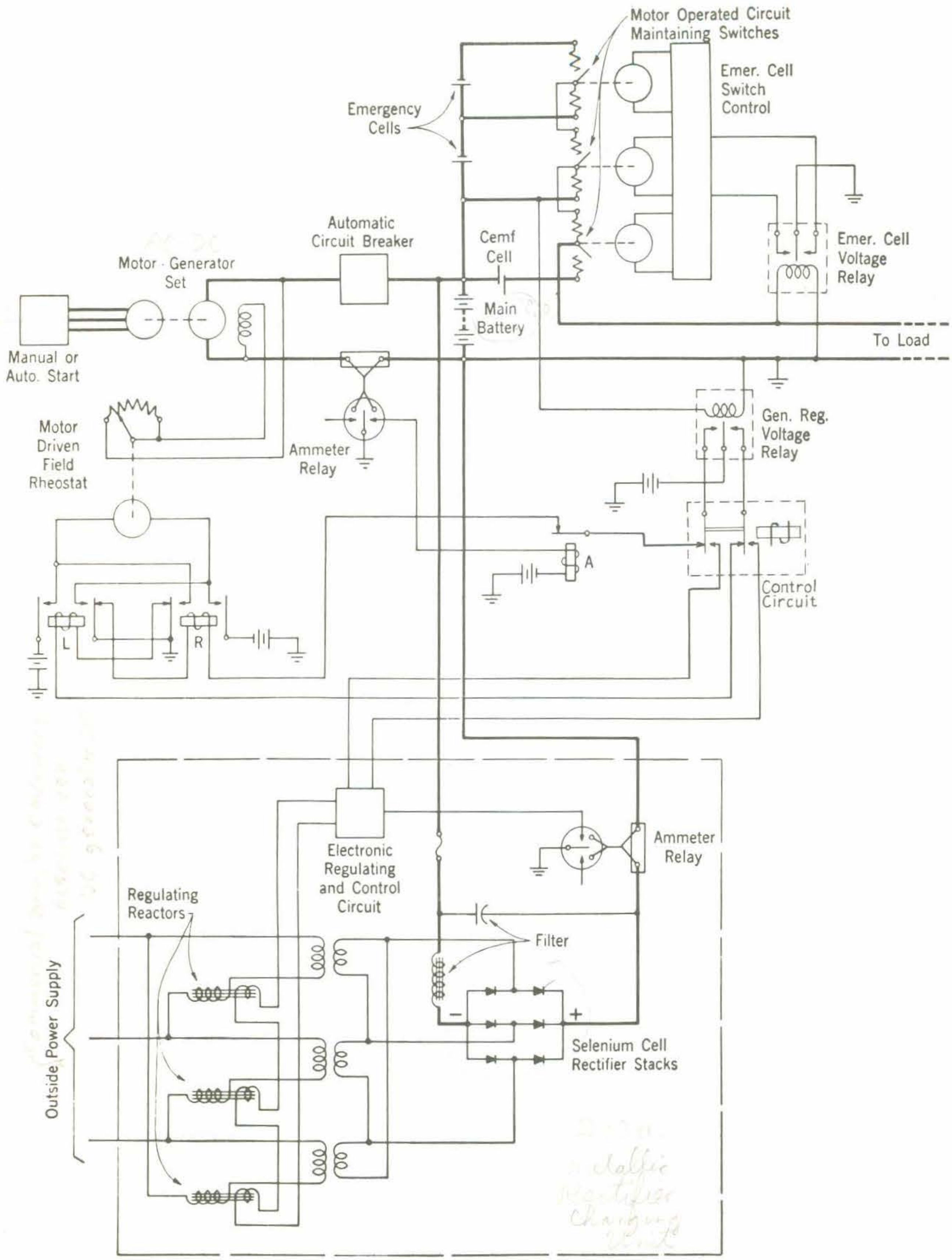
Rectifiers may be
well as Motor-Generator
See next page.)



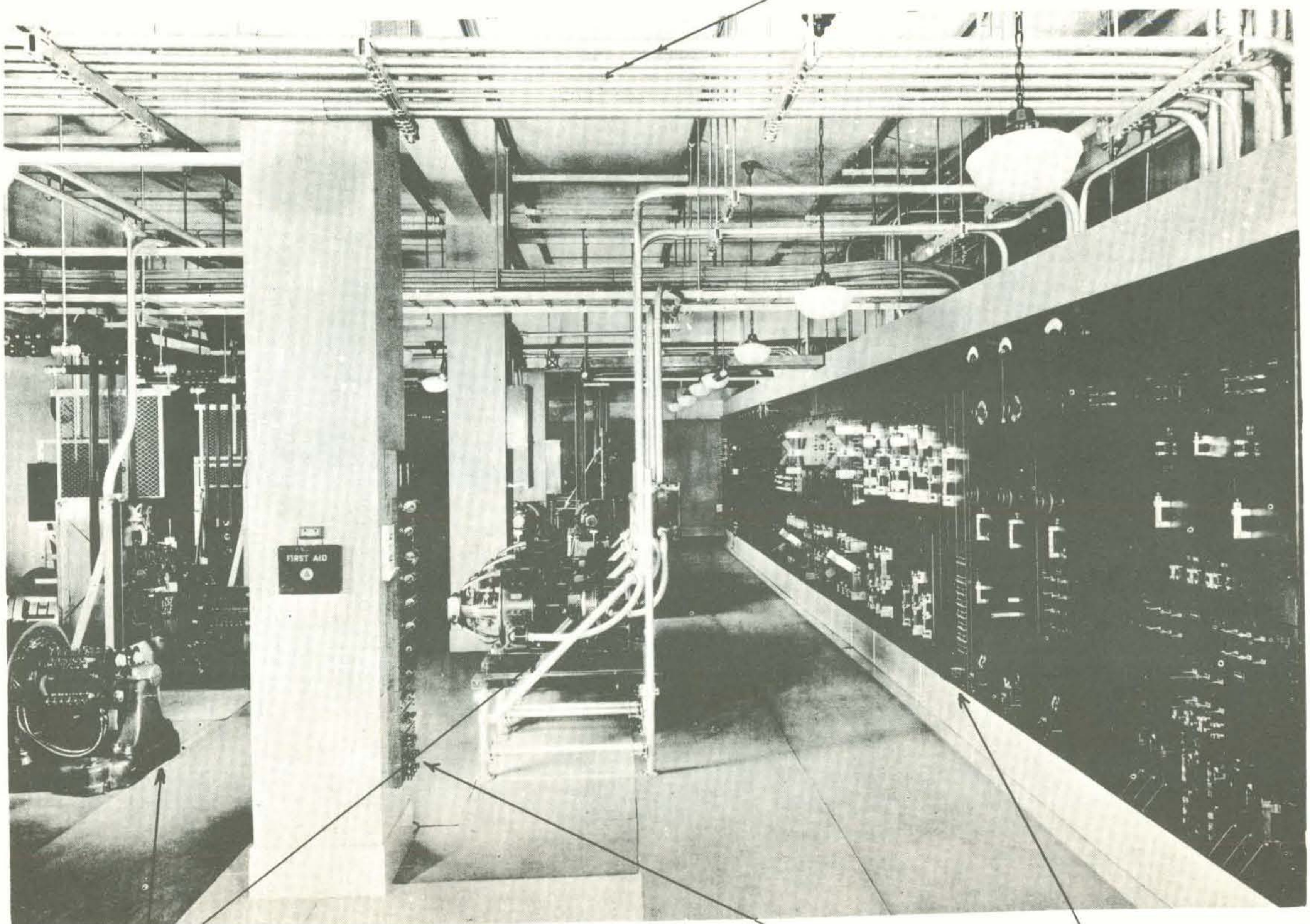
tc.
ace
s
n is heavy.



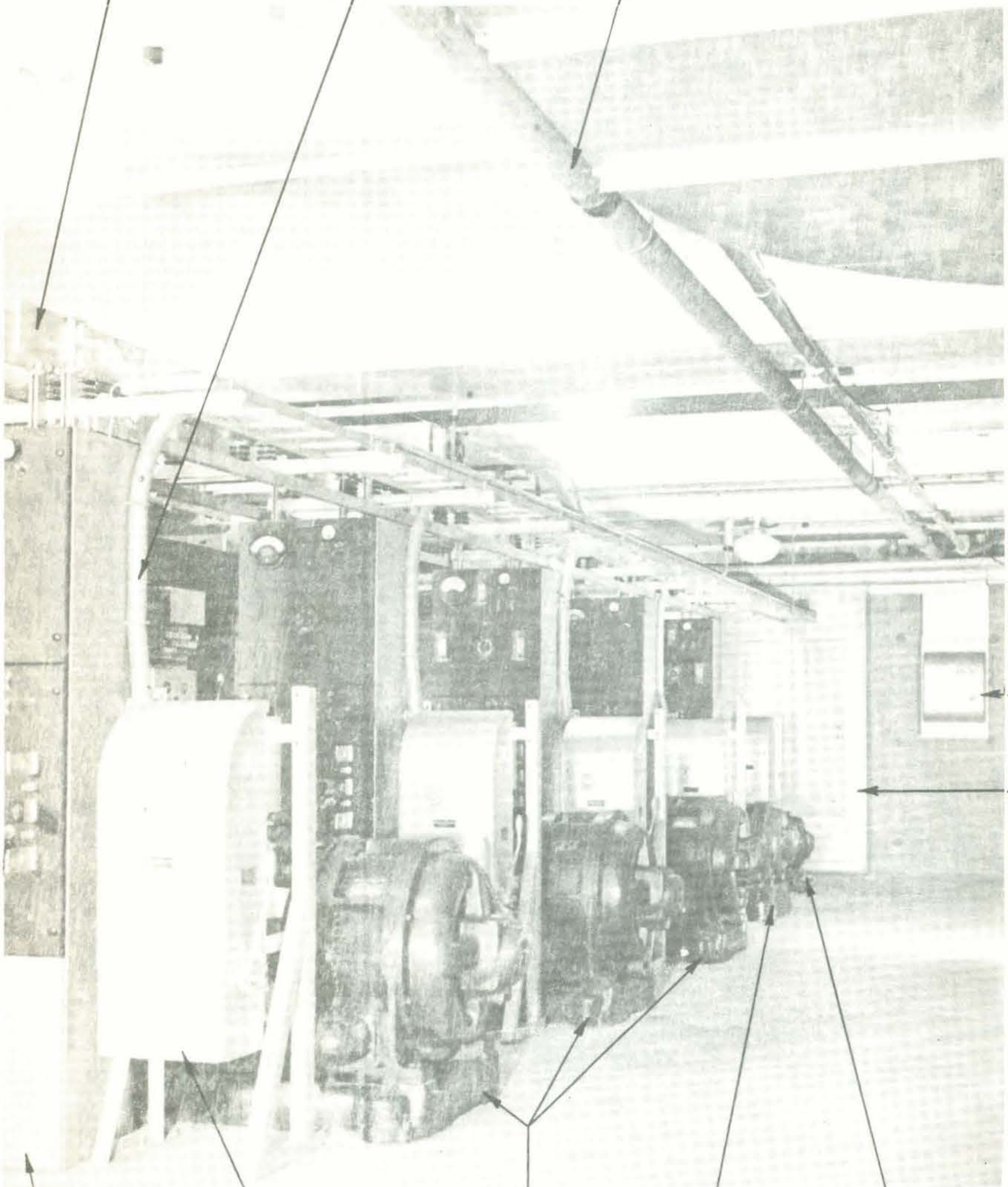
200 Ampere Metallic Rectifier
Charging Unit



Simplified Schematic of Fully Autmoatic Charging Equipment
(48-v or 24-v D.C.)



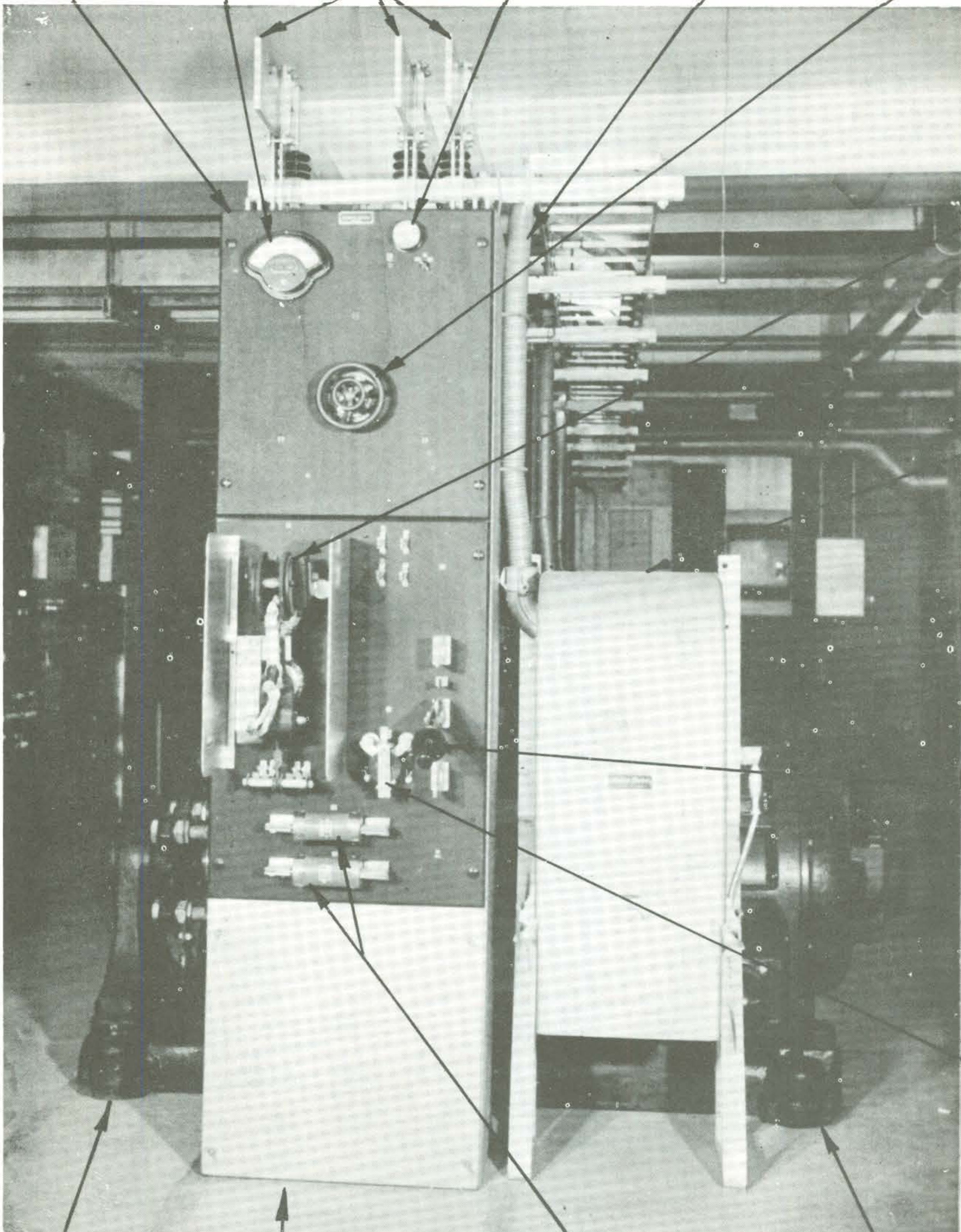
General View of Power Room



CHARGING GENERATOR UNITS

OAKLAND OFFICE, CHICAGO

AUG. 1940



CHARGING GENERATOR UNIT

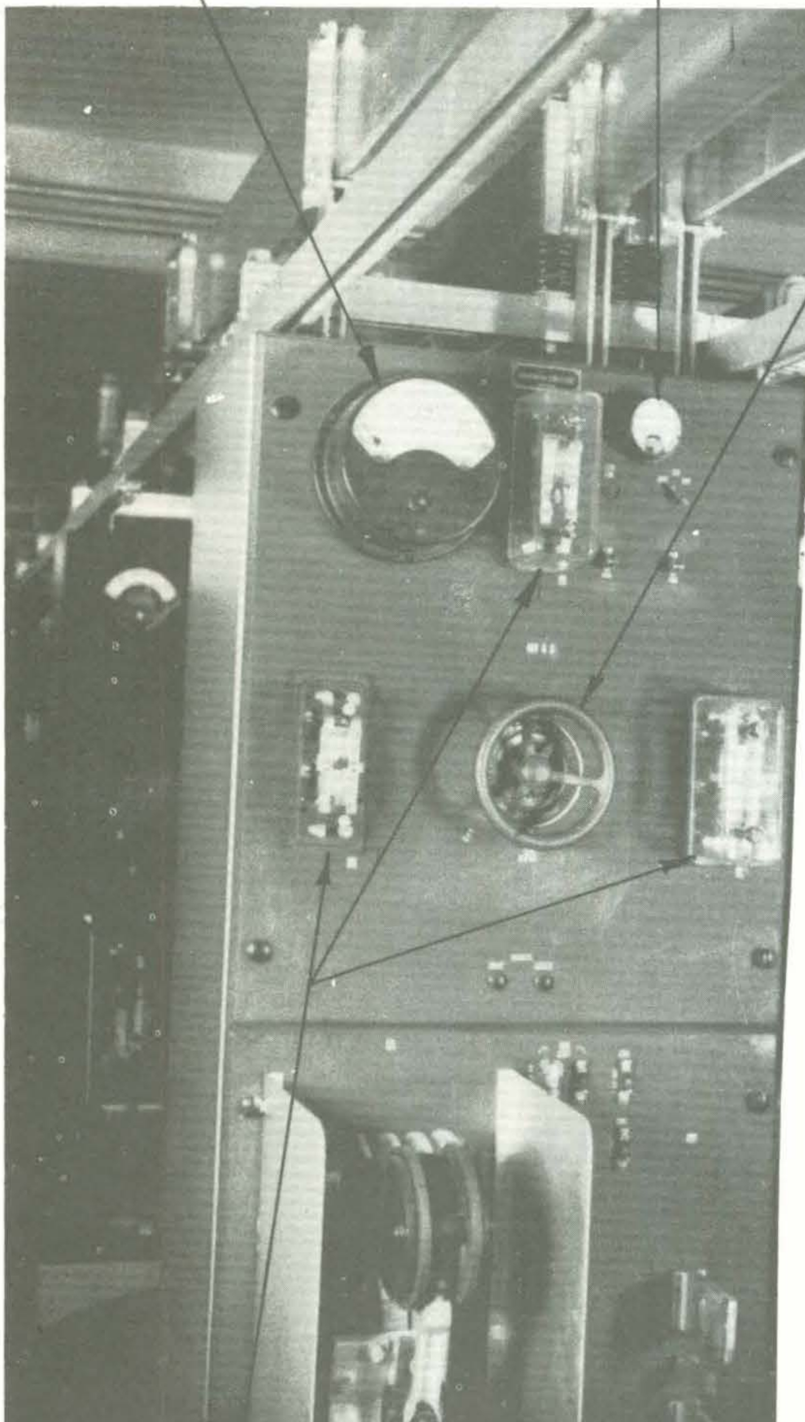
OAKLAND OFFICE, CHICAGO

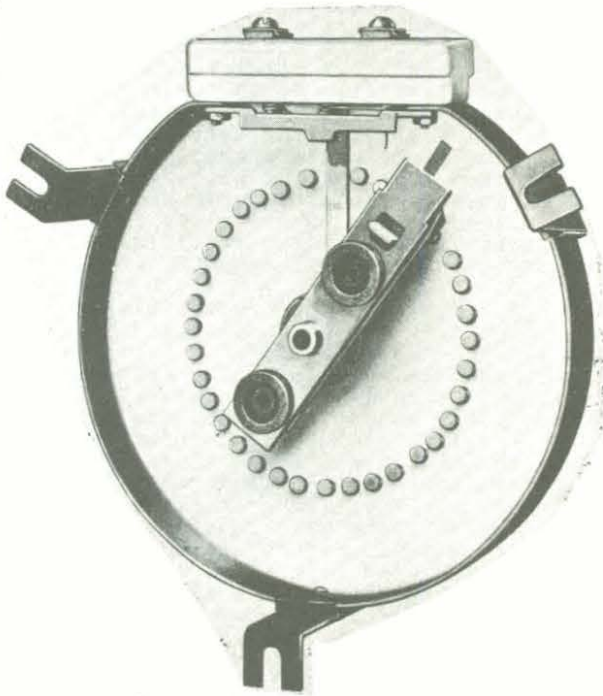
Manual Operation

DIRECT CURRENT AMMETER RELAY

VOLTMETER (MODEL 301)

234 HAND WHEEL

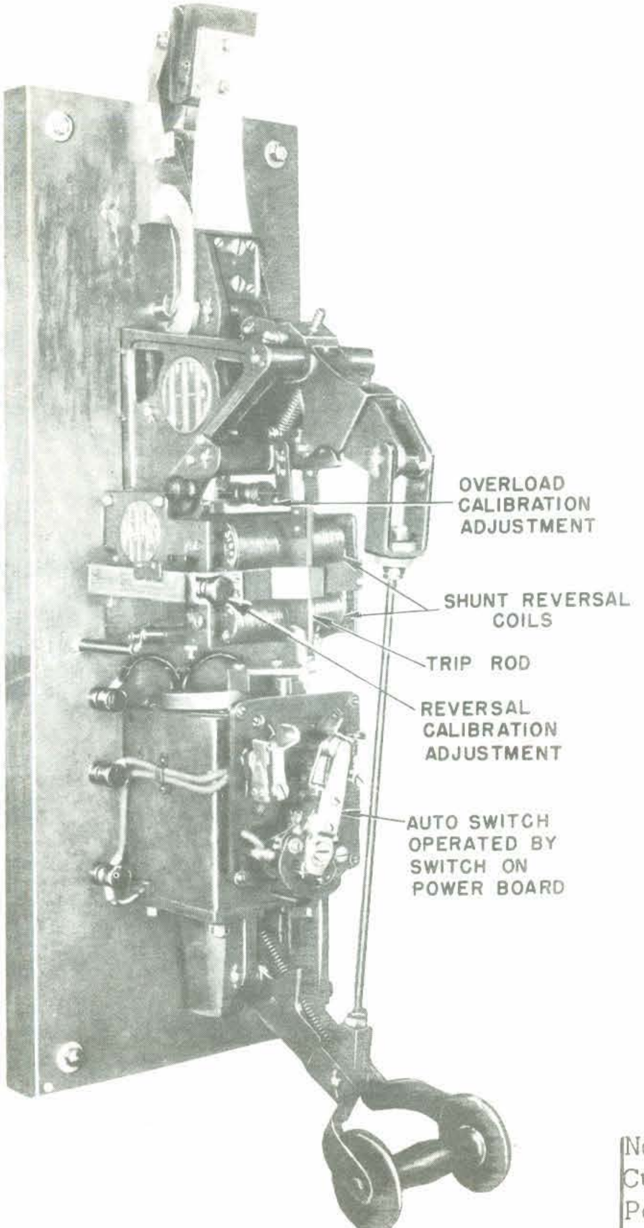




Generator Field Rheostat
Mounted Behind Panel.
Set Manually by Handwheel.

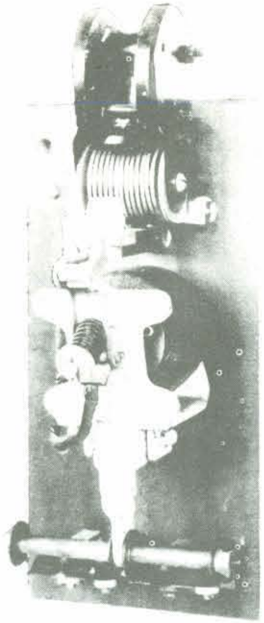
CONTROL RELAYS (NUN CO.)

Meter and Control Panel
Charging Generator Unit
Control Relays operated by Voltage Controller on Battery Control Board for Automatic Operation

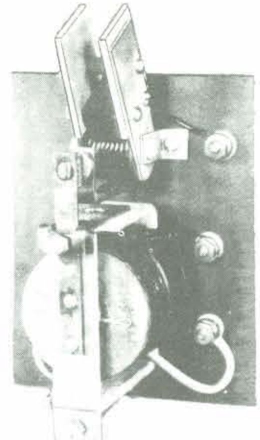


<u>Circuit Breaker</u>

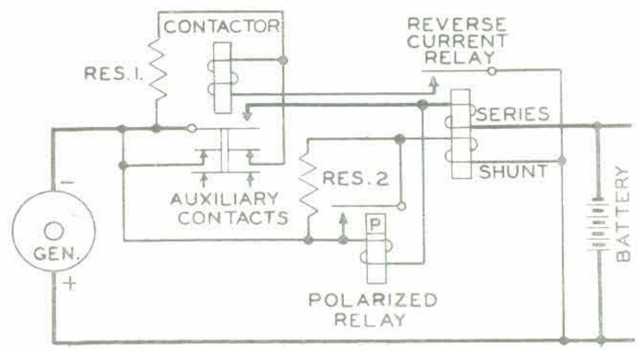
Formerly used on Power Boards, between the Charging Unit and the Battery, for Overload and Reverse Current protection.



CONTACTOR

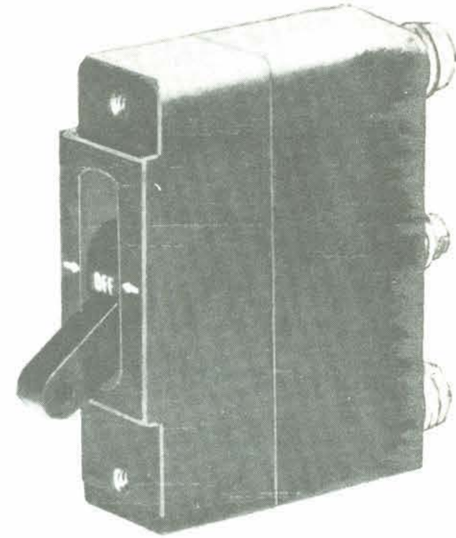


REVERSE CURRENT RELAY



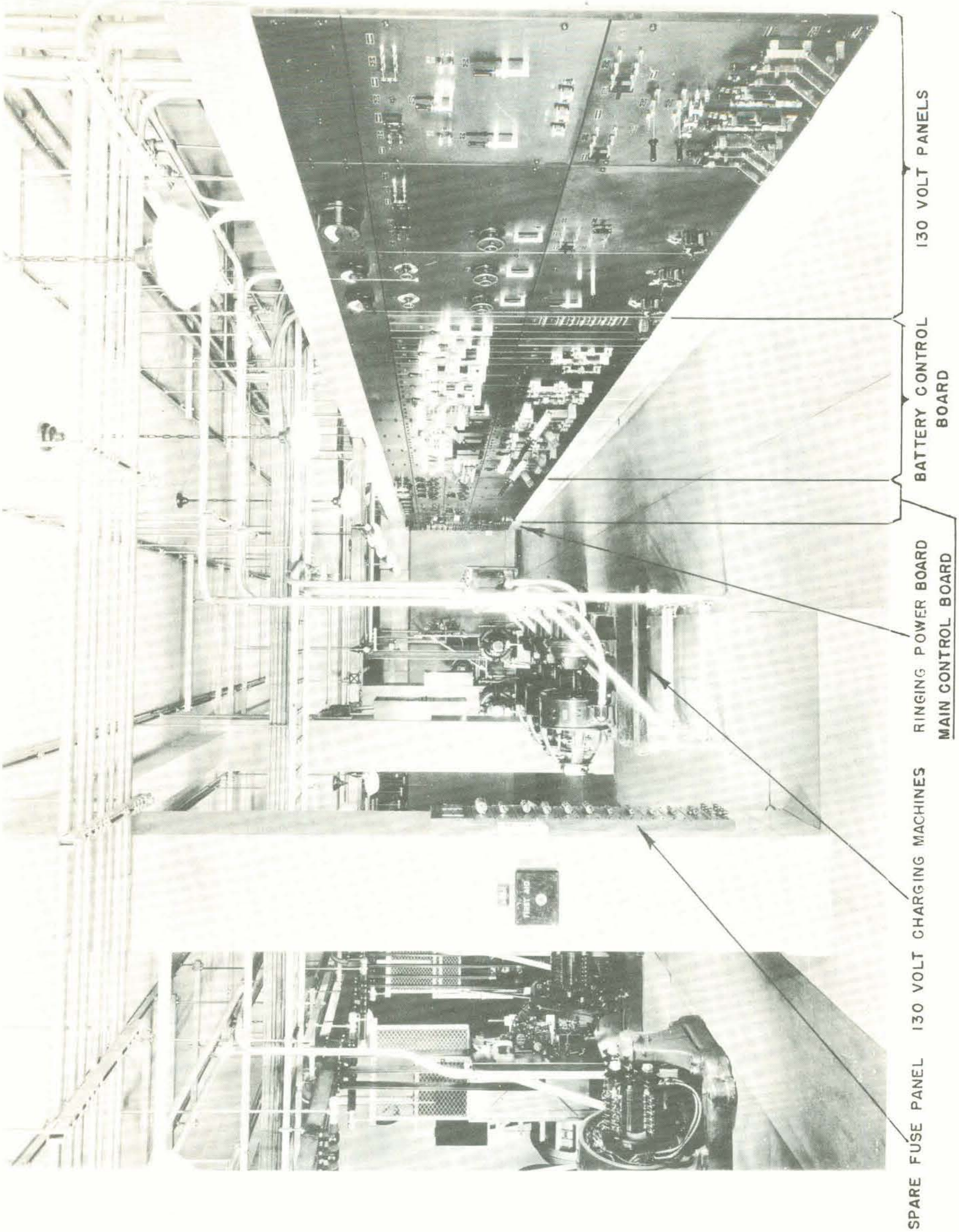
<u>Automatic Reverse-Current Switch</u>

Now used in place of Circuit Breakers. Reverse Current Switch, made up of 1) a Contactor, 2) a Polarized Relay and 3) A Reverse Current Relay, connects the Charging Unit to the Battery at a predetermined voltage, and disconnects the Charging Unit from the Battery when current tends to flow backward, from the Battery to the Charging Unit.



<u>Typical KS-Type Circuit Breaker</u>

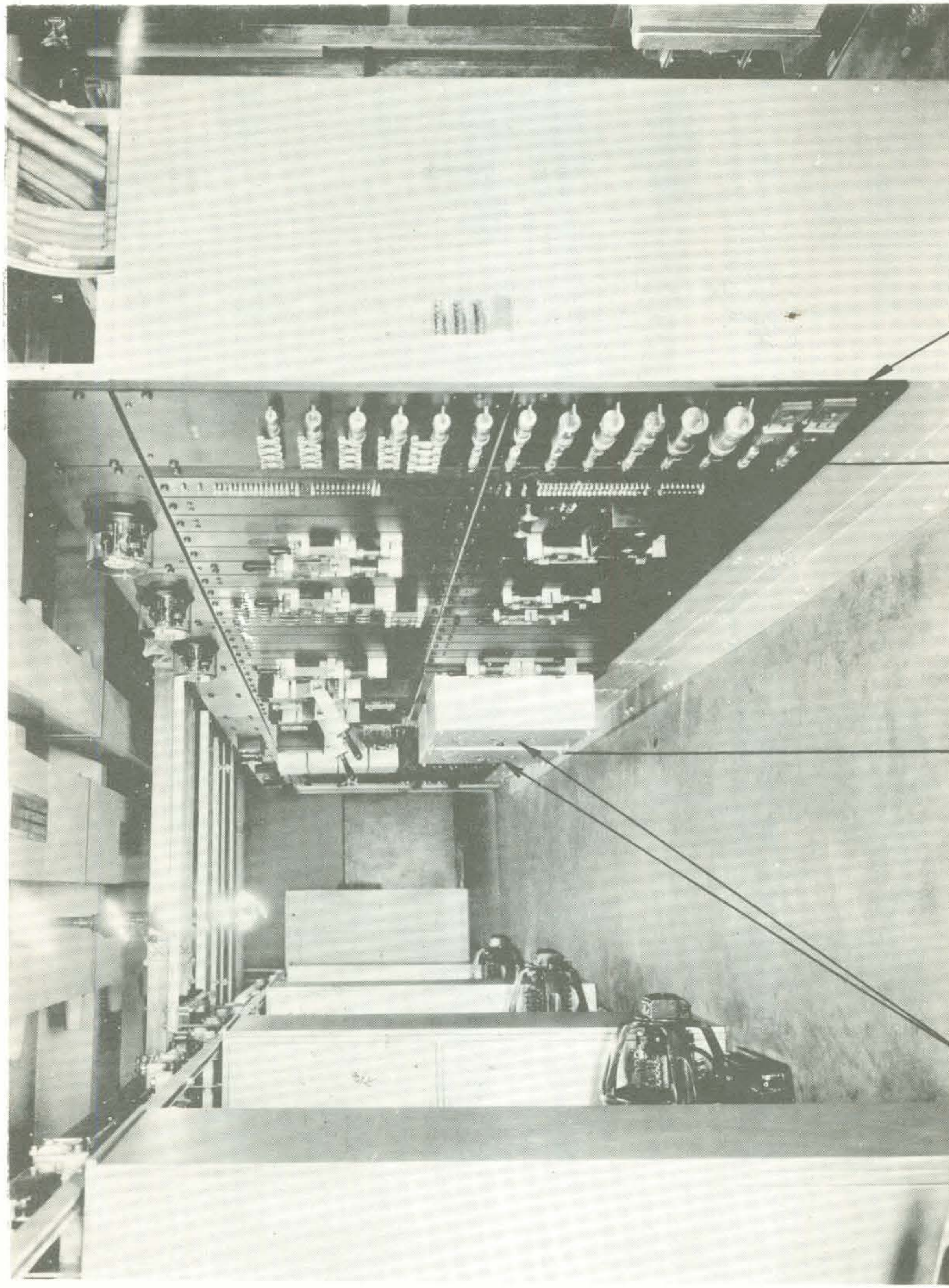
Used on some Rectifier Panels.



FRONT VIEW OF POWER BOARD

MAIN OFFICE, DENVER, COLO.

DEC. 1927

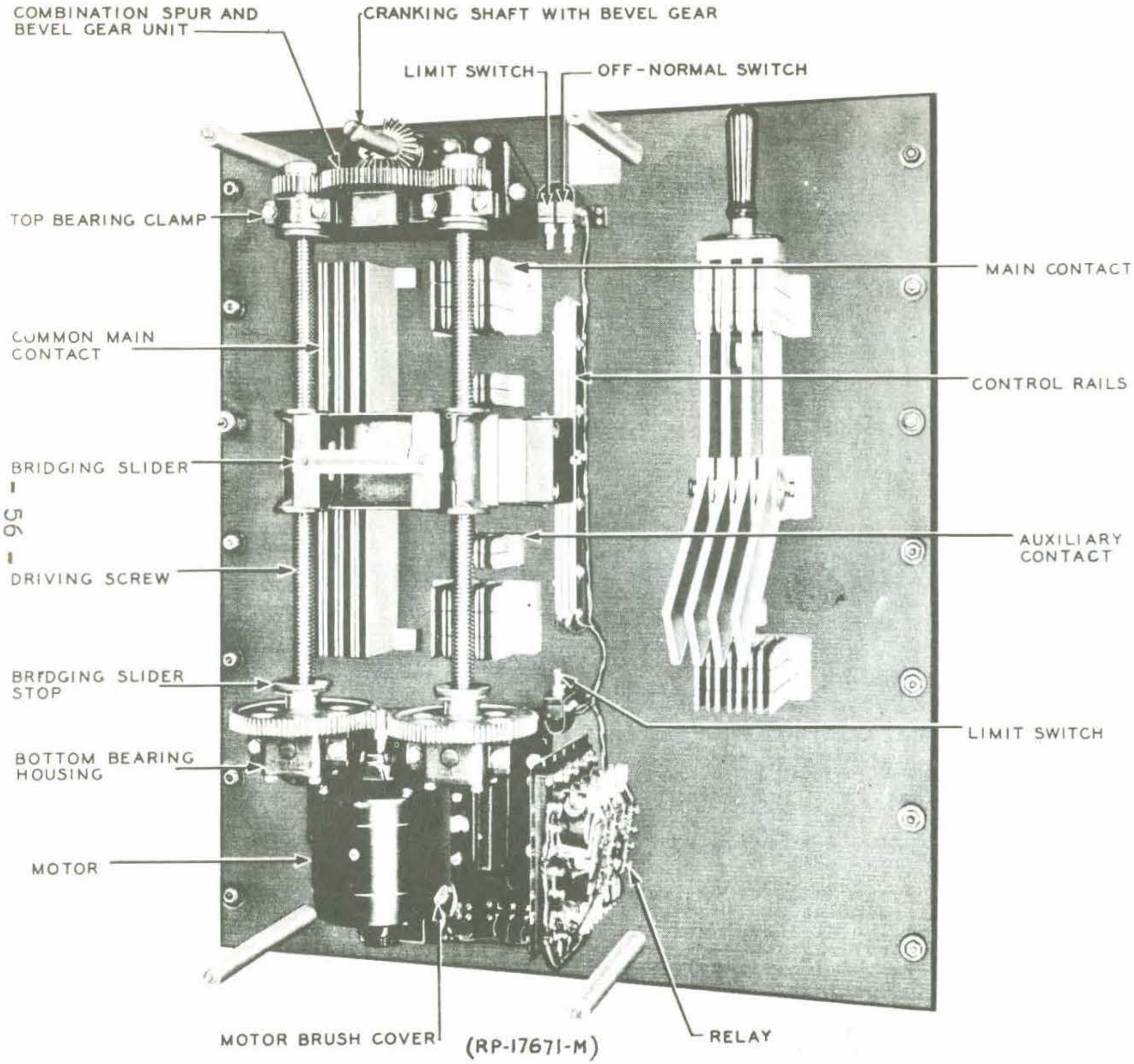


FRONT VIEW OF POWER BOARD

(FROM BATTERY CONTROL BOARD END)

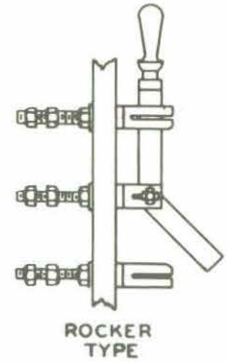
ROANOKE, VA.

SEPT. 1934

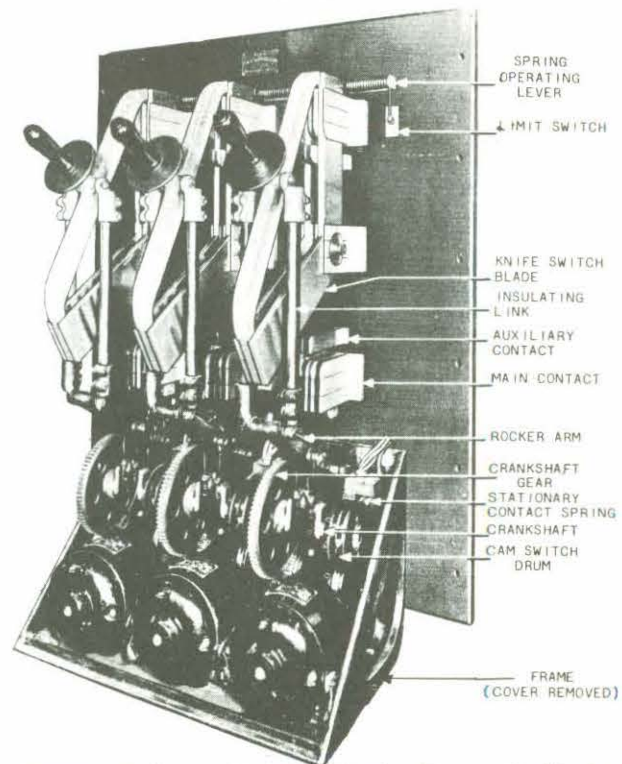


Motor-Driven Slider Type Switch

- 56 -

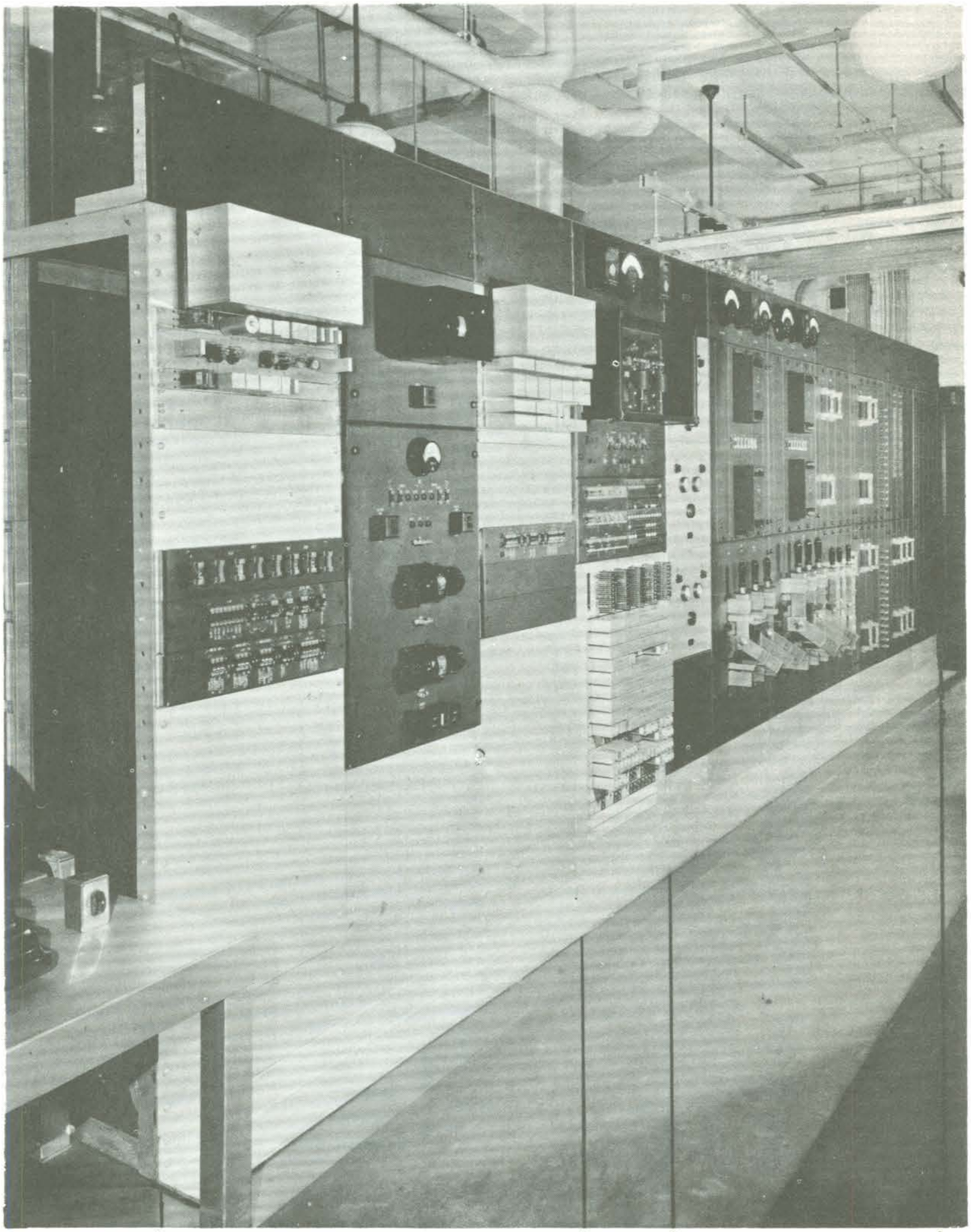


Rocker Type Knife Switch
Manually Operated



Motor-Driven Knife Blade Type Switch

EMERGENCY CELL SWITCHES
Mounted on Battery Control Board



RINGING POWER BOARD

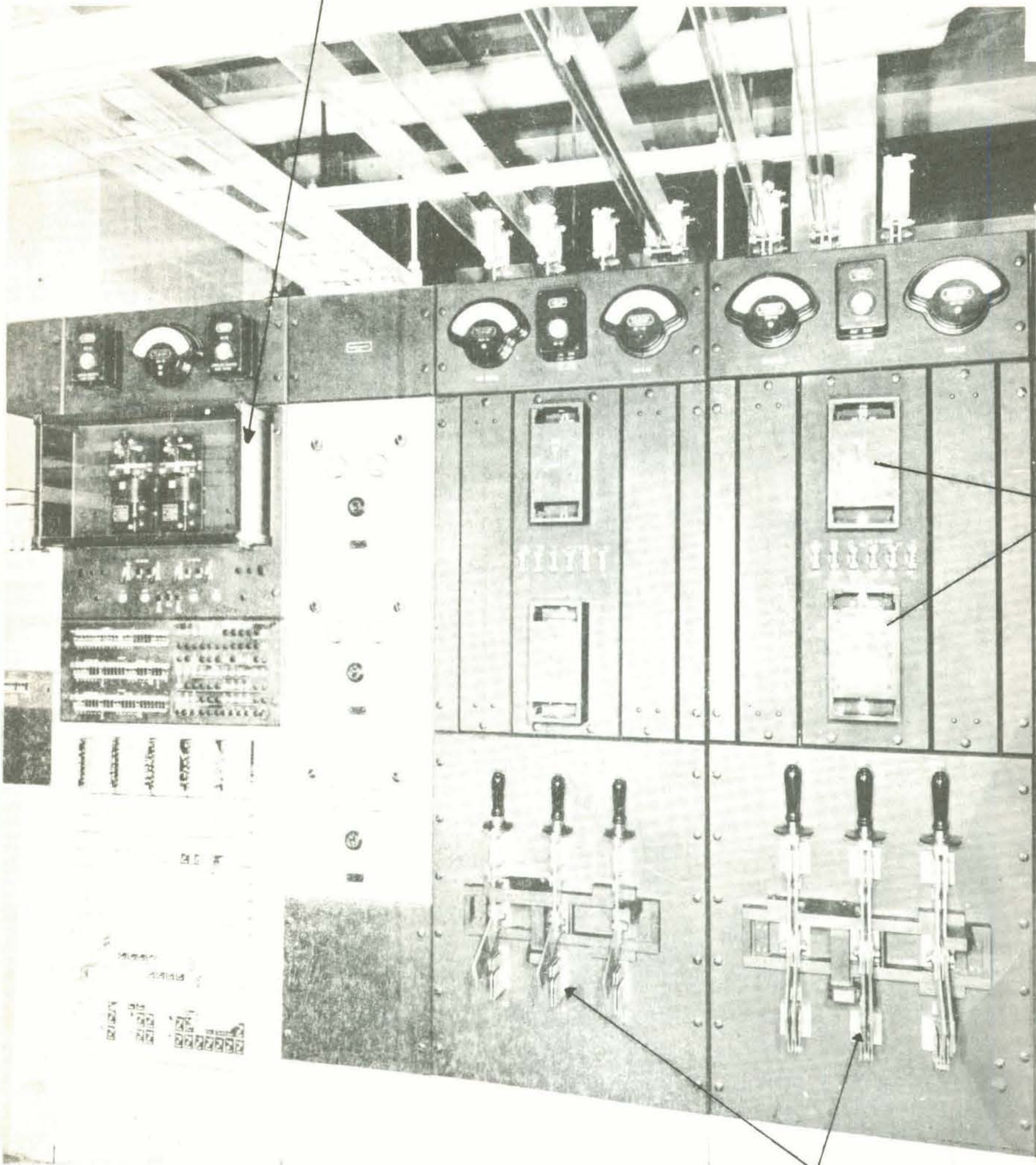
MAIN CONTROL BOARD

BATTERY CONTROL BOARD

FRONT VIEW OF POWER BOARD
(FROM RINGING PANEL END)
150TH ST. N.Y.

DEC. 1937

Voltage Controllers



MAIN CONTROL BOARD

TRICKLE CHARGE RECTIFIERS

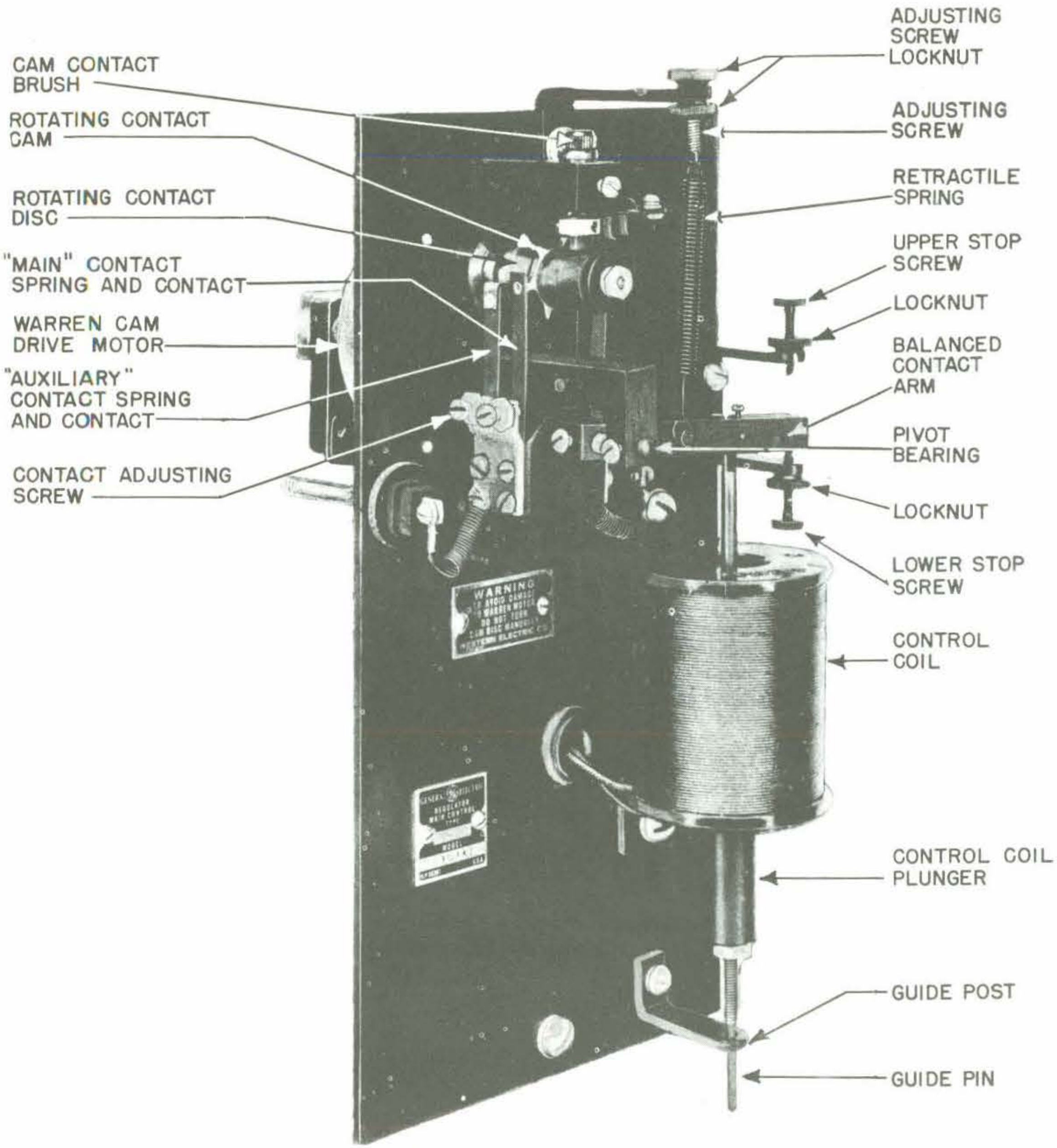
BATTERY CONTROL BOARD

Link Type Fuses & Barriers

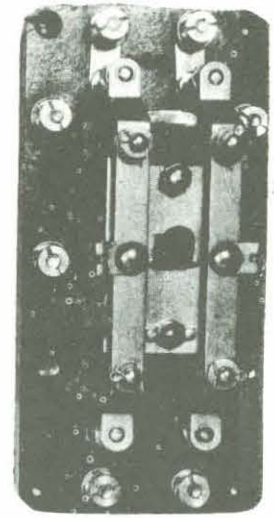
Rocker Type Interlocking Emergency Cell Switches

POWER BOARD
(PARTIAL VIEW)
150 TH ST. N.Y.

DEC. 1937



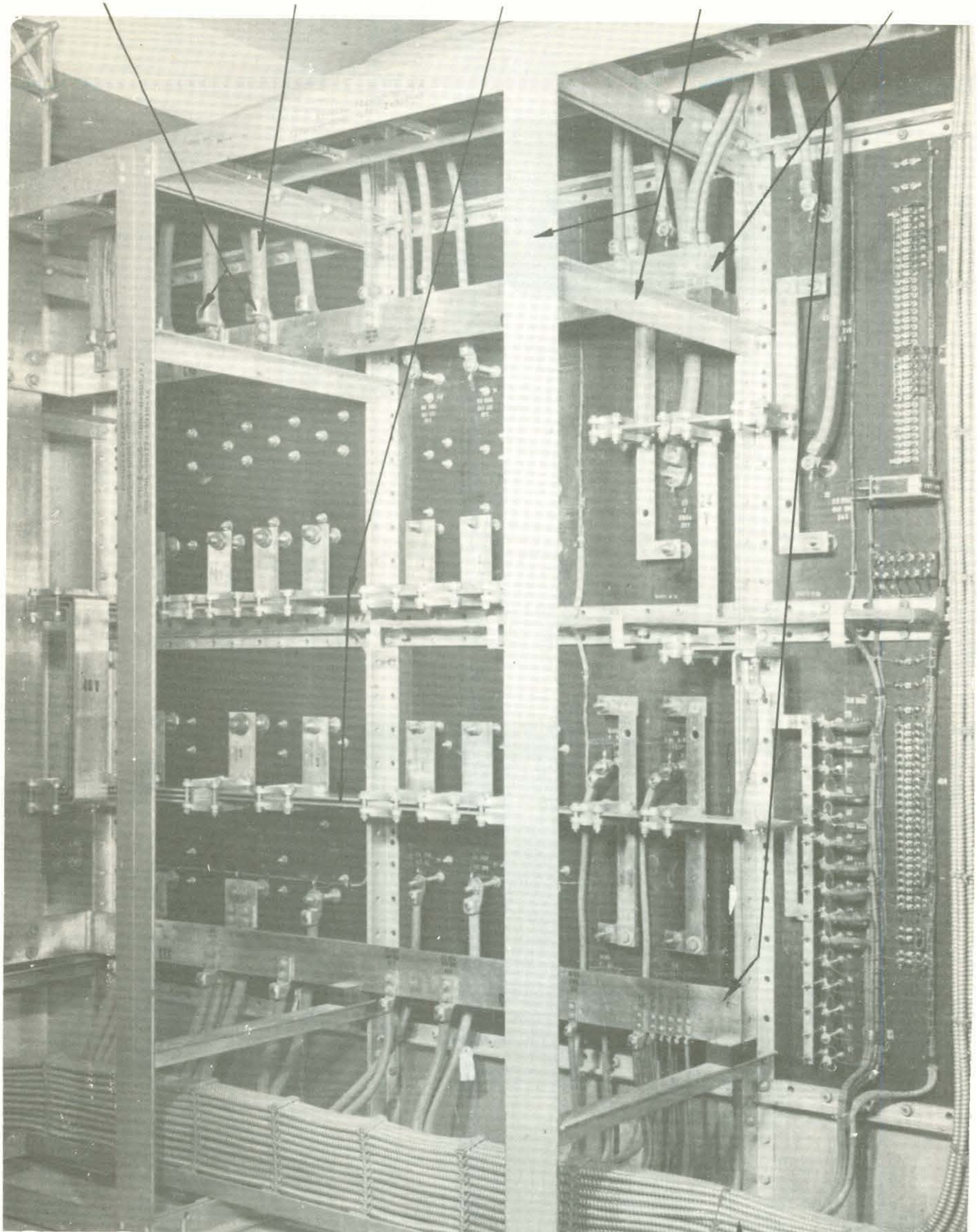
Voltage Controller



Control Relay

Mounted on Charging Generator Unit Meter and Control Panel, and operated by Voltage Controller on Main Control Board.

Voltage Controller on Main Control Board (Power Board) operates Control Relays on Charging Generator Unit Meter and Control Panel, to maintain automatically the proper Output Voltage. Voltage Relays are also used to operate Alarm Circuits and control Emergency Cell Switching Circuits.



BATTERY CONTROL BOARD
(REAR VIEW)

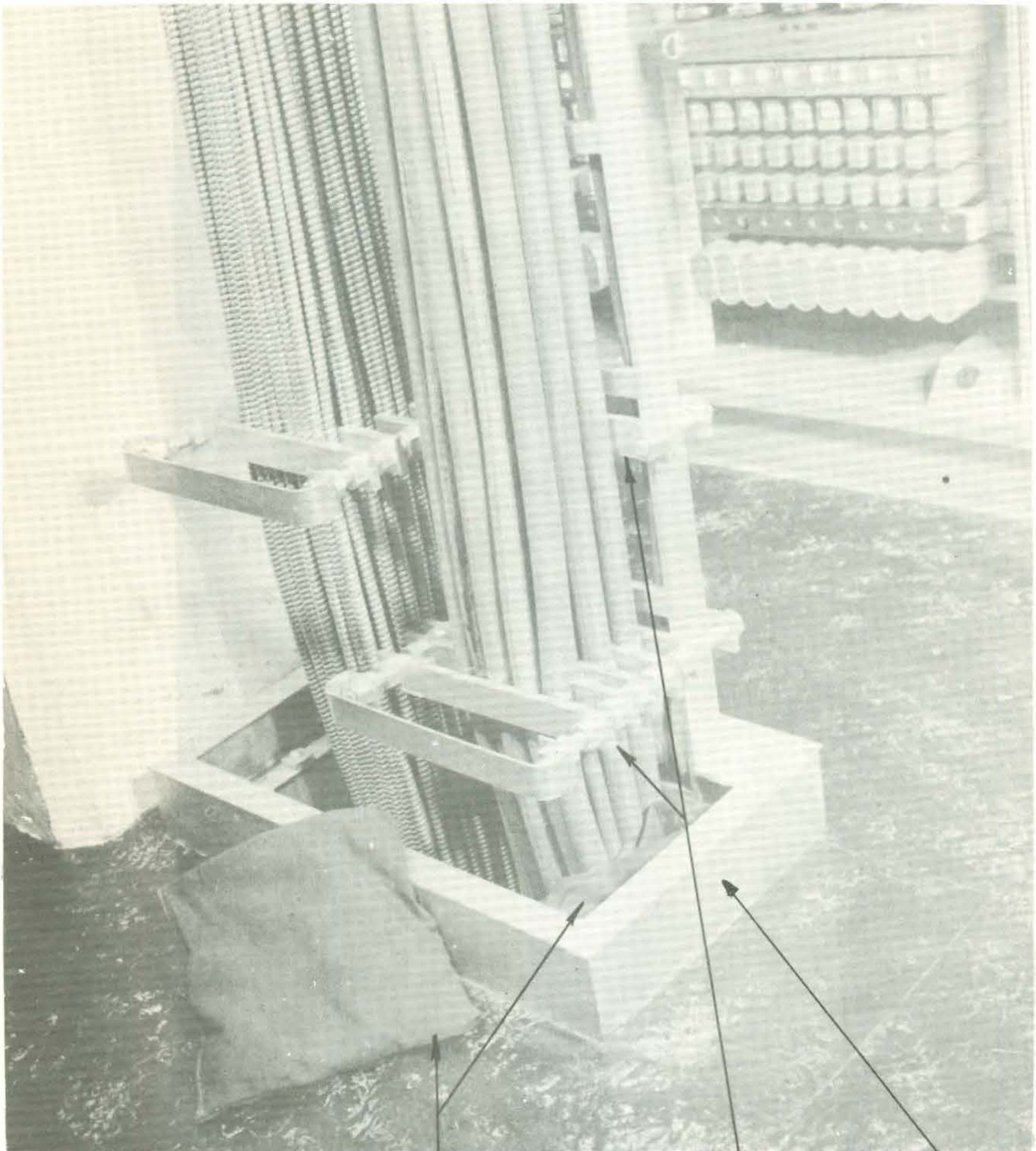
OAKLAND OFFICE, CHICAGO

AUG. 1940

POWER CABLING — CABLE SLOT

OAKLAND OFFICE, CHICAGO

AUG. 1940



CANVAS BAGS FILLED WITH MINERAL WOOL

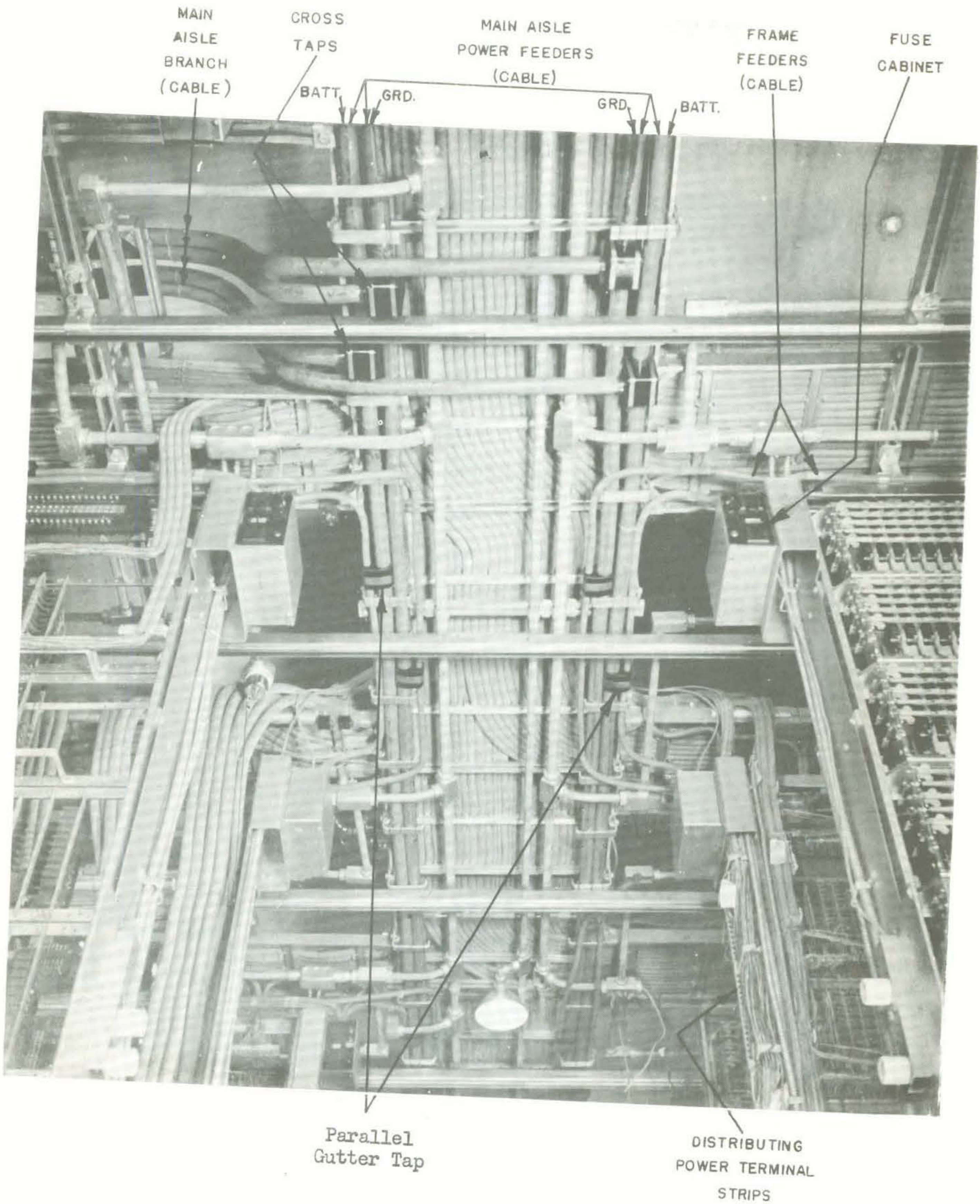
POWER CABLE CLAMPS

Cable Well

POWER CABLING BETWEEN FLOORS

OAKLAND OFFICE, CHICAGO

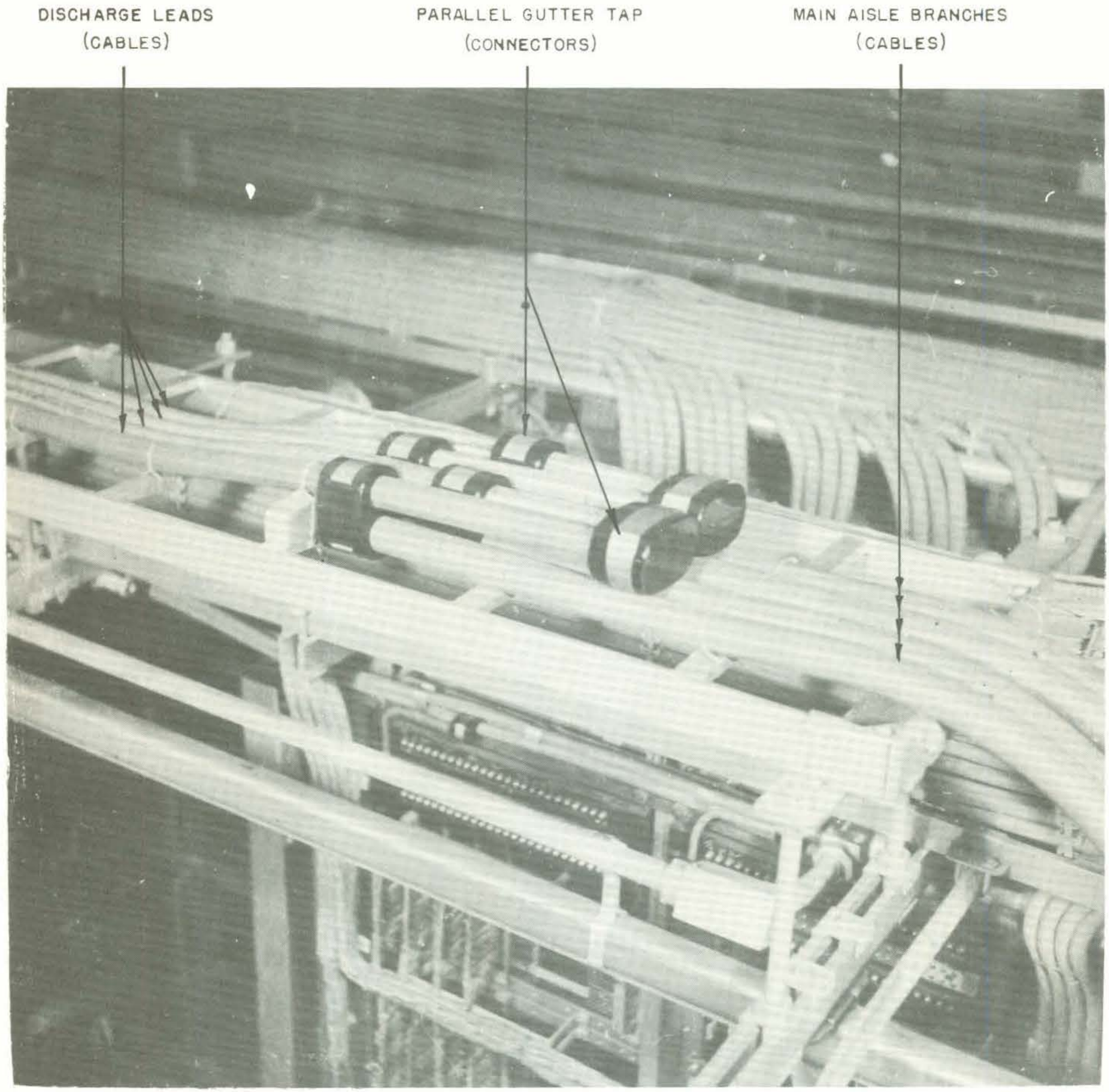
AUG. 1940



POWER CABLING-MAIN AISLE

OAKLAND OFFICE. CHICAGO

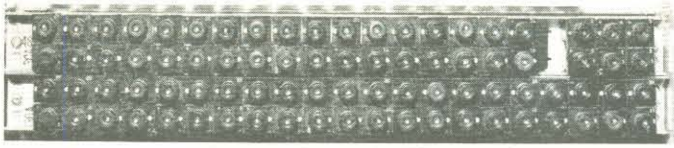
AUG. 1940



EQUALIZING CENTER

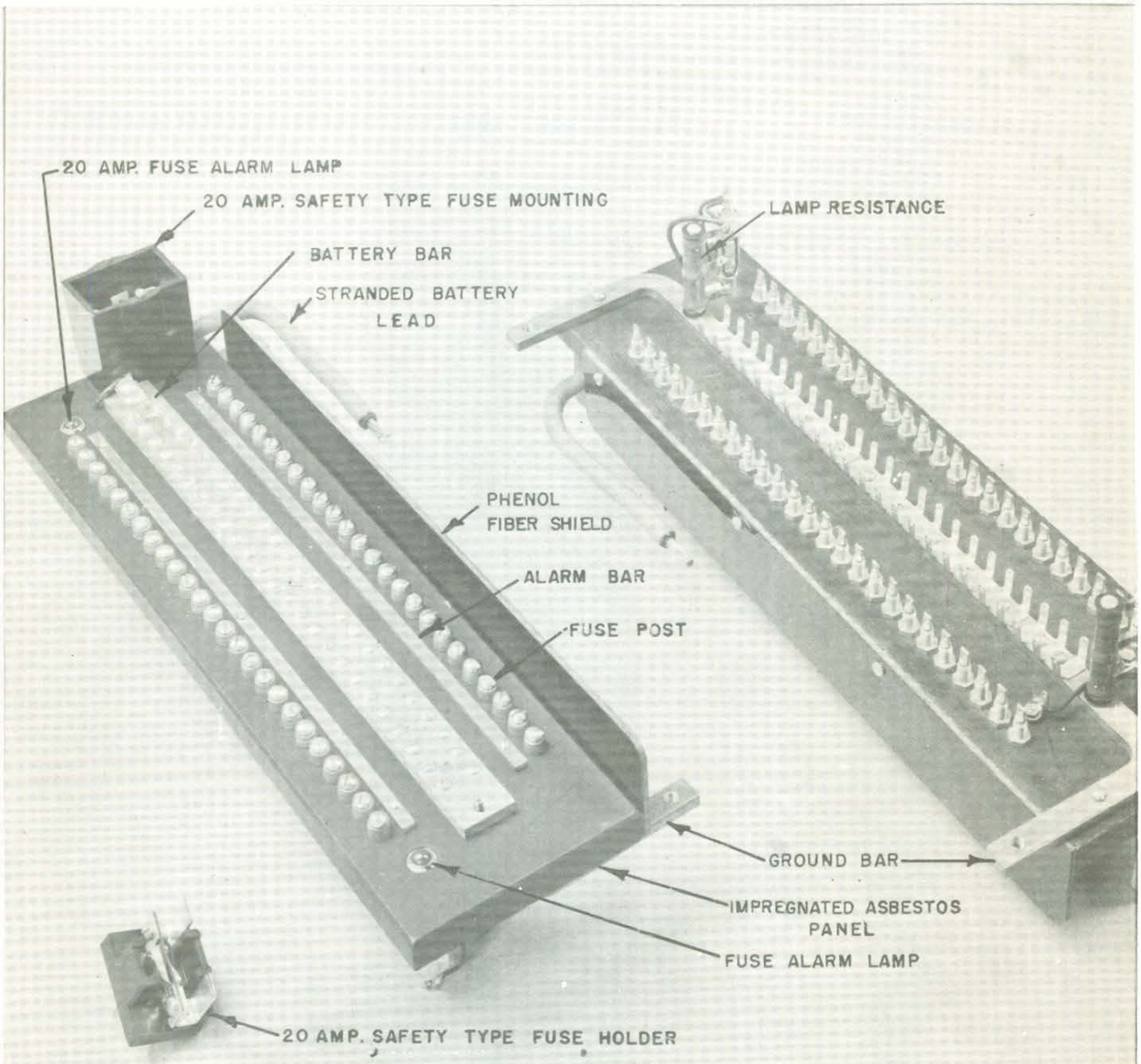
OAKLAND OFFICE, CHICAGO

AUG. 1940

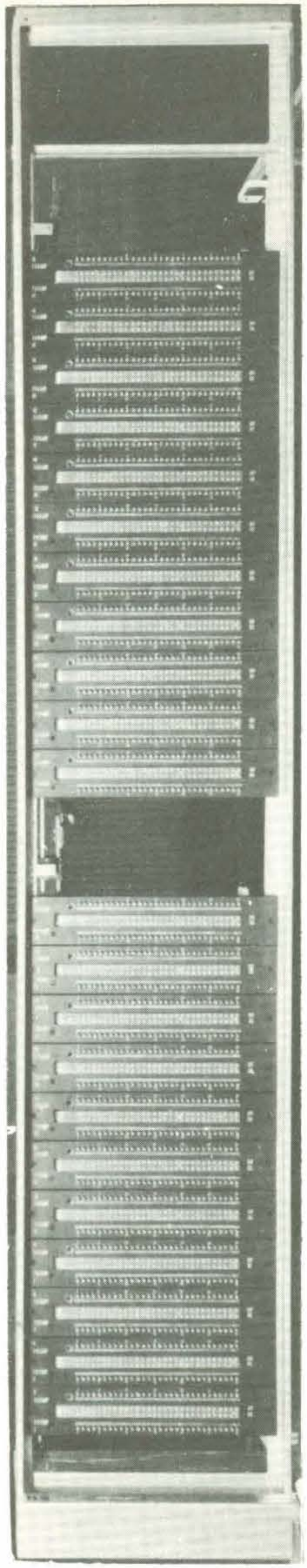


<u>New Fuse Panel</u>

Mounts 70-Type tubular fuses. Fuse element is under spring tension. Operation of fuse releases spring, forcing metal cap of fuse against alarm terminal of fuse block. The colored indicator protrudes through a hole in the fuse mounting cap, indicating the operated fuse.



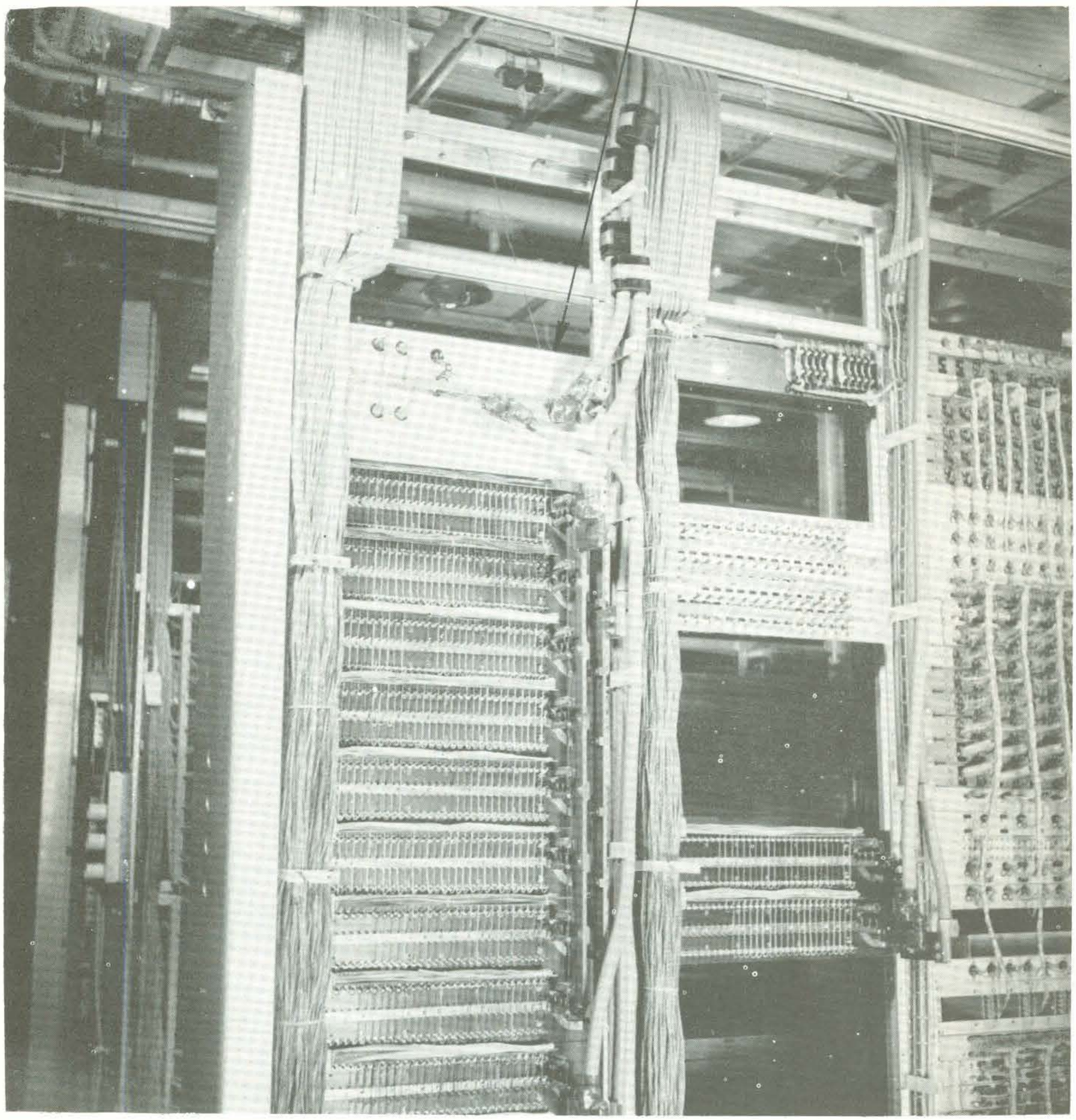
Fuse Panel Mounting "Grasshopper," 35-Type Fuses



FUSING BAY
(FRONT VIEW)

CABLES TO FRAMES, RACKS & DESKS

DECENTRALIZED (FRAME) FILTER PANEL

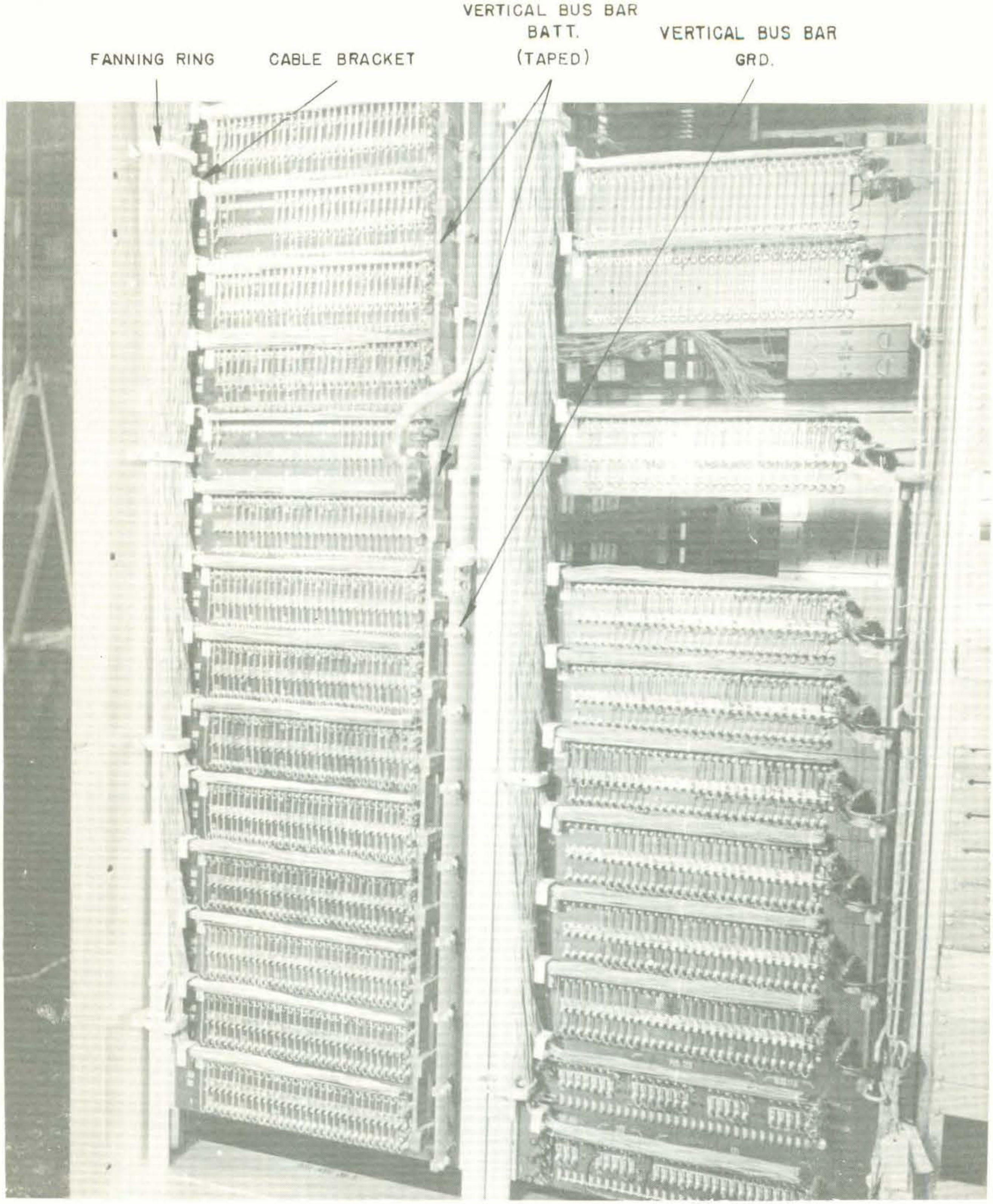


FUSING BAY

(UPPER PART REAR VIEW)

OAKLAND OFFICE, CHICAGO

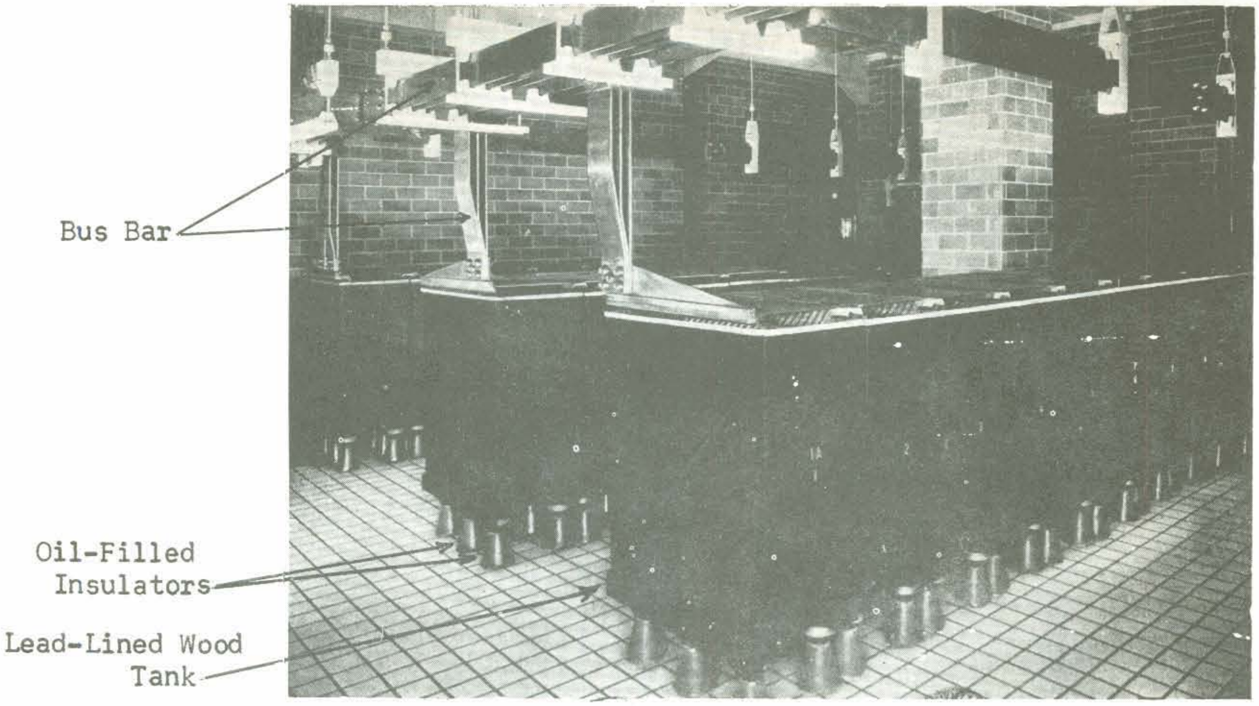
AUG. 1940



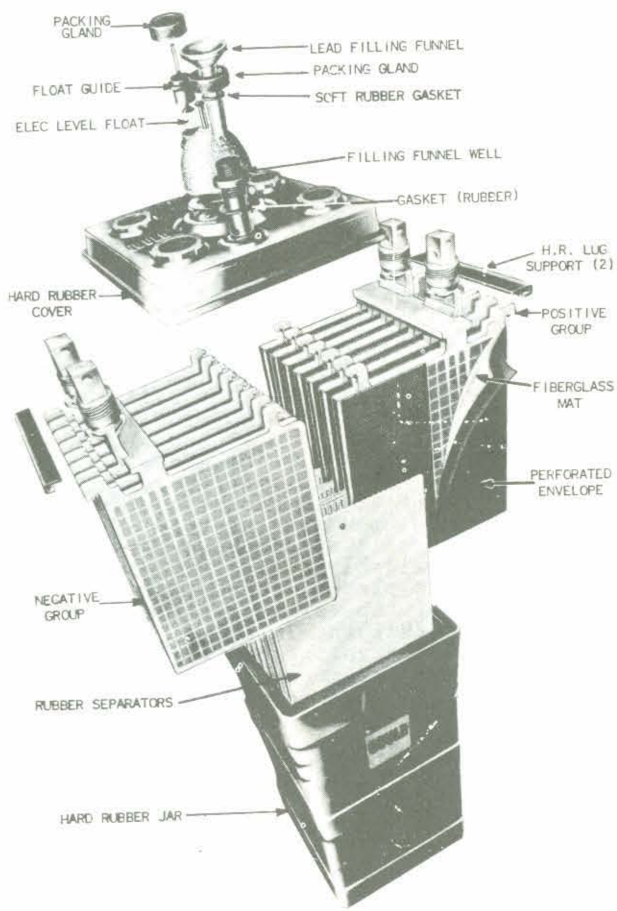
FUSING BAY

(LOWER PART REAR VIEW)
OAKLAND OFFICE, CHICAGO

AUG. 1940

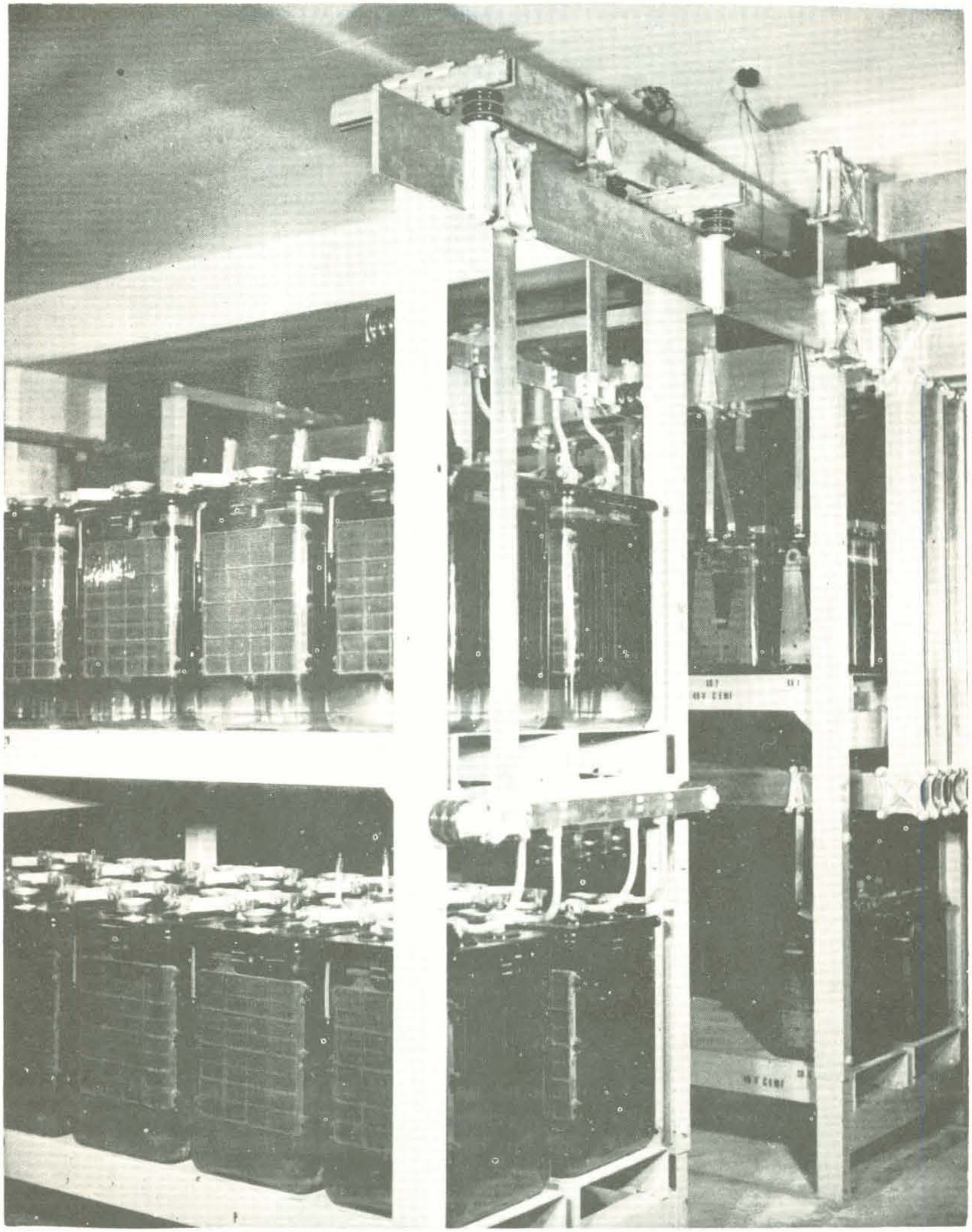


Central Office Battery - Open-Tank Type Cells
(Lead-Acid Type Cell)
24-V Battery - 12 Cells
48-V Battery - 23 Cells

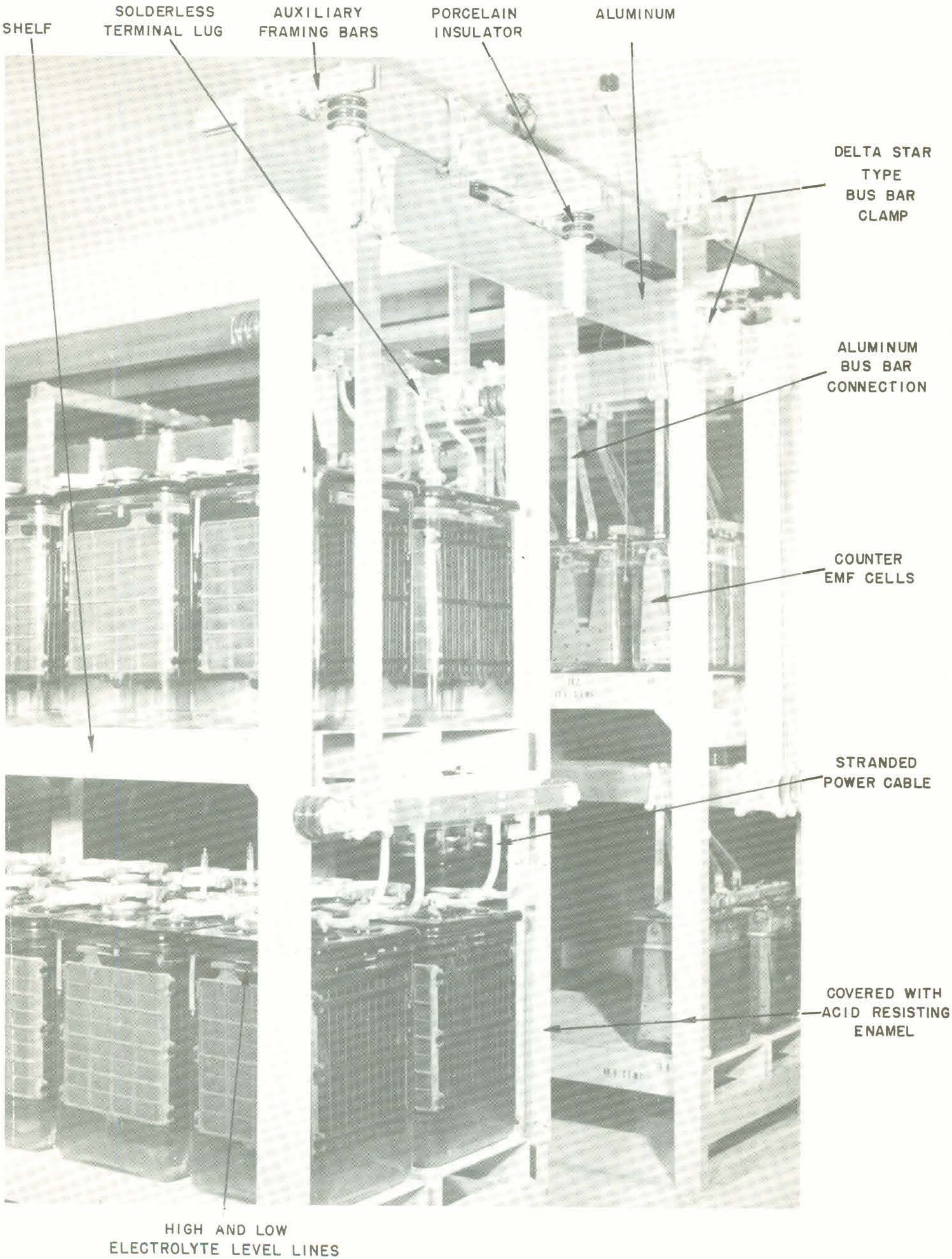


Fully Enclosed Rubber Jar Type Cell
(Exploded View)
(Lead-Acid Type Cell)

Open-Tank Type Cells must be installed in a separate, well-ventilated Battery Room, as they gas quite freely on charge. Enclosed Jar Type Cells are installed in the Power Room, directly in back of the Power Board.



Central Office Battery - Enclosed Glass Jar Type Cell
(Lead-Acid Type Cell)
Cell Voltage - 2.55-v At Full Charge
2.17-v Normal Voltage
1.75-v When Discharged.

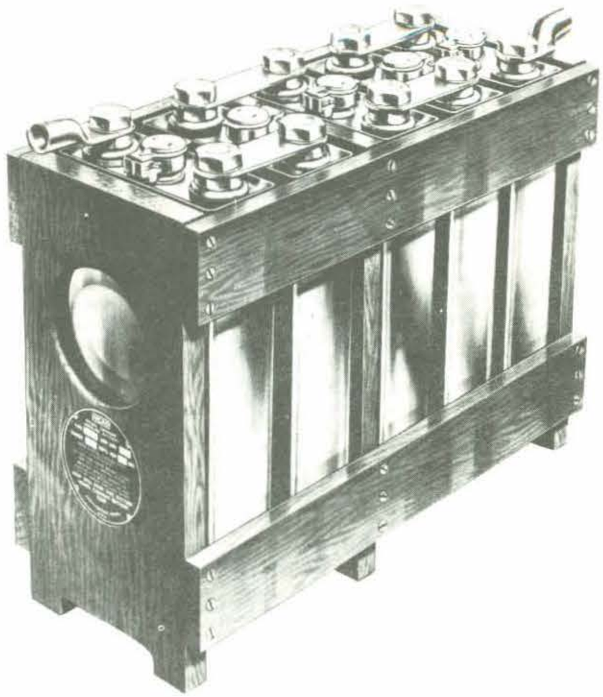


BUS BAR CONNECTIONS AT BATTERY STAND

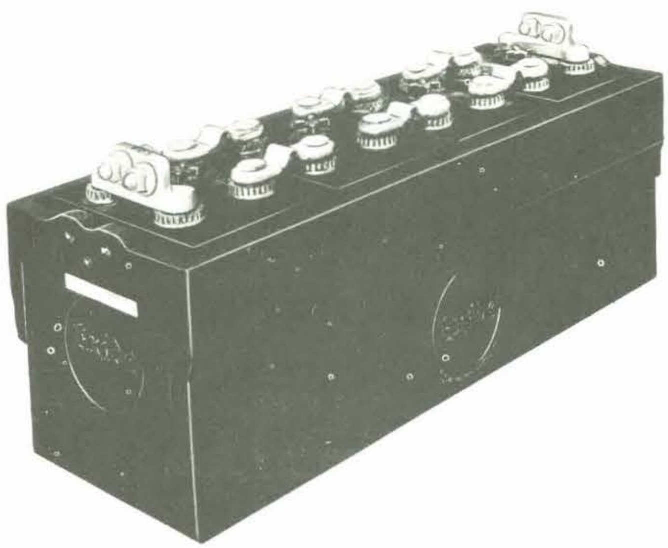
OAKLAND OFFICE, CHICAGO

AUG. 1940

Engine Starting Batteries



Tray of Ni-Cad Battery Cells
Nickel-Cadmium Plates
Alkaline Electrolyte
1.4-v Per Cell

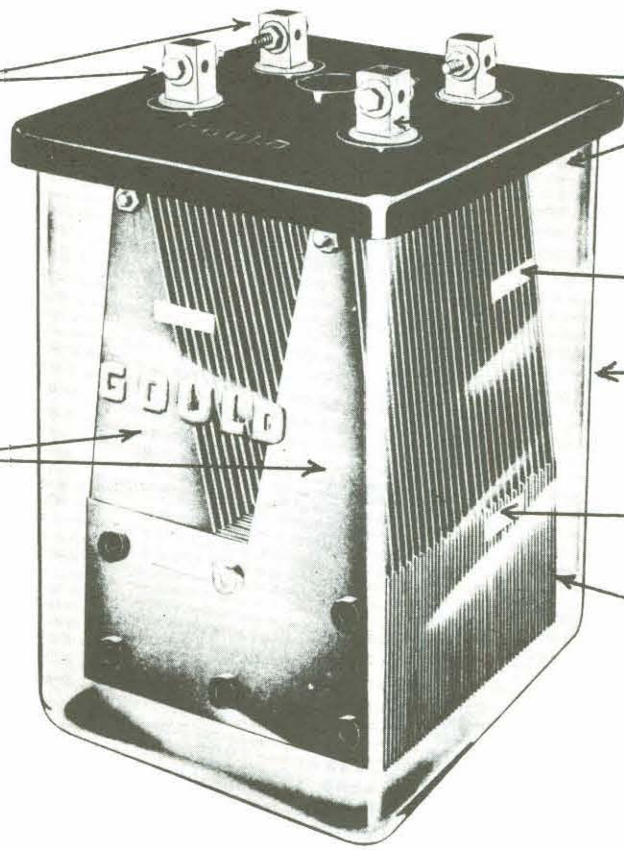


Lead-Acid Type Engine Starting Battery

CEMF (Counter-Electromotive Force) CELLS

In Series with the Central Office Battery and the Load (Switching Equipment) to:

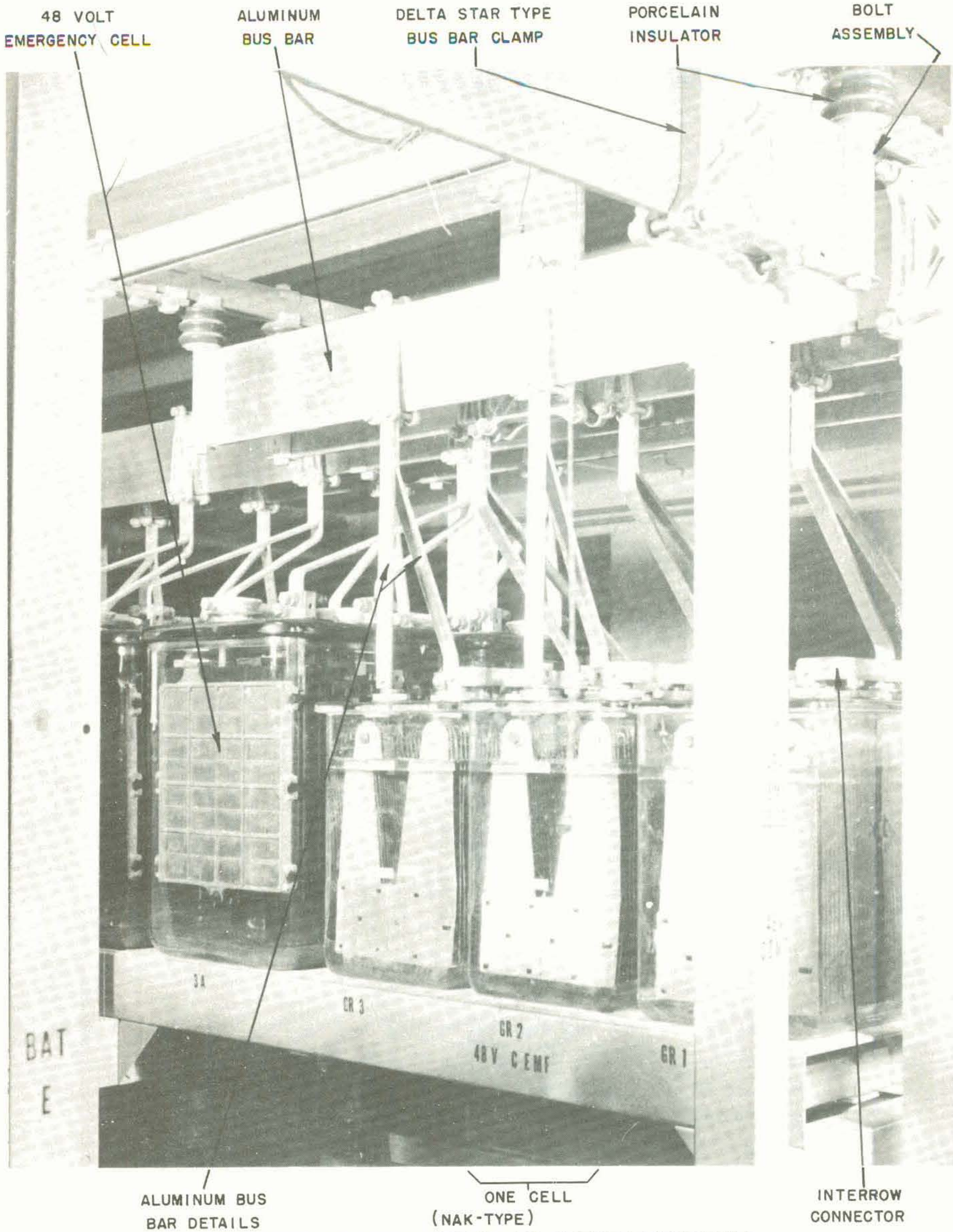
1) Prevent higher battery-charging voltage from reaching the Switching Equipment, or
2) Provide a continuous reduced-voltage supply; such as 48-v to 24-v, when the 24-v current drain is relatively light.



Voltage drop in the CEMF Cell is the voltage expended in forcing the current through the Caustic Solution, from one set of plates to the other.

Voltage Drop per Cell: 1.85-v at 10% Rated Load
2.15-v at Full Load.

A CEMF Cell does not have a storage capacity. The Cell has no polarity; therefore it may be connected for either direction of current flow.

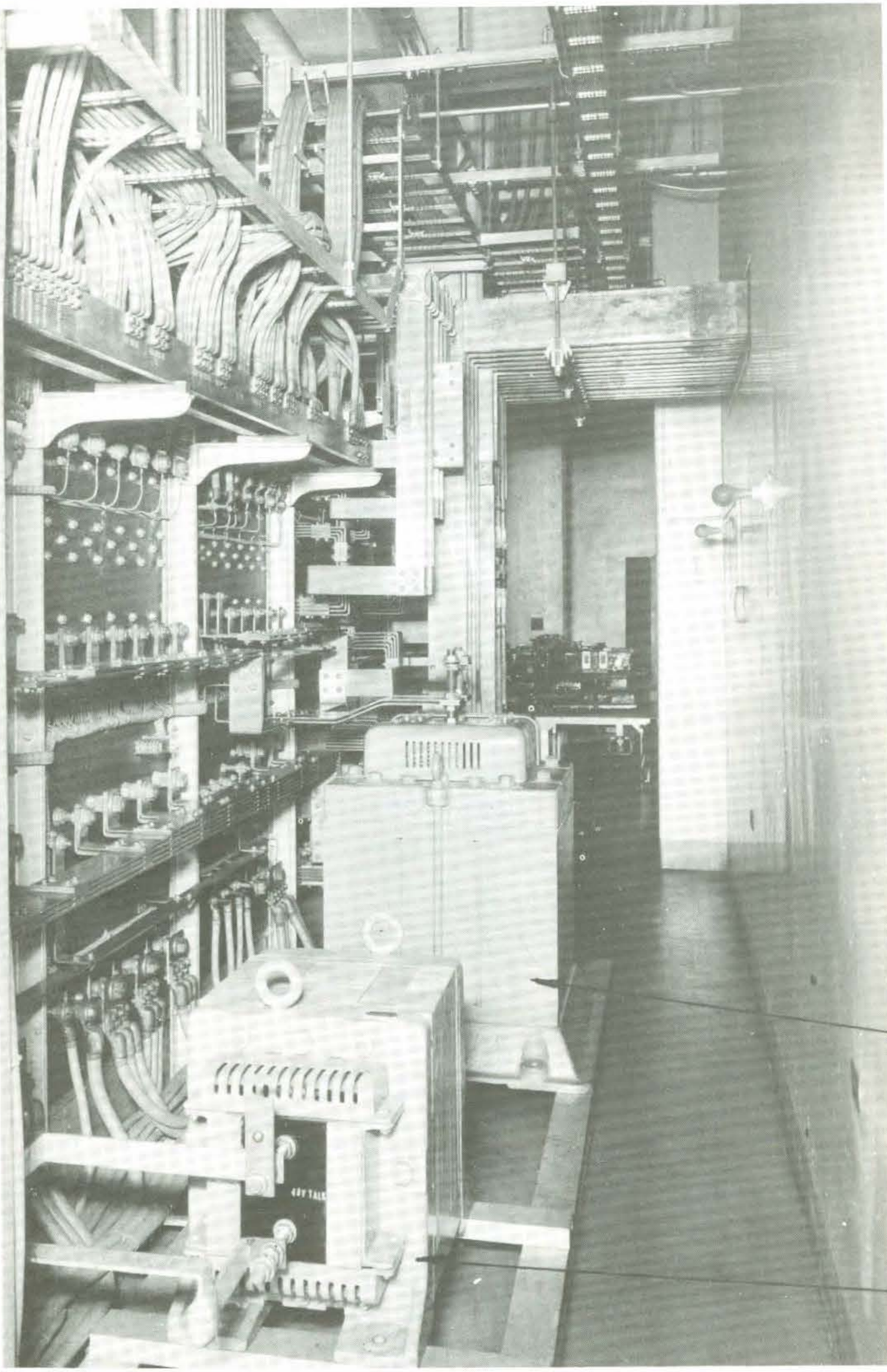


48 VOLT COUNTER ELECTROMOTIVE FORCE (CEMF) CELLS

OAKLAND OFFICE, CHICAGO

AUG. 1940

Large Common TALKING BATTERY FILTERS located behind Power Board in Older Offices. Decentralized Filters mounted on Relay Rack Bays, Fuse Bays, Cable Racks, at top of frames. etc.. in newer offices.



15 A CHOKE COIL 1000 AMP. (3920 LBS.) 24-v. Talking Battery Supply

12 A CHOKE COIL 400 AMP. (1128 LBS) 48-v. Talking Battery Supply

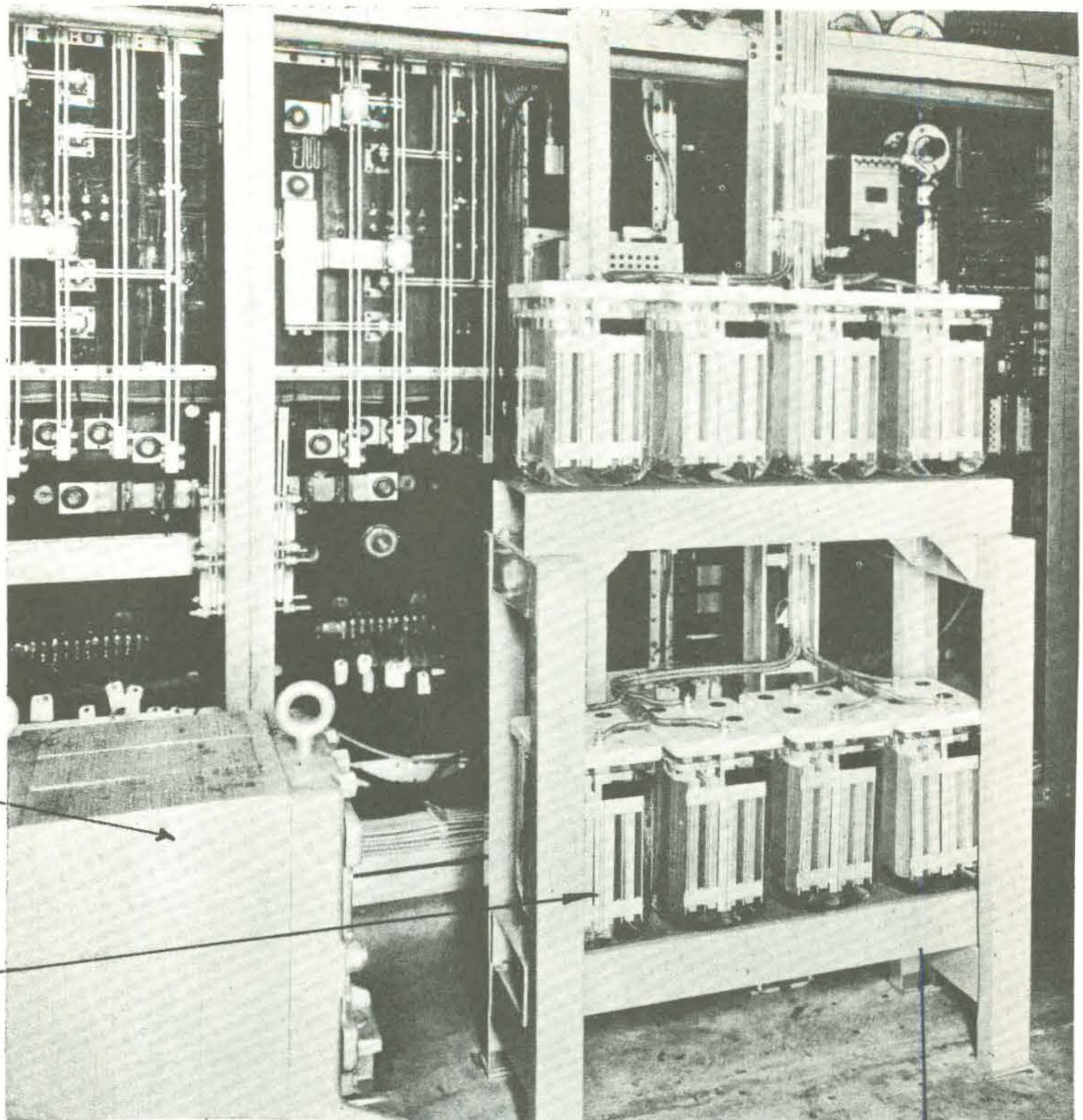
Signal Battery, unfiltered 24-v. or 48-v. from Motor-Generator Charging Units. Used for operating relays and switches, lighting switchboard lamps, etc.

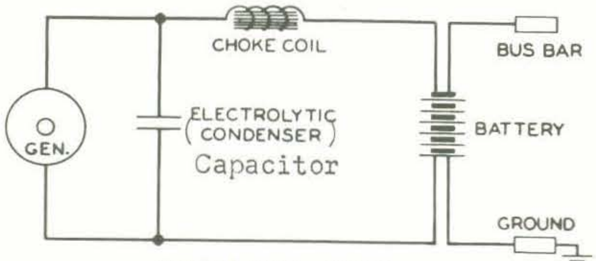
"Quiet" or Talking Battery, 24-v. or 48-v., filtered Signal Battery.

CHOKE COILS

WABASH OFFICE, CHICAGO

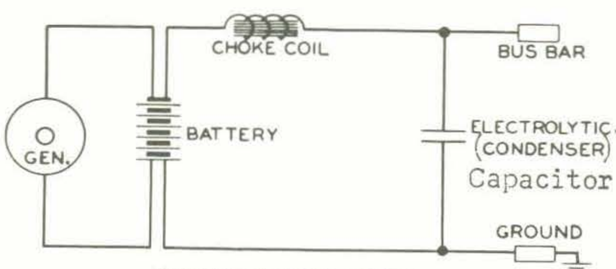
Talking Battery Filter



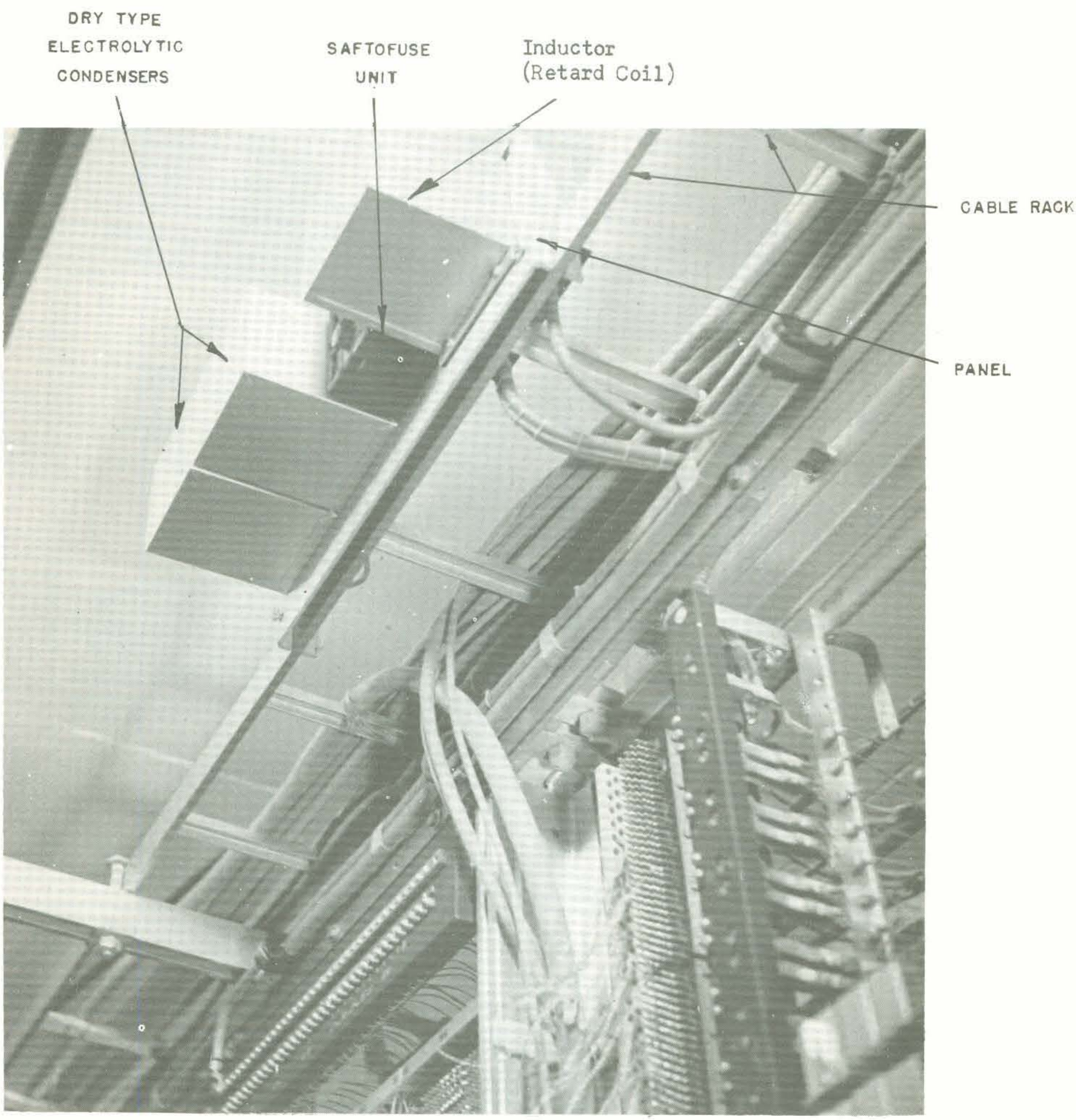


CHARGE LEAD FILTER

The Choke Coil or Inductor opposes any change in Current Flow.
The Electrolytic Capacitor opposes any change in Voltage.



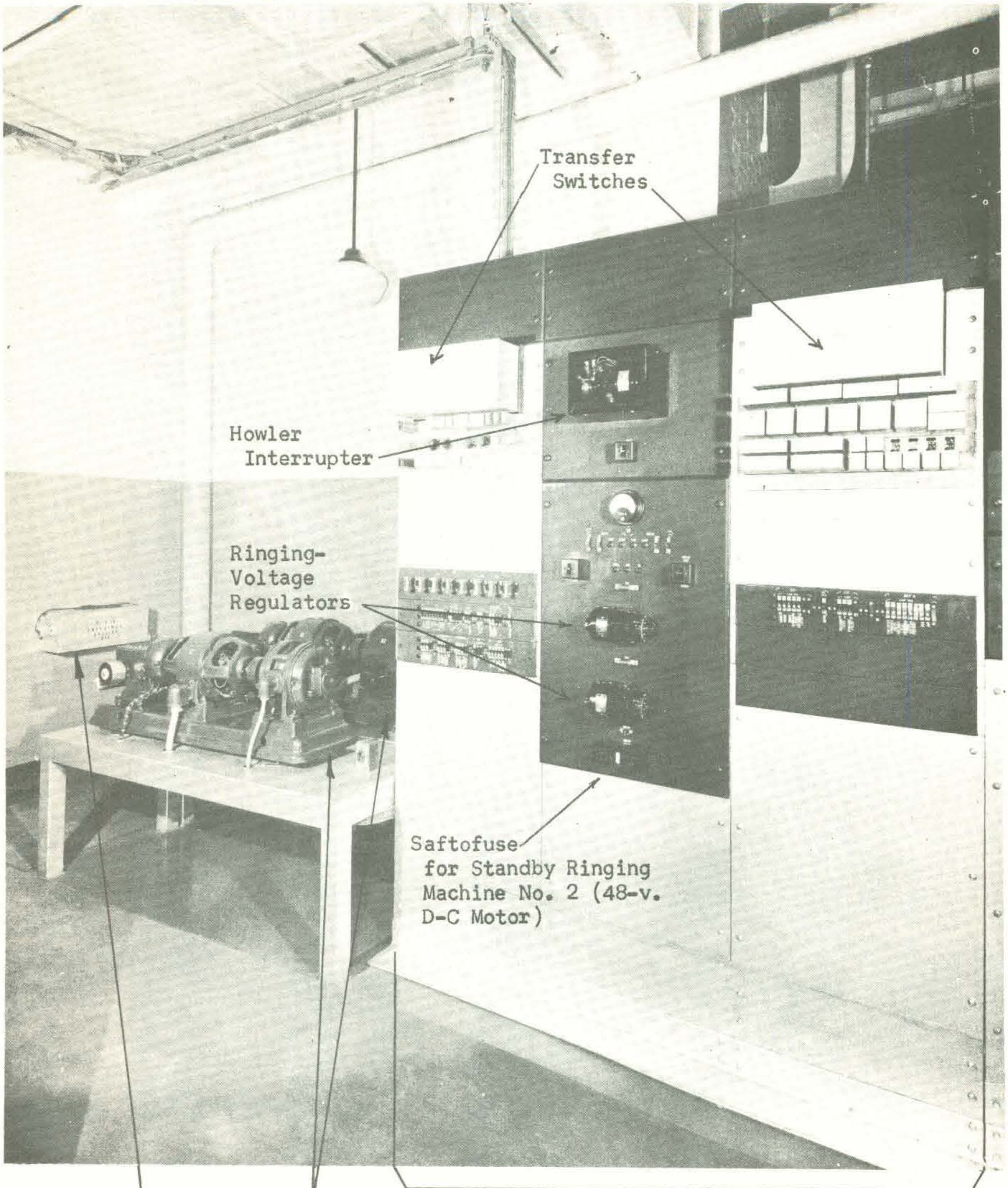
DISCHARGE LEAD FILTER



TALKING BATTERY SUPPLY DECENTRALIZED (FRAME) FILTER

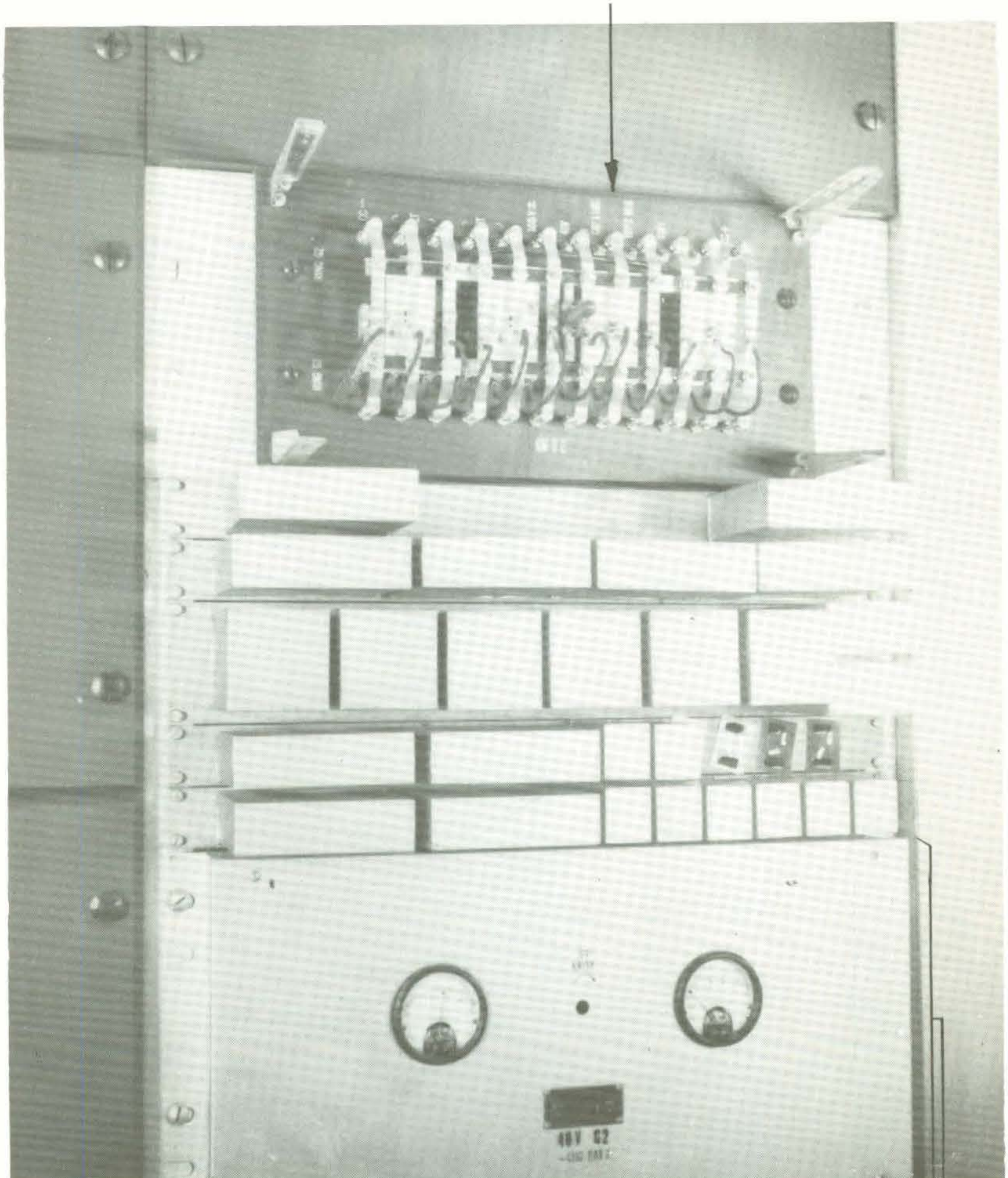
OAKLAND OFFICE, CHICAGO

The Ringing Power Plant must furnish not only 20-cycle Ringing Current and Tones for Signaling, but various interruptions of Ringing Current and Tones.



803C TYPE
RINGING POWER PLANT
150TH ST. N.Y.
2- to 6-Ampere Capacity

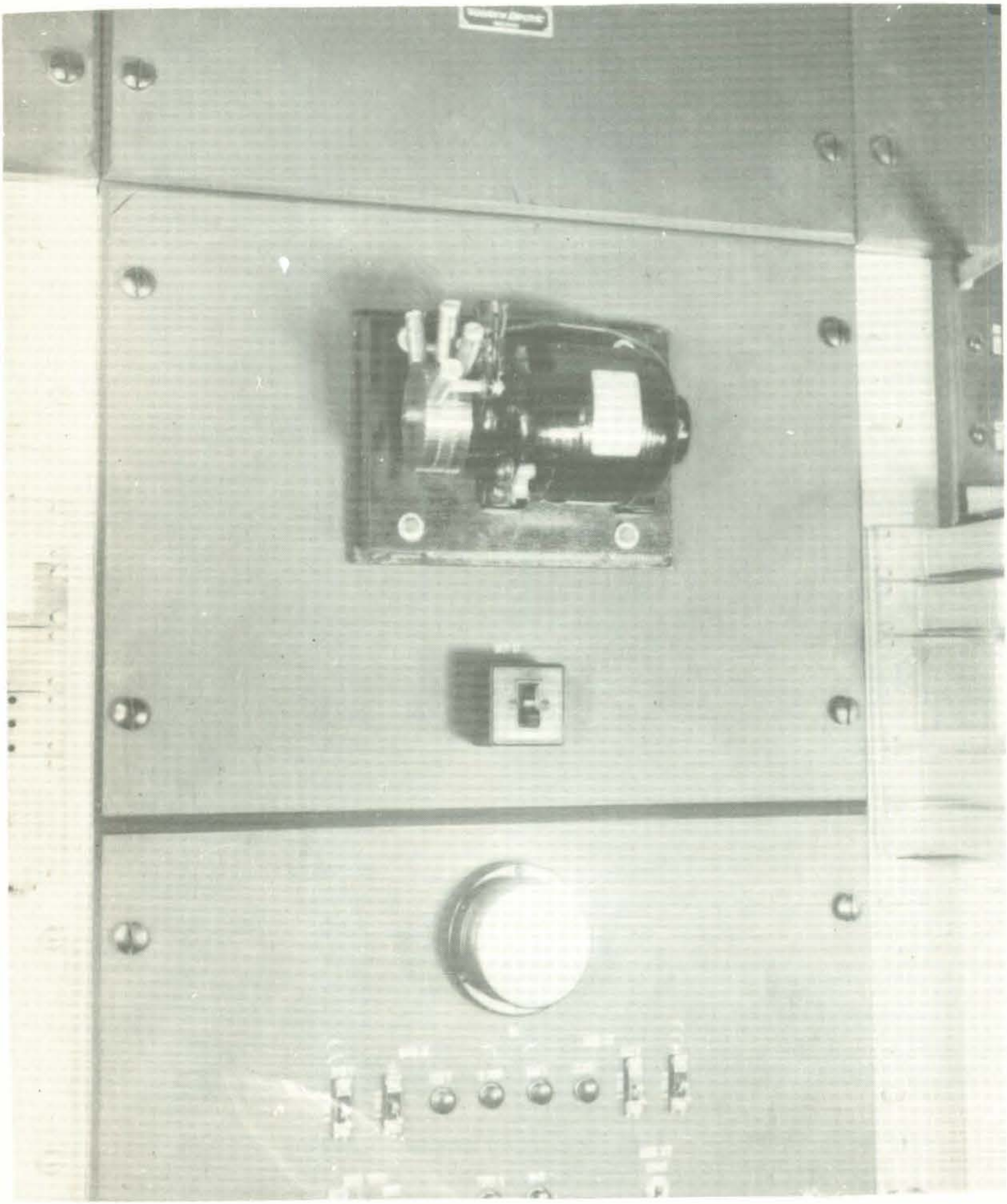
TRANSFER SWITCH FOR RINGING GENERATOR



Regulated Tube Rectifier for Superimposed Ringing Battery

MULTI-POLE ELECTRICALLY OPERATED TRANSFER SWITCH

Howler Interrupter Tone is applied to a Subscriber Line at the Local Test Desk or DSA Board (Dial System "A" Switchboard) Sender-Monitor Position, by means of a Howler Cord, to attract the Subscriber's attention in case of a "Permanent" (Handset OFF Switchhook).

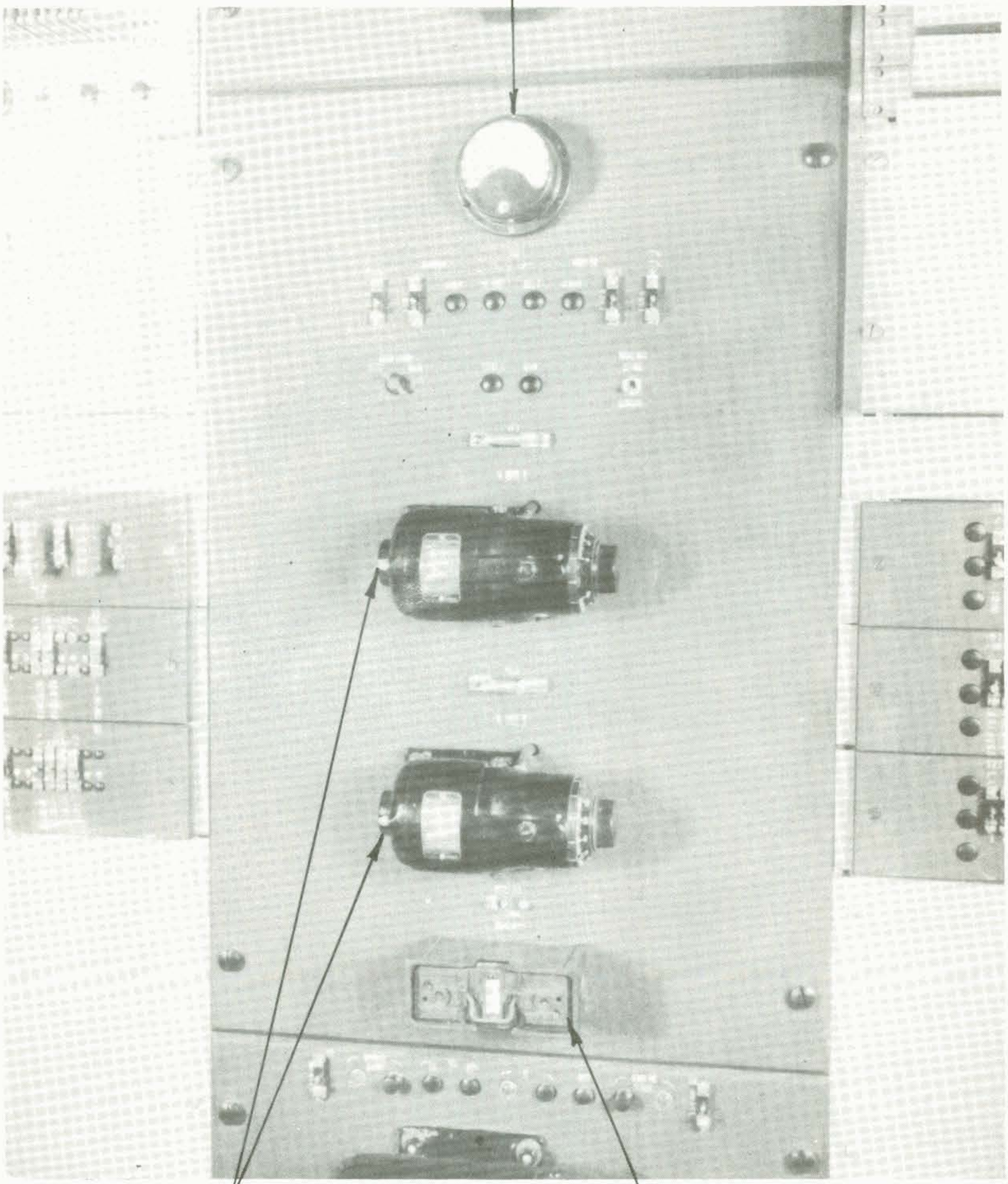


MOTOR DRIVEN HOWLER INTERRUPTER

OAKLAND OFFICE, CHICAGO

AUG. 1940

WESTON VOLTMETER

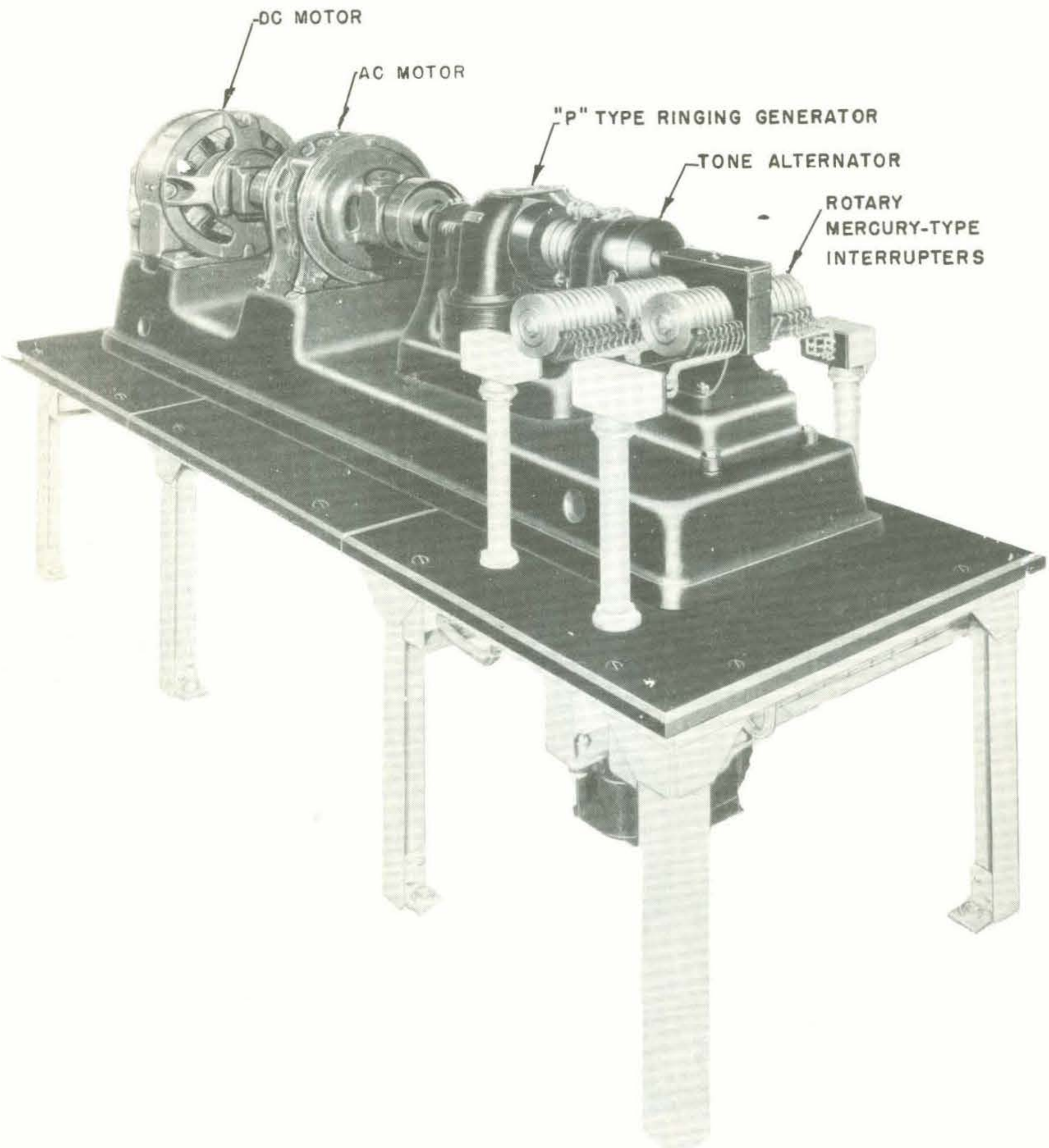


CENTRIFUGAL TYPE AUTOMATIC VOLTAGE REGULATOR
(TYPE BY)

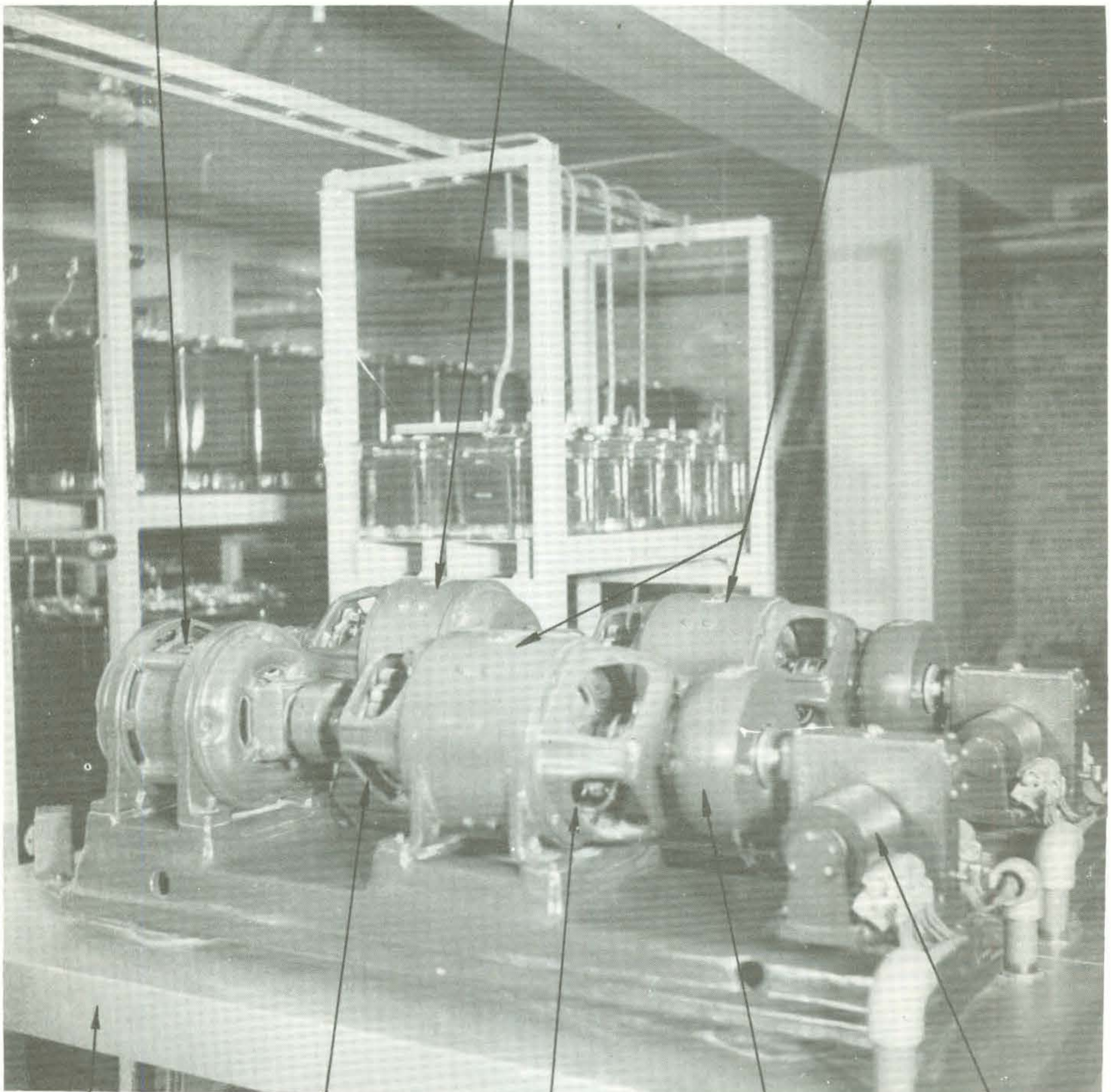
SAFTOFUSE UNIT

CENTRIFUGAL TYPE AUTOMATIC VOLTAGE REGULATOR

OAKLAND OFFICE, CHICAGO



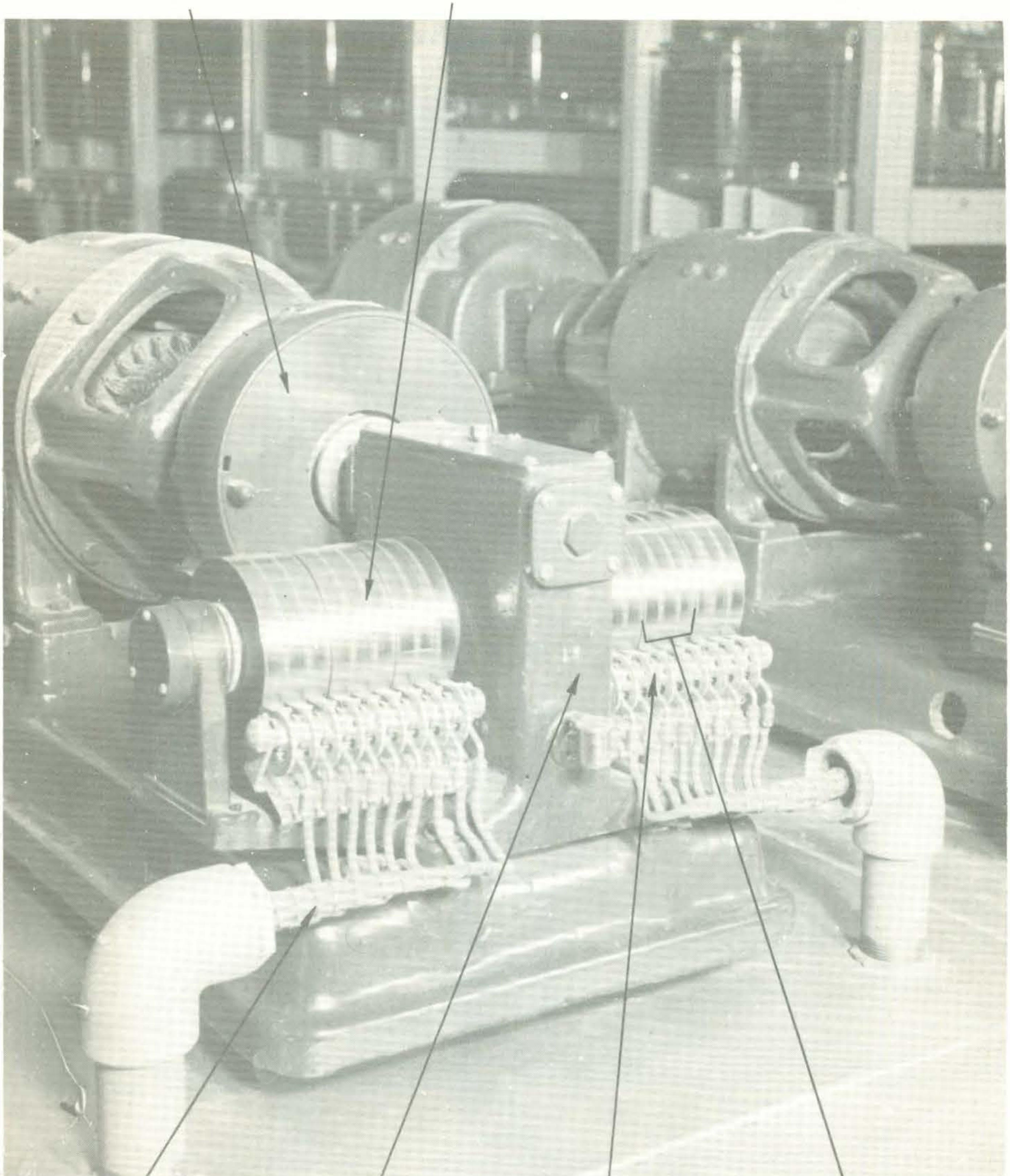
"P" TYPE RINGING MACHINE
WITH TONE ALTERNATOR & MERCURY INTERRUPTER



COMMERCIAL TYPE RINGING MACHINES

OAKLAND OFFICE, CHICAGO

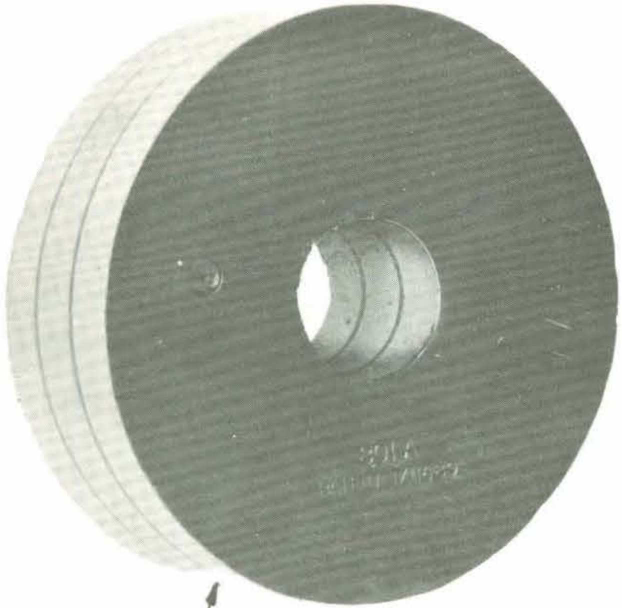
AUG. 1940



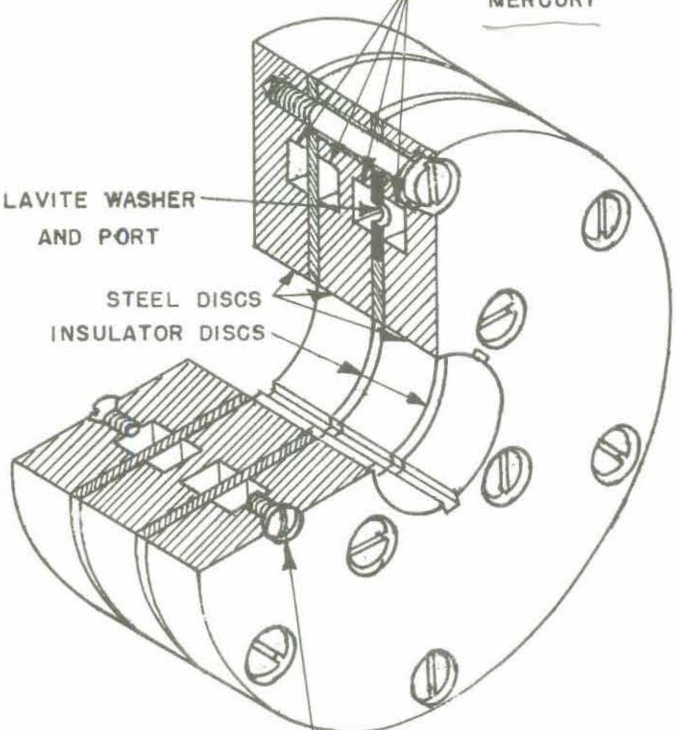
RINGING MACHINE — INTERRUPTER END

OAKLAND OFFICE, CHICAGO

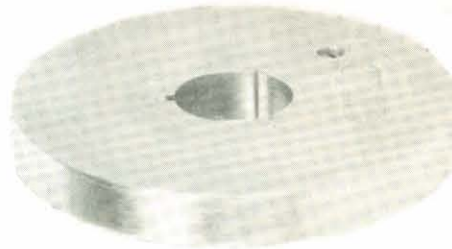
AUG. 1940



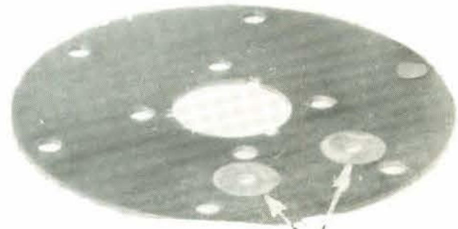
ASSEMBLY



SECTION THROUGH ASSEMBLY

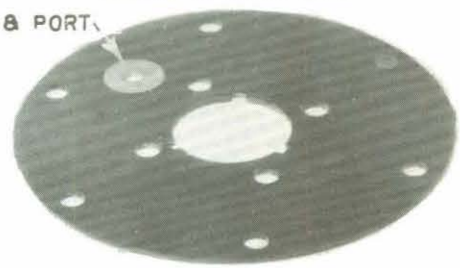


STEEL END DISC

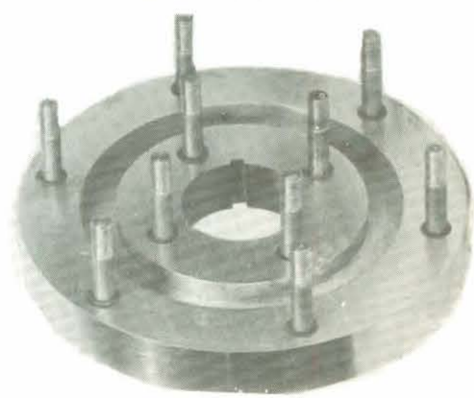


INSULATOR DISC

STEEL CENTER DISC



INSULATOR DISC



STEEL END DISC

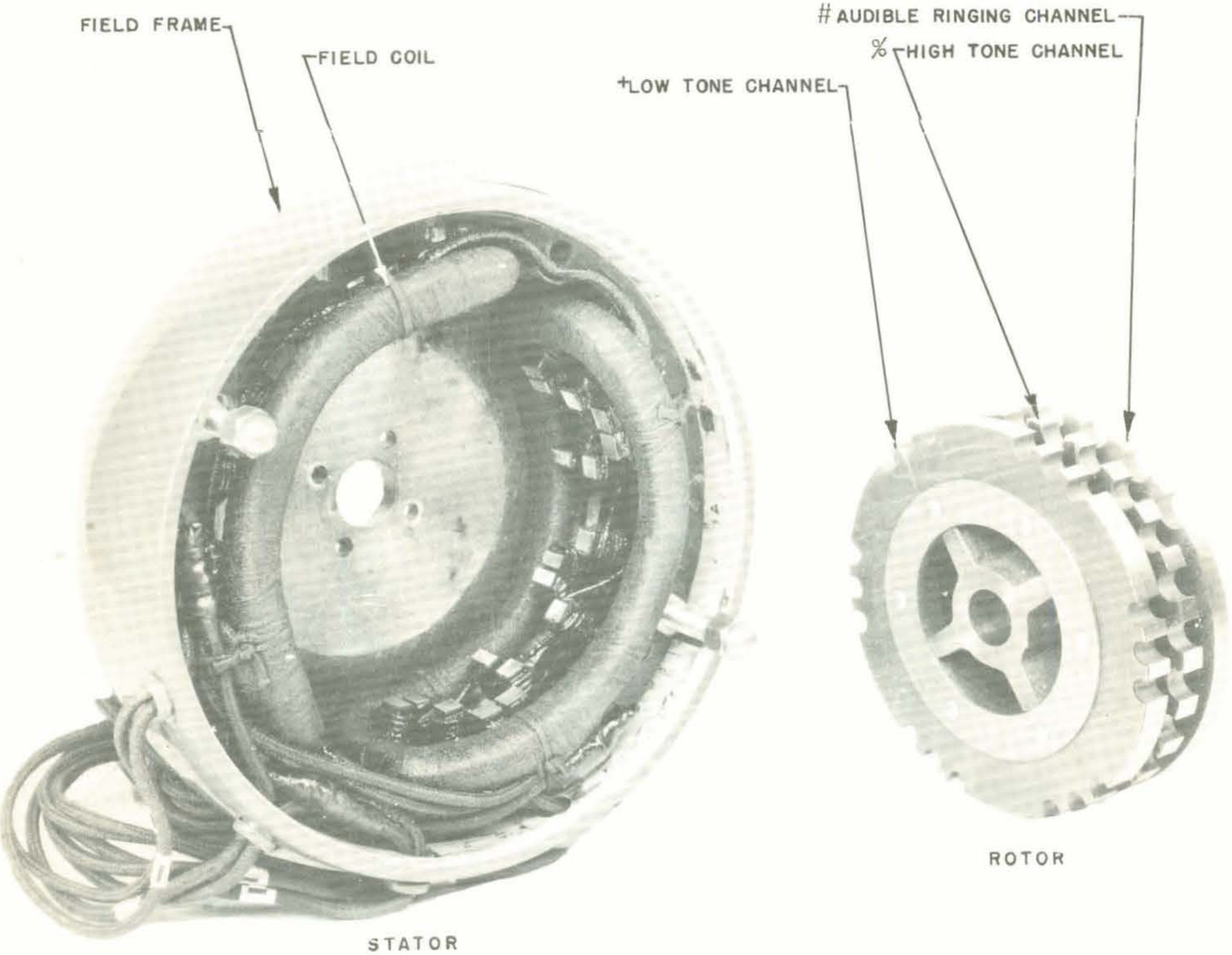
DISASSEMBLED UNIT

MERCURY INTERRUPTER UNIT

DOUBLE UNIT

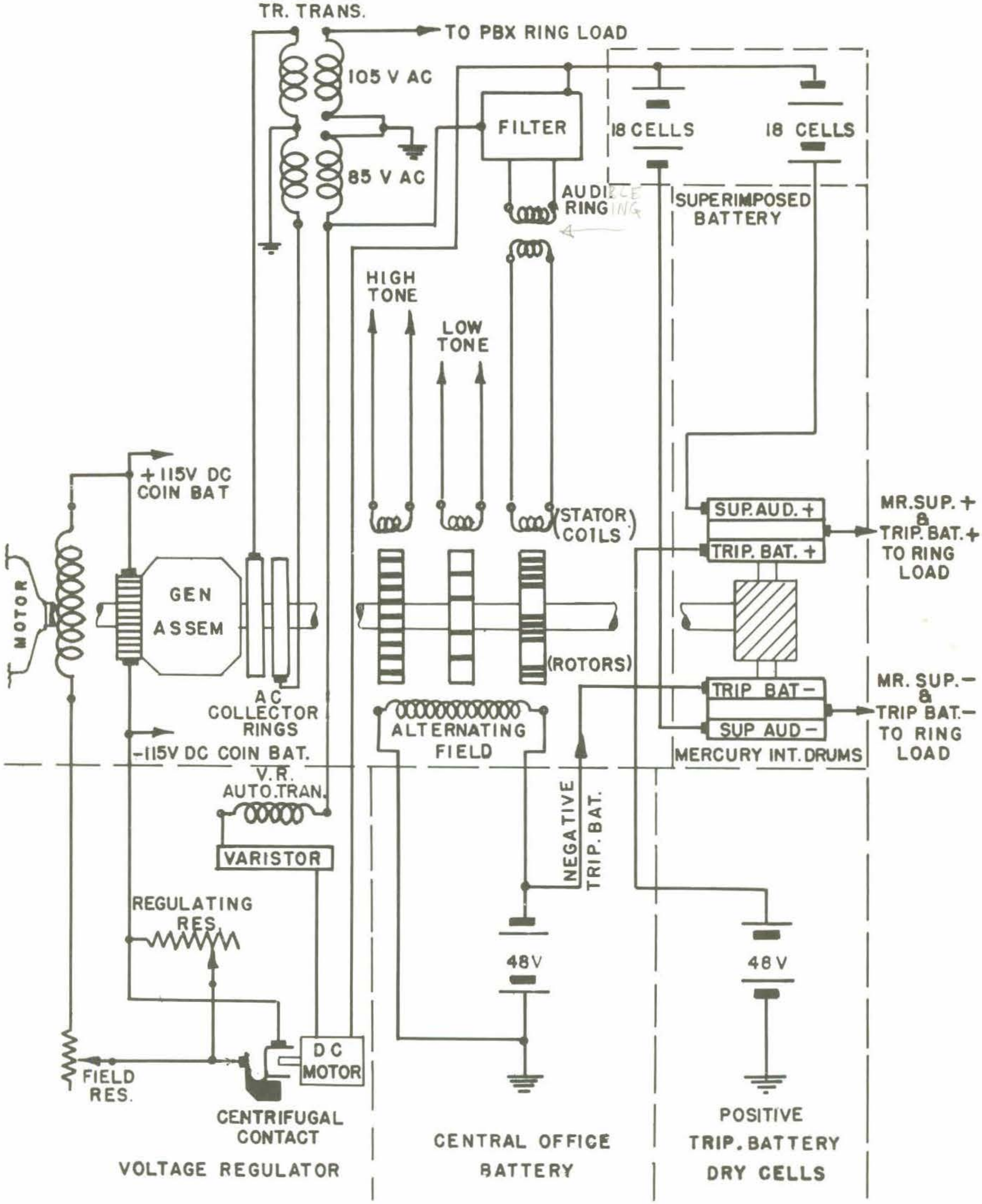
+Low Tone - 600-Cycle, amplitude modulated by 120-Cycles:
1) Used as Standard Dial Tone
2) At a higher level and Interrupted - Standard Busy Tone.

%High Tone - 500-Cycle Tone, used primarily for Operator Signals.



#Audible Ringing Tone - 20-Cycle Ringing Current is inaudible. When Ringing Current is applied to the Called Subscriber Line, the Calling Subscriber hears an Audible Ringing Tone developed by modulating High-Tone (500-Cycles) with a 40-Cycle Tone. This combination is superimposed on the 20-Cycle Ringing Current by means of a Network known as a 106A Frequency Generator.

TONE ALTERNATOR



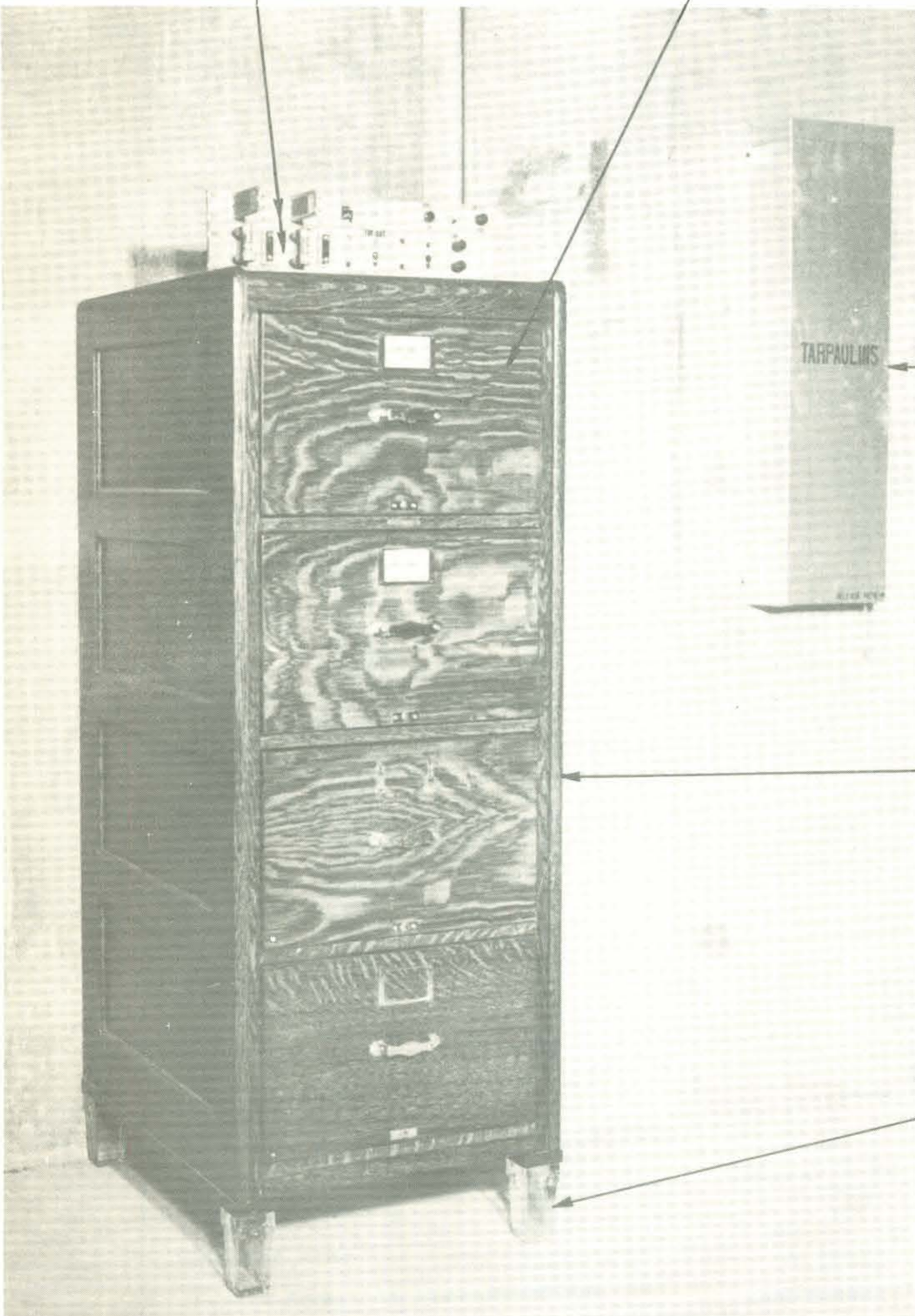
SCHEMATIC OF RINGING MACHINE CONNECTIONS
FULL SELECTIVE SUPERIMPOSED 4 PARTY RINGING

48-V. Central Office Battery may be used as the Negative Tripping Battery.

MOUNTING PLATES CONTAINING FUSES, FUSE ALARM, AND TESTING EQUIPMENT

DRY CELLS IN DRAWERS

A Regulated Tube Rectifier may also be used to furnish Tripping Voltage.



FIRE PROTECTION

Tarpaulins are unfolded and thrown over a small fire to "smother" it.

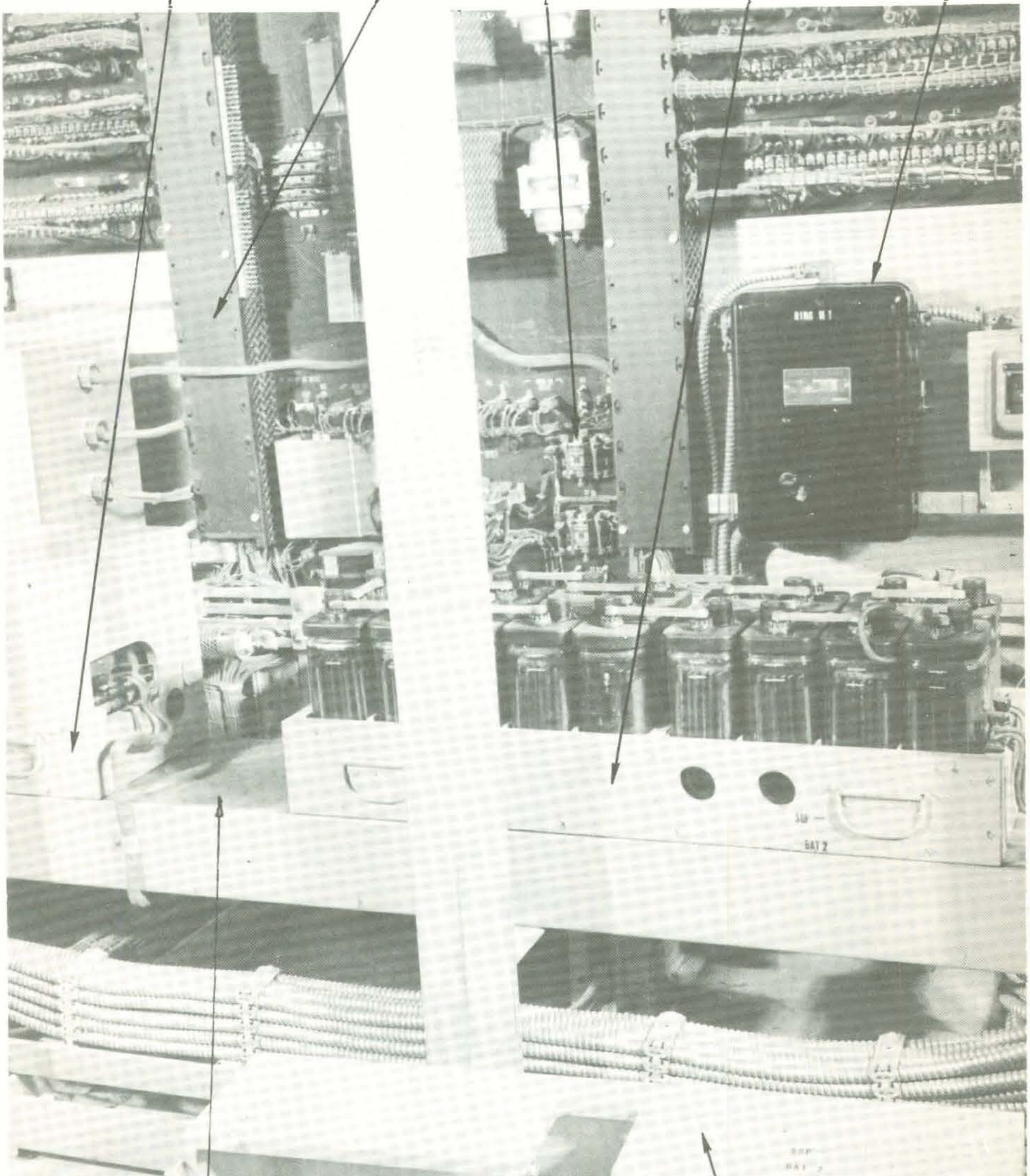
FILING TYPE DRY BATTERY CABINET

GLASS LEGS

Tripping Battery is furnished through the Low-Speed Interrupters to operate the Tripping (Ringing Cut-Off) Relay when the Called Subscriber answers during the silent interval.

TRIPPING BATTERY EQUIPMENT

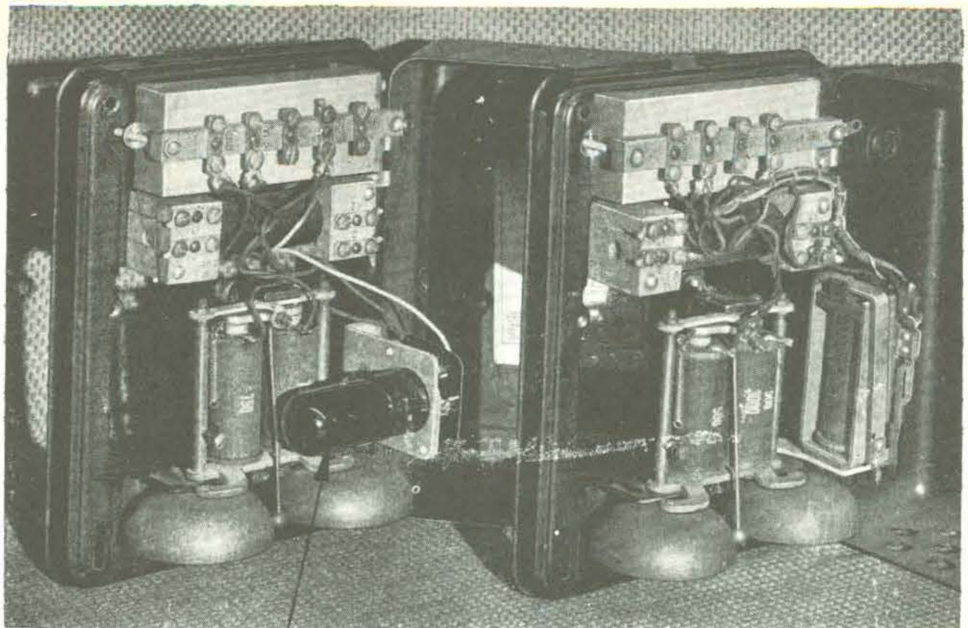
OAKLAND OFFICE, CHICAGO



BATTERIES ASSOCIATED WITH RINGING MOUNTED IN REAR OF RINGING POWER BOARD

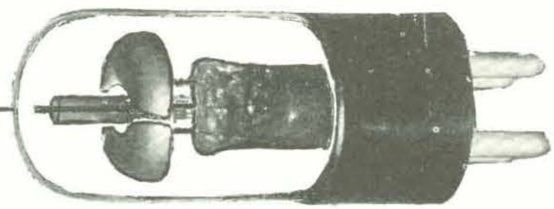
OAKLAND OFFICE, CHICAGO

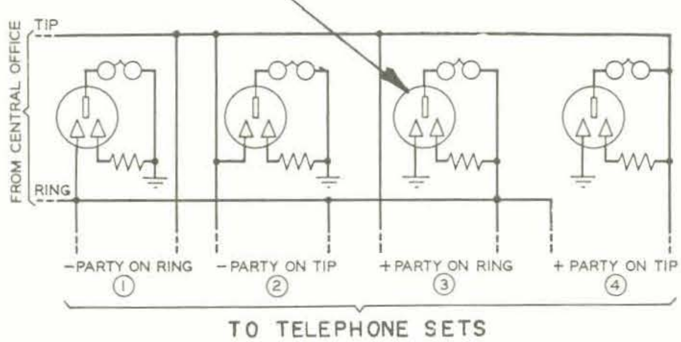
Superimposed Battery (+ and -) for Full-Selective Ringing, 4-Party Lines. **AUG.1940**



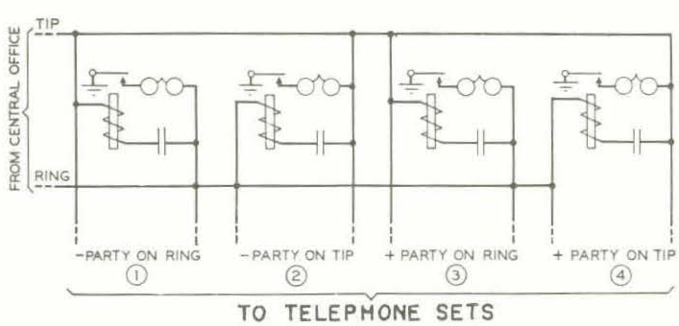
Tube-Type Subset — Relay-Type Subset

313A COLD CATHODE GAS FILLED TUBE





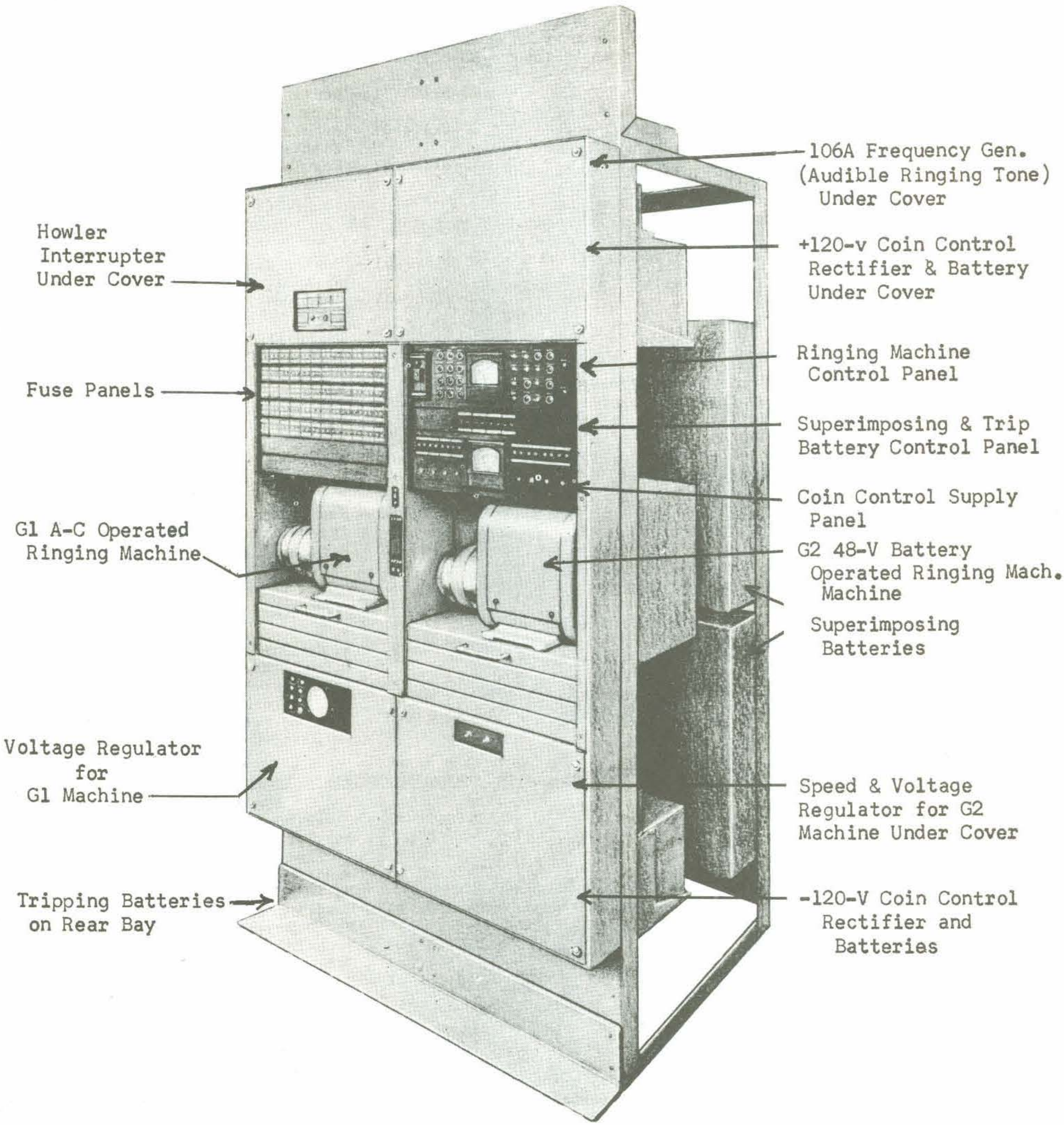
CONNECTIONS FOR THE VACUUM-TUBE SUBSCRIBER SET FOR A FOUR-PARTY FULL-SELECTIVE CIRCUIT.



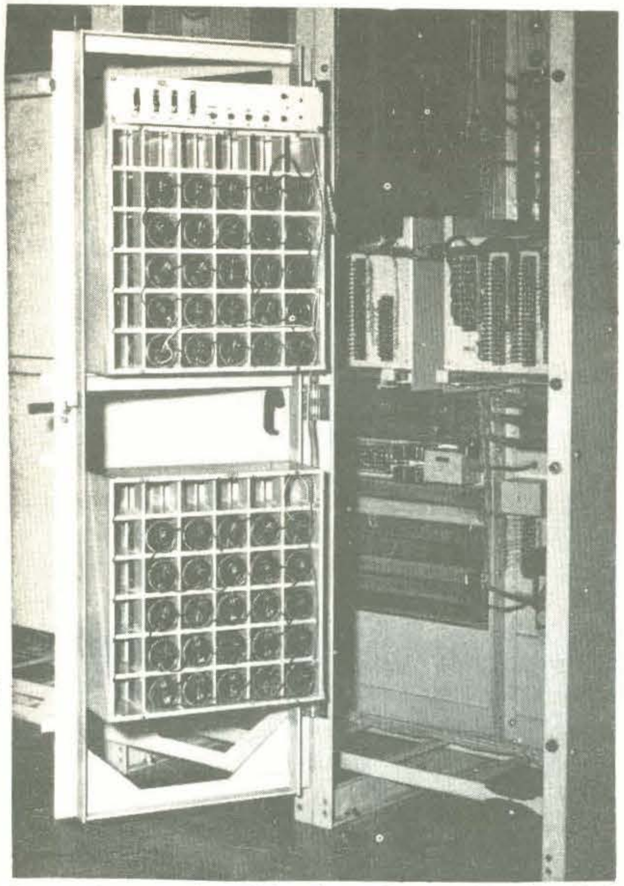
SUBSTATION CONNECTIONS FOR A FOUR-PARTY FULL-SELECTIVE CIRCUIT USING RELAY-TYPE SUBSCRIBER SETS.

SELECTIVE RINGING

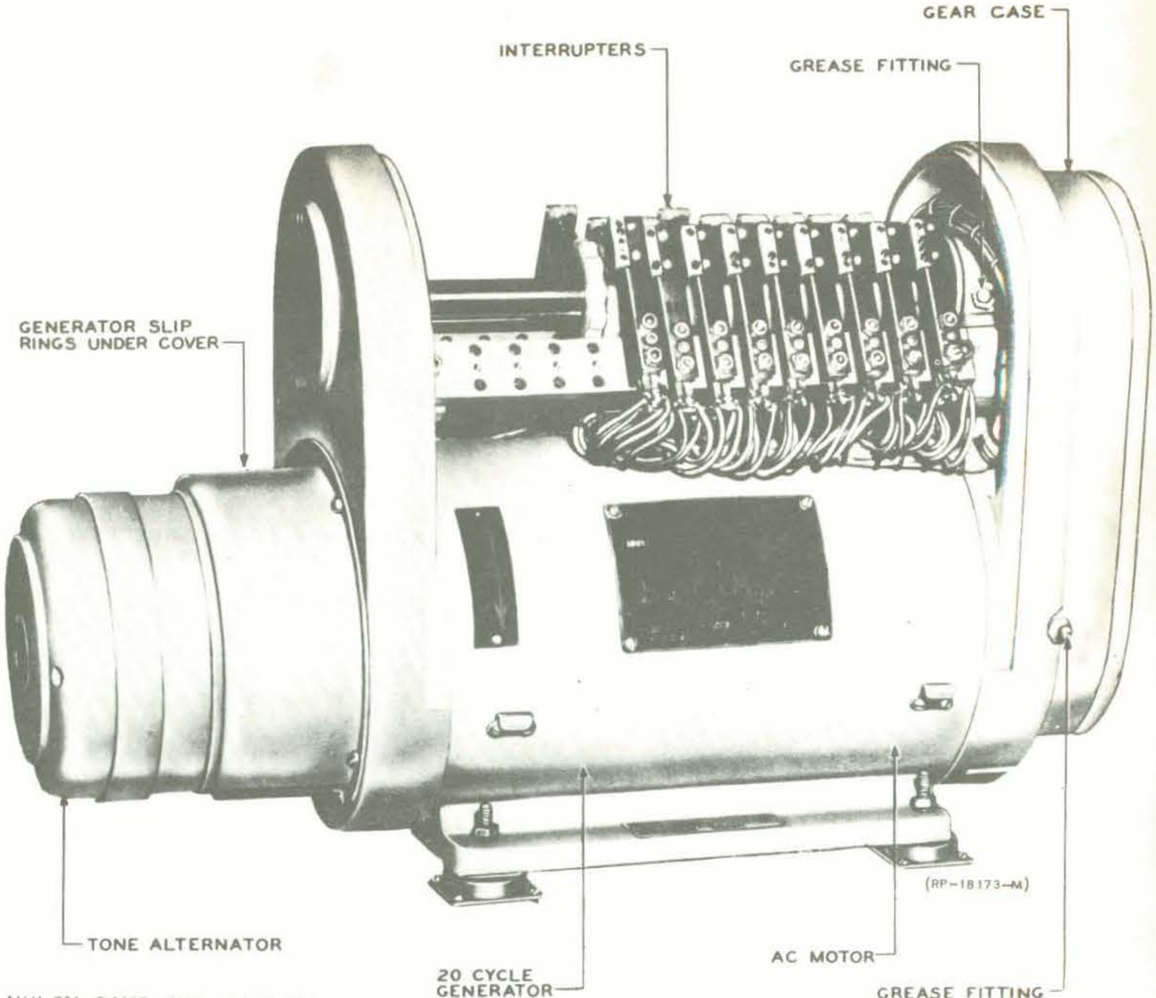
(VACUUM-TUBE OR RELAY OPERATION)



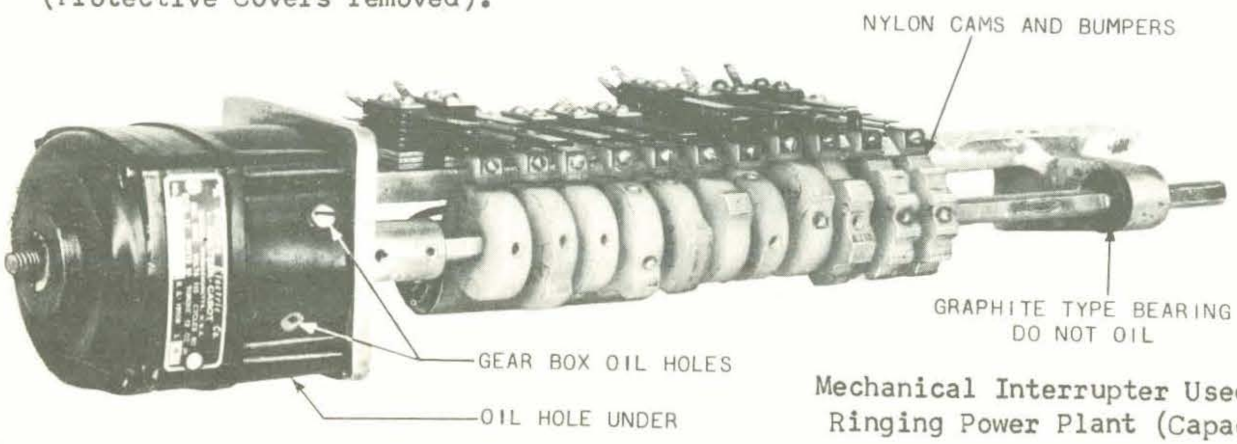
804C RINGING POWER PLANT
1-Ampere Capacity
Up To 50,000 Busy-Hour Calls



Superimposed Batteries for 4-Party Selective Ringing mounted on Hinged Gate in Rear of Bay (Protective Covers removed).



804-C Ringing Machine "RING G1"



Mechanical Interrupter Used in 806F Type Ringing Power Plant (Capacity ½-Ampere)

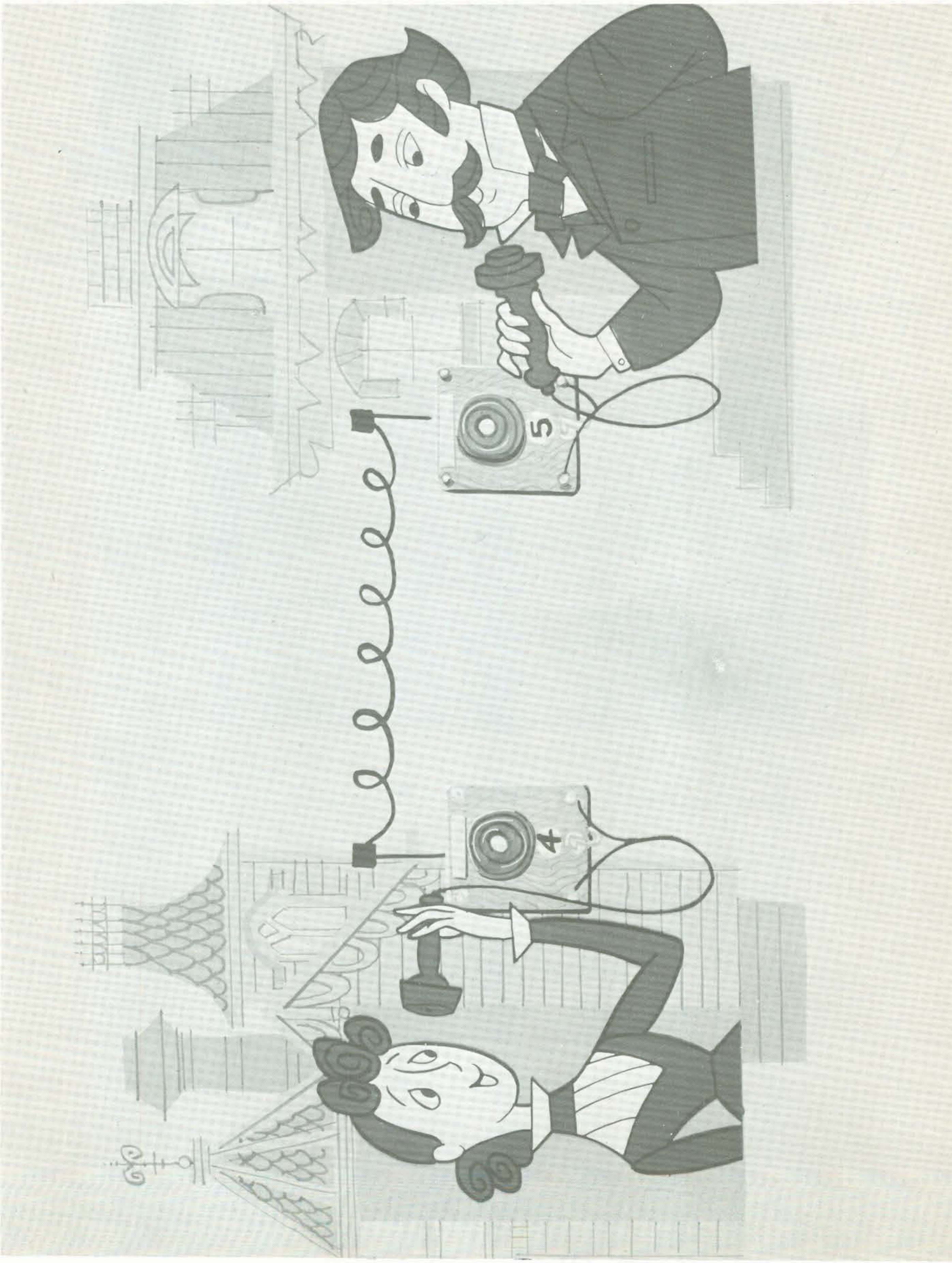
Lesson No. 1

FUNDAMENTALS OF TELEPHONY

Section 8

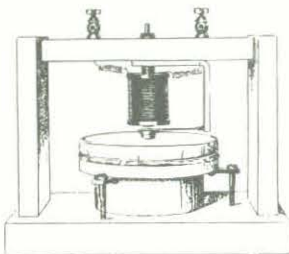
The Manual Switching System

CONTENTS


5
4

THE MANUAL SWITCHING SYSTEM

1876 - Telephone patented by Alexander Graham Bell.



"Gallows Frame"
Telephone
June, 1875
First Electrical Transmitter of Speech Sounds.

Liquid Transmitter.
March 10, 1876
First Instrument to Transmit Articulate Speech

- - - - -

1878 - First Switchboard installed in New Haven, Connecticut; serving 21 Subscribers on 8 Subscriber Lines.

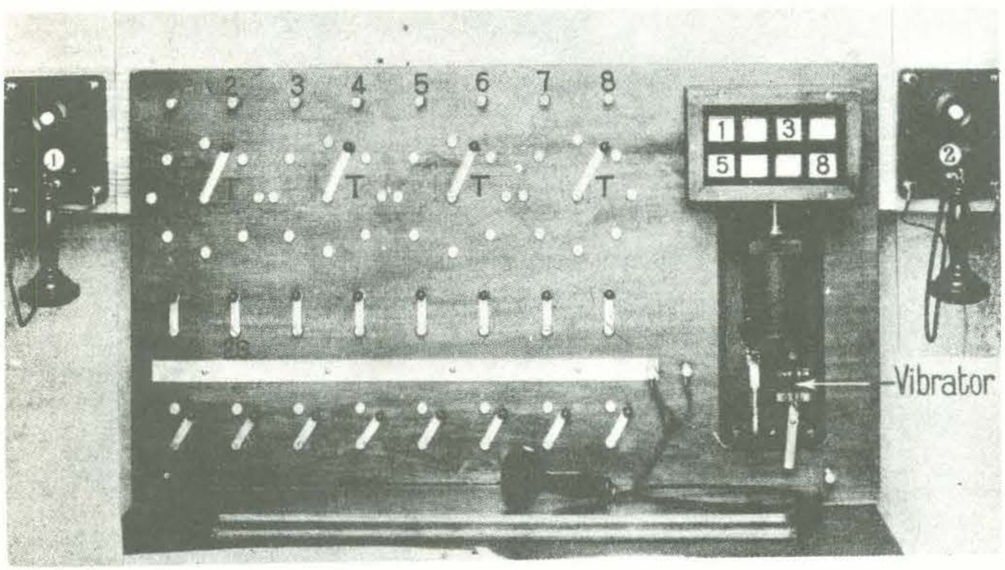
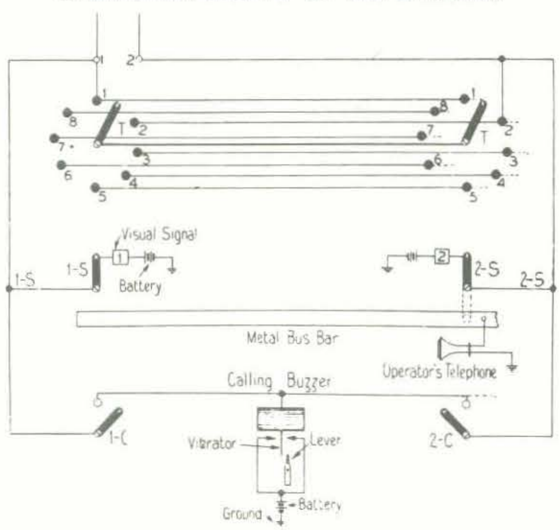


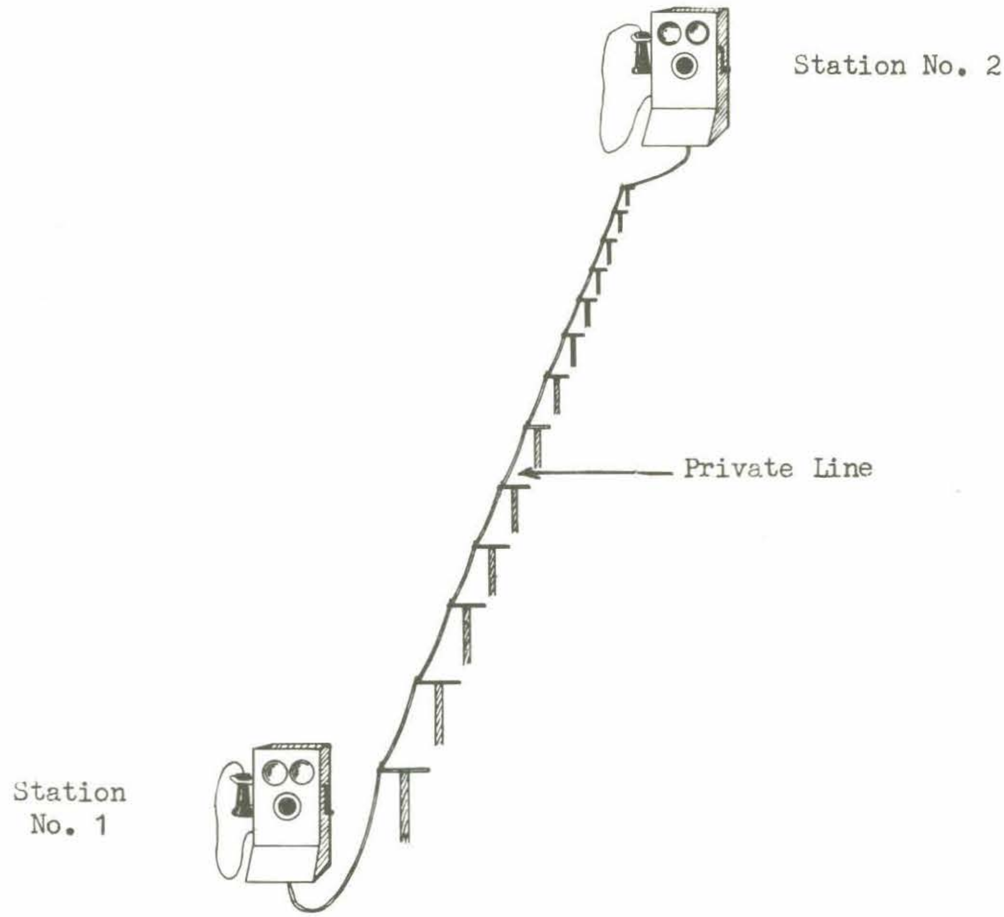
Fig. 1 New Haven Board 1878

SCHEMATIC WIRING DIAGRAM OF NEW HAVEN SWITCHBOARD

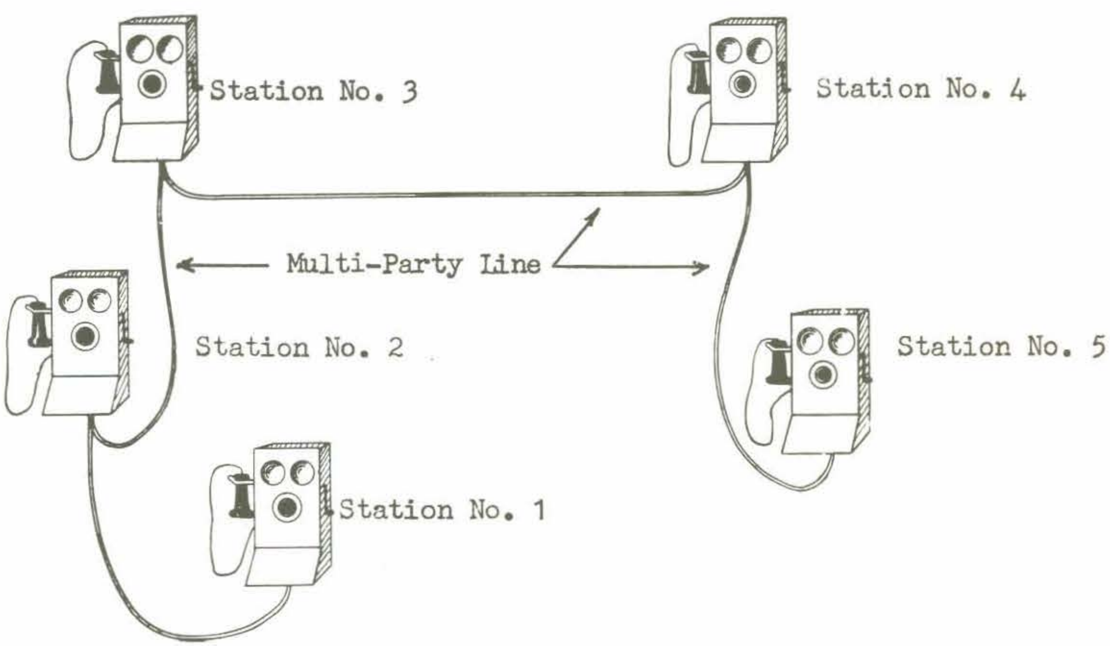


Growth of Manual Switching:

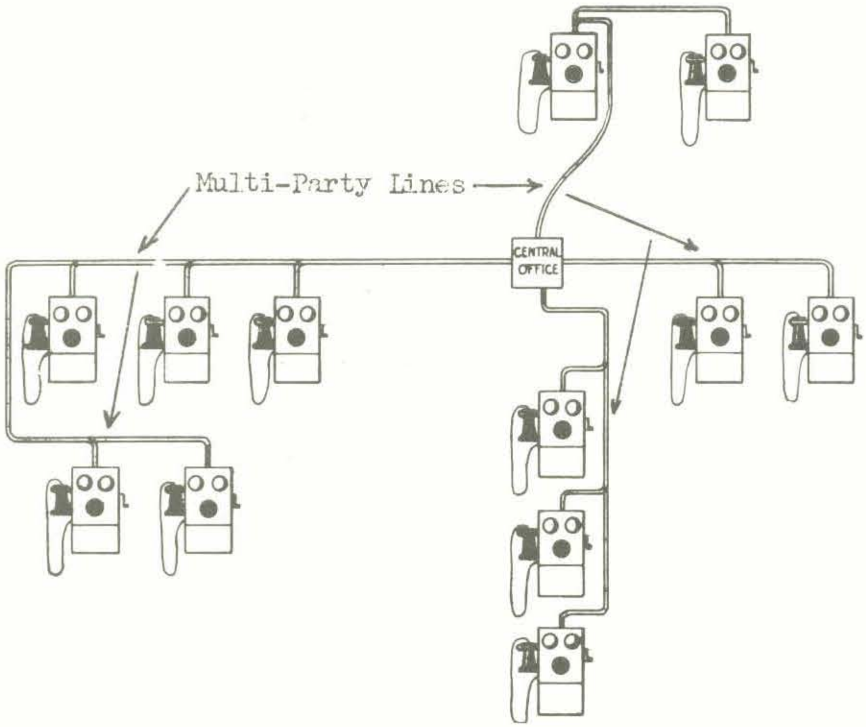
1) Private Line - Two Subsets permanently connected to a pair of wires.



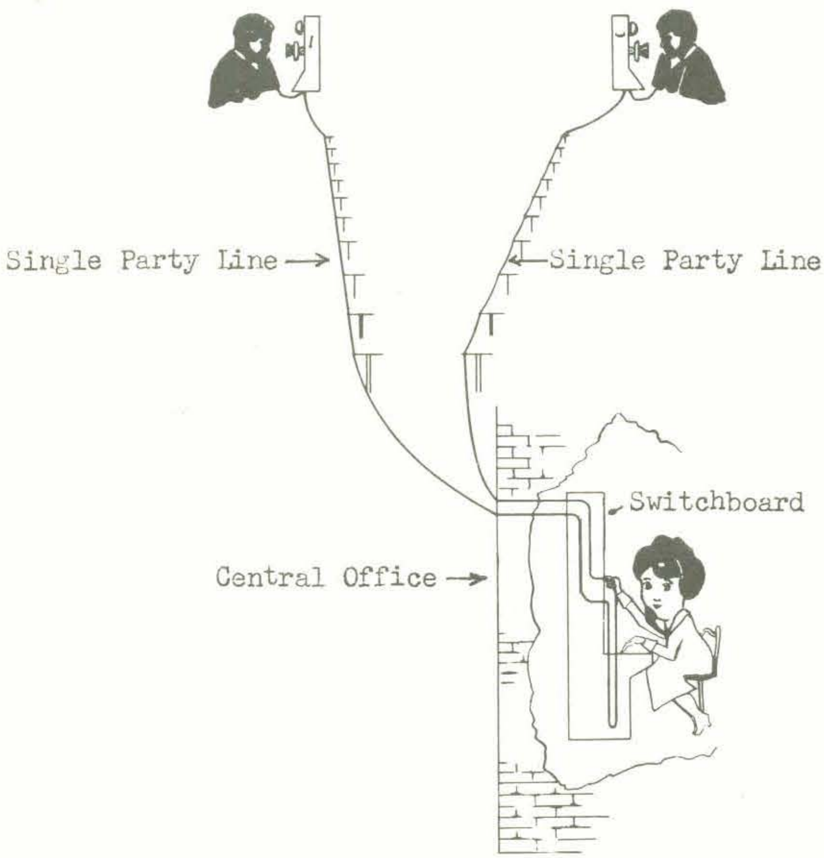
2) Multi-Party Line - Several Stations connected to the same pair of wires.



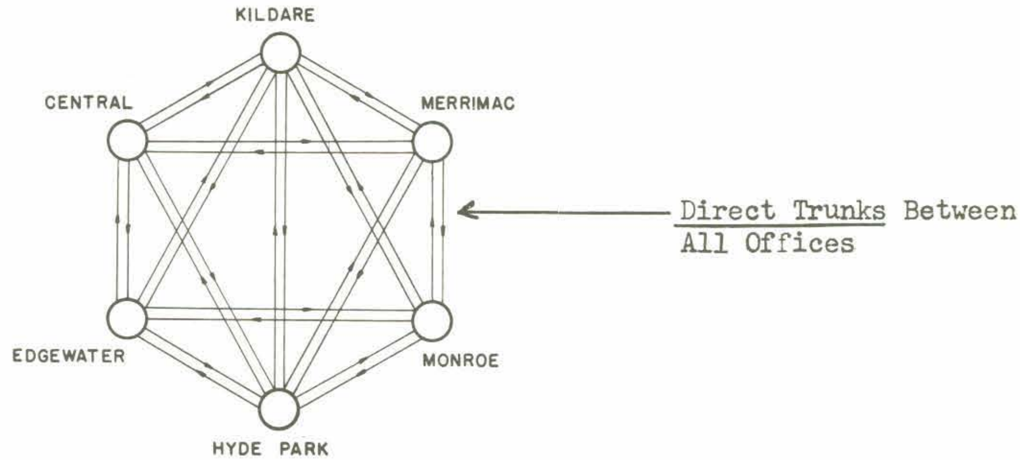
3) Several Party Lines Connected to a Switchboard located in a Central Office. A Subscriber on one party line is connected to a Subscriber on another party line by an Operator at the Switchboard.



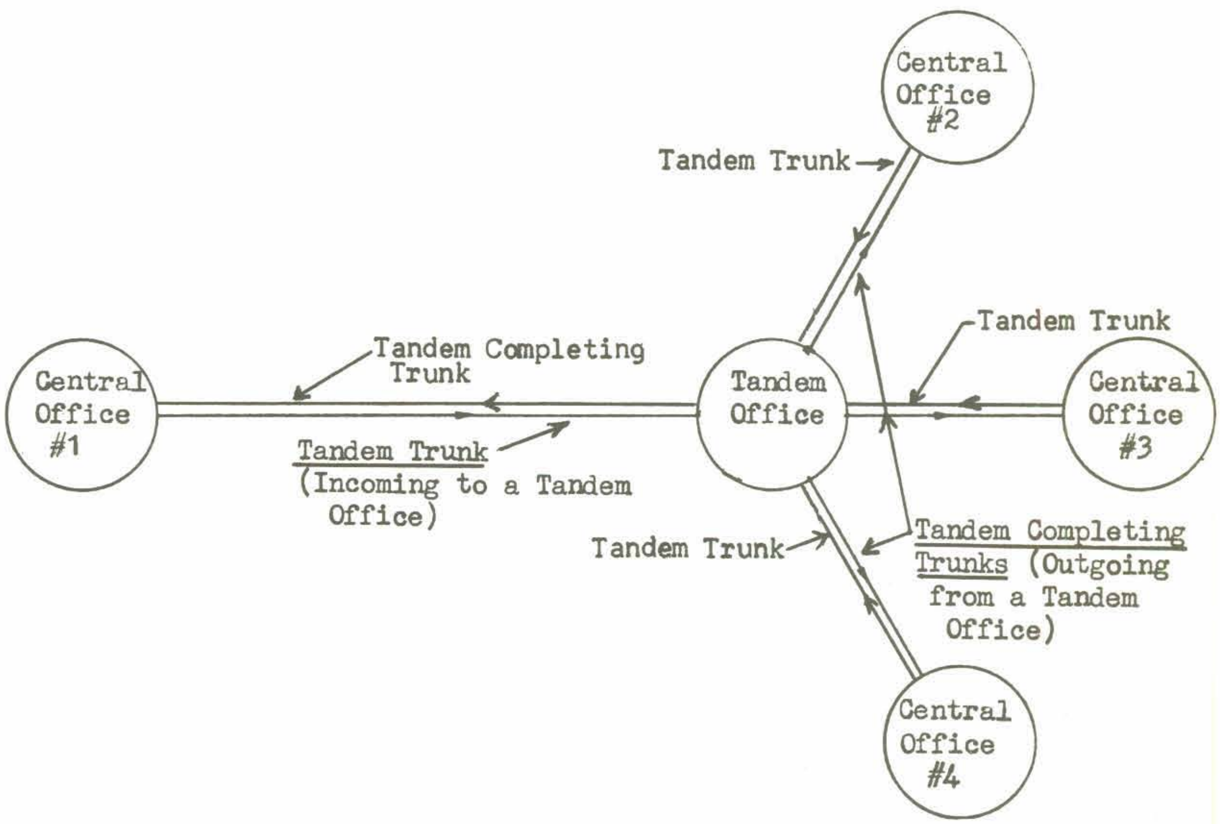
4) Two Single-Party Lines connected together by an Operator at the Central Office Switchboard.



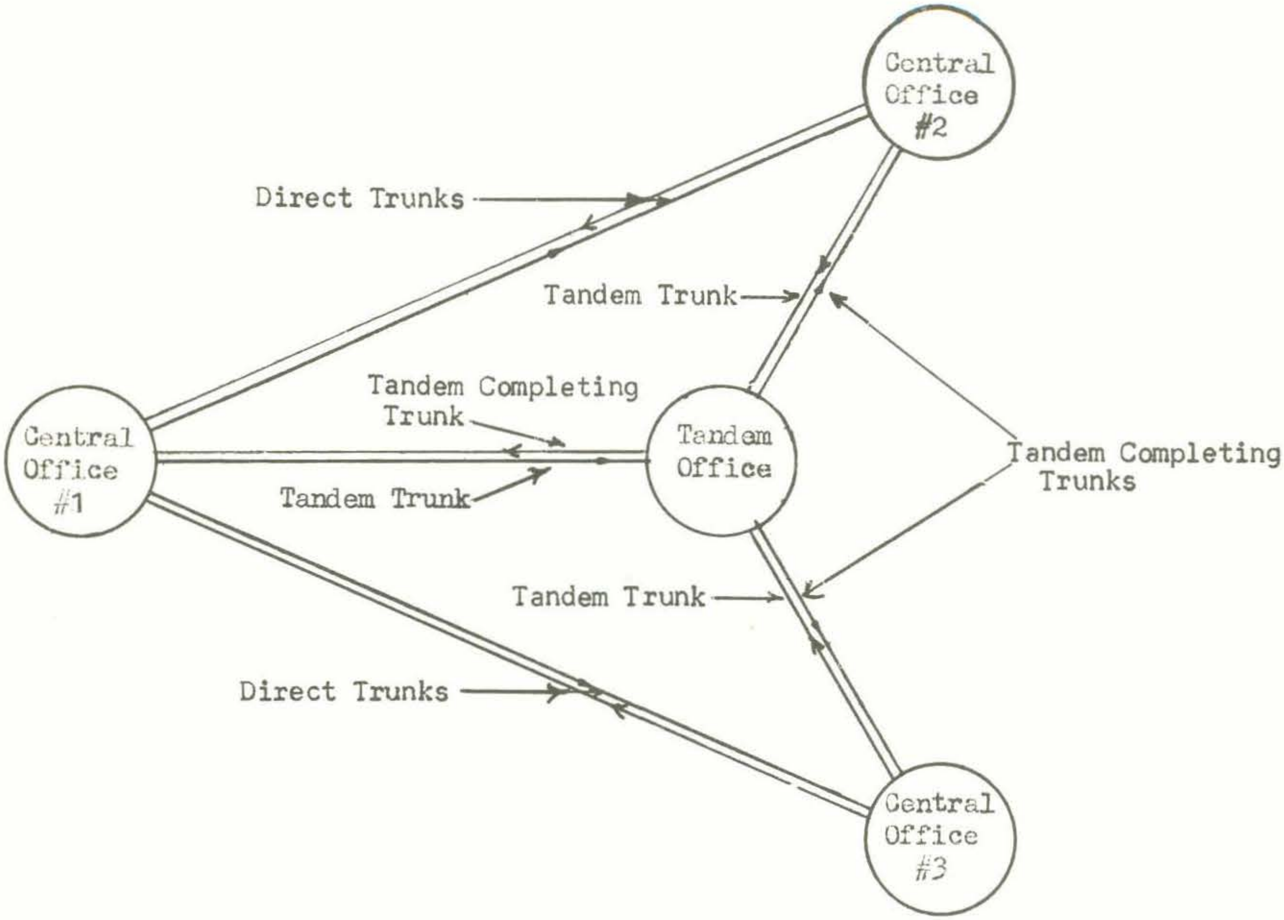
5) Several Central Offices, interconnected by Trunks, required to service a large Exchange Area.



6) Tandem Office - A Central Office used as an intermediate switching point for traffic between other Central Offices, and affording:
   1) Economical trunking between outlying offices with low traffic volume.
   2) Alternate Routes between all Central Offices in an Exchange Area handling overflow traffic from Direct Trunks.



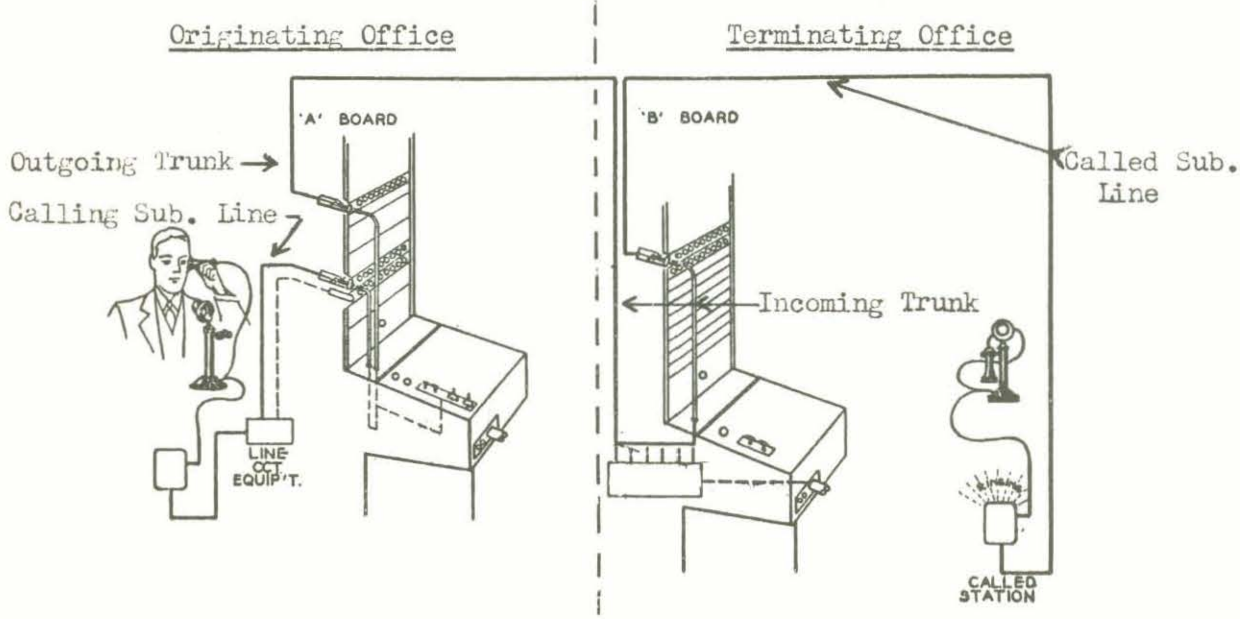
7) A combination of Direct and Tandem Trunking provides the most economical method of handling traffic between several Central Offices.



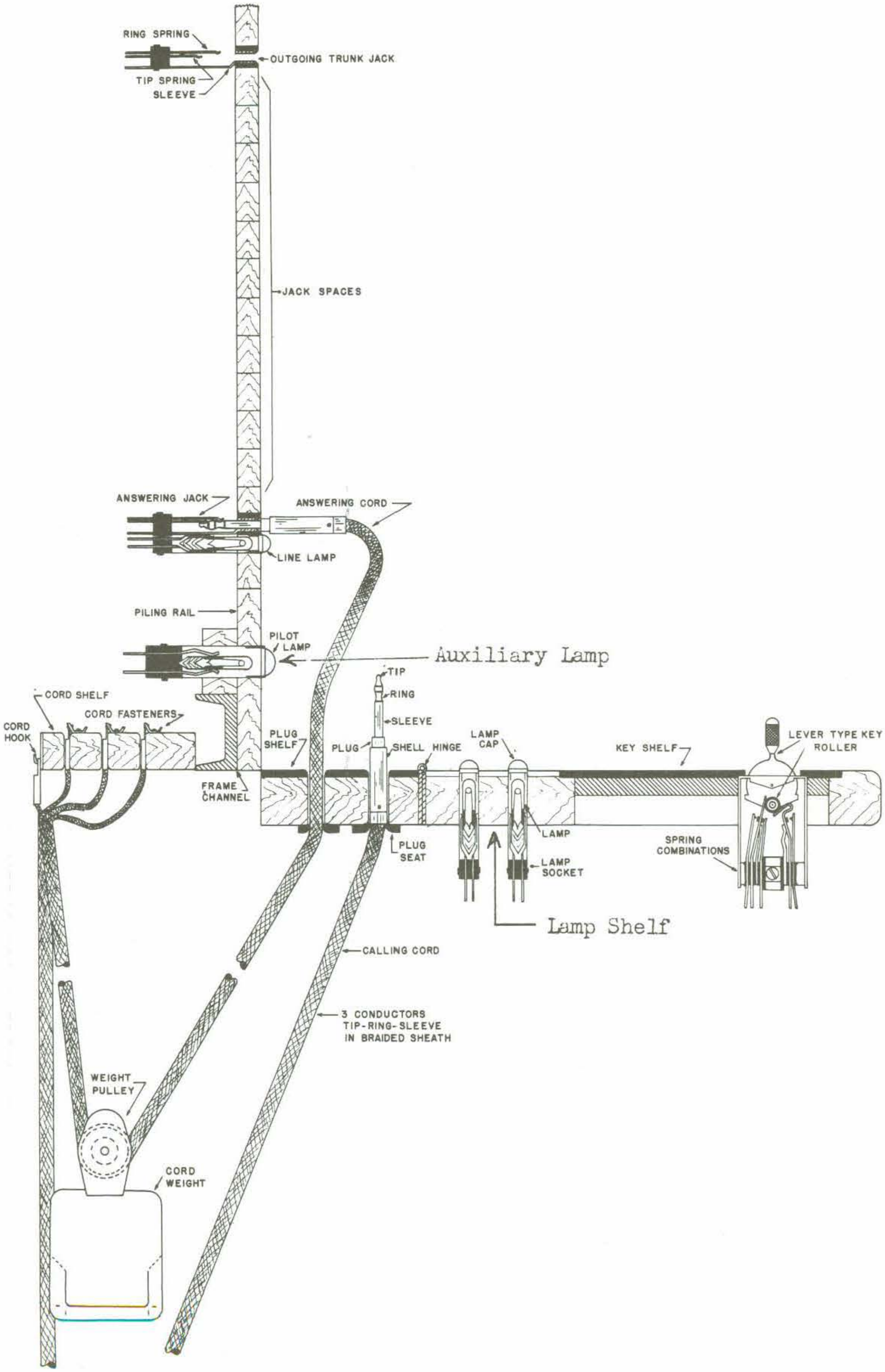
SWITCHBOARD EQUIPMENT

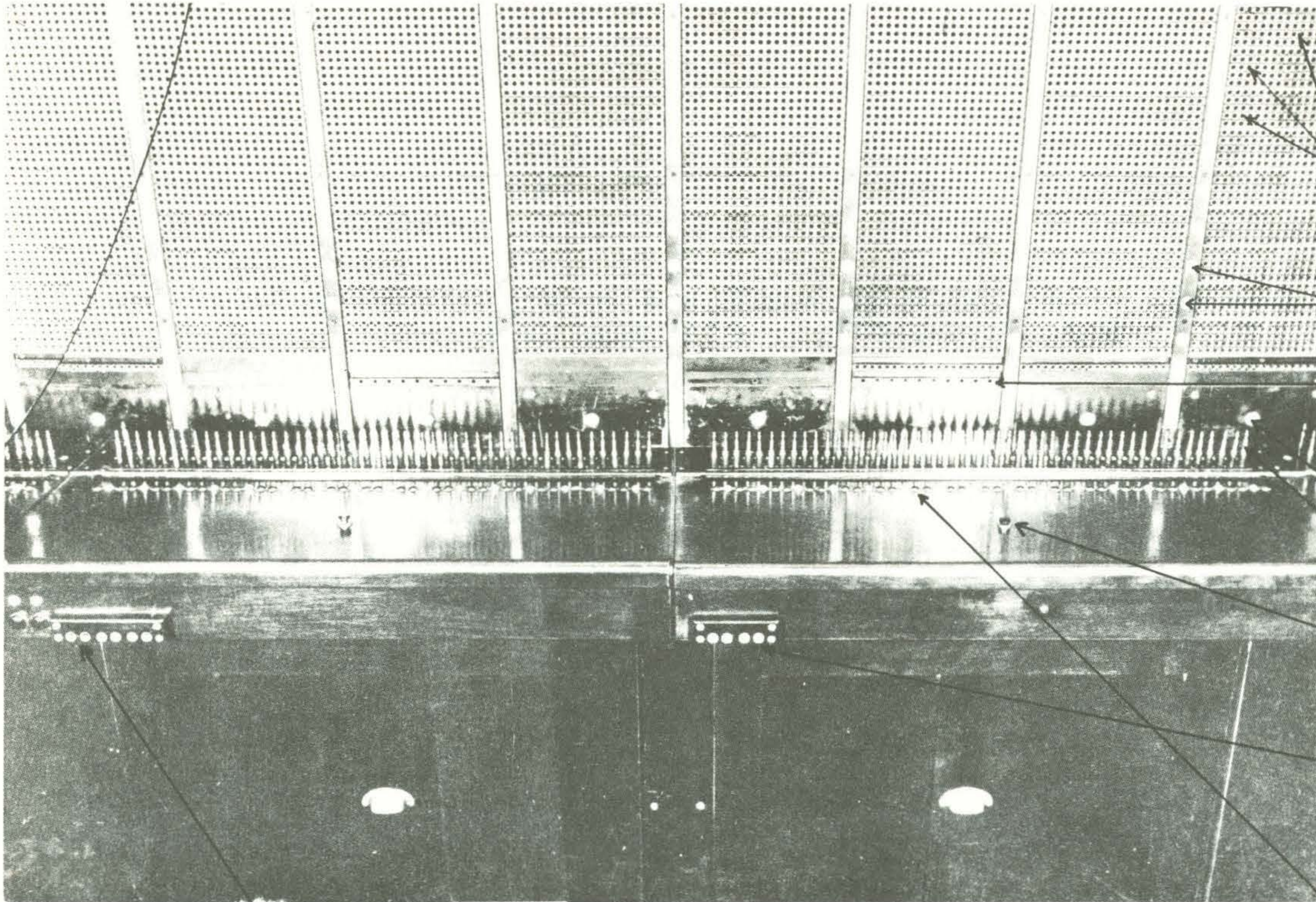
Subscriber Lines and Outgoing Trunks - appear on the "A" Switchboard in the Originating Office.

Incoming Trunks and Subscriber Lines - appear on the "B" Switchboard in the Terminating Office.

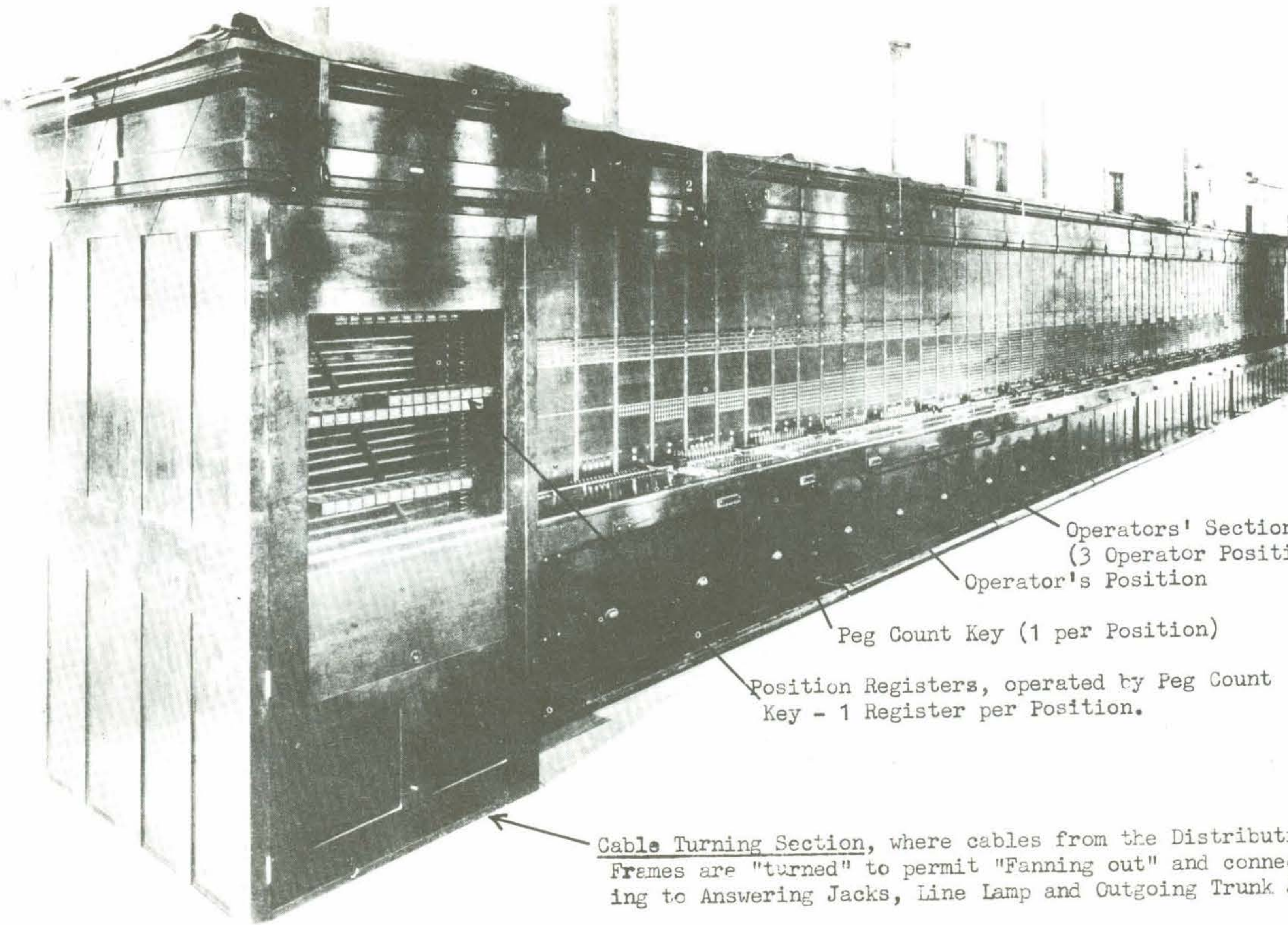


"A" Switchboard Equipment

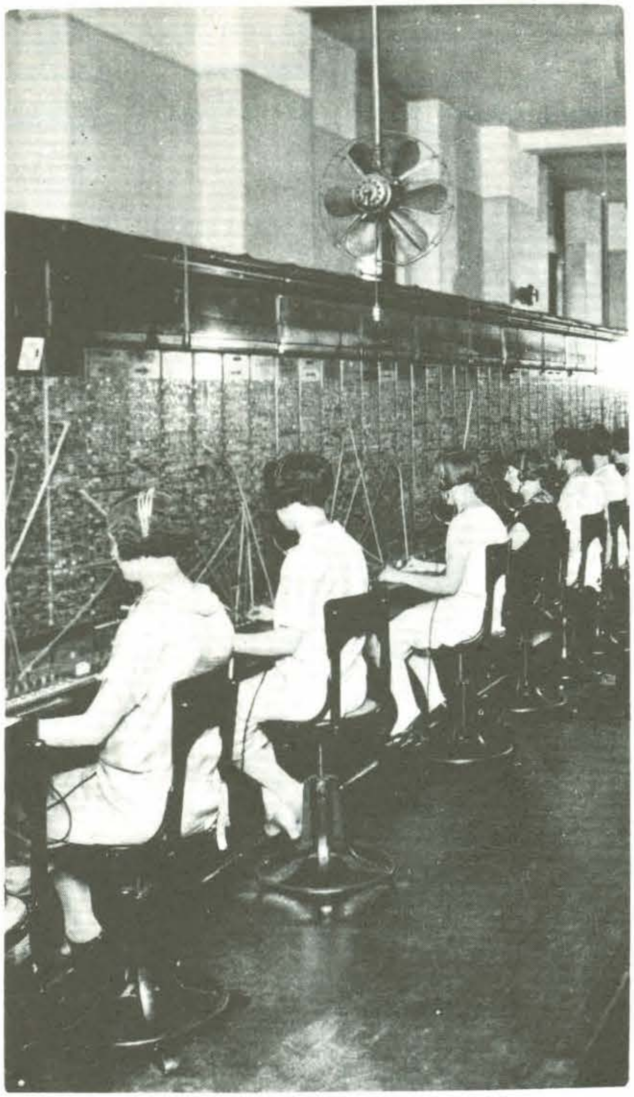




"B" Switchboard Equipment

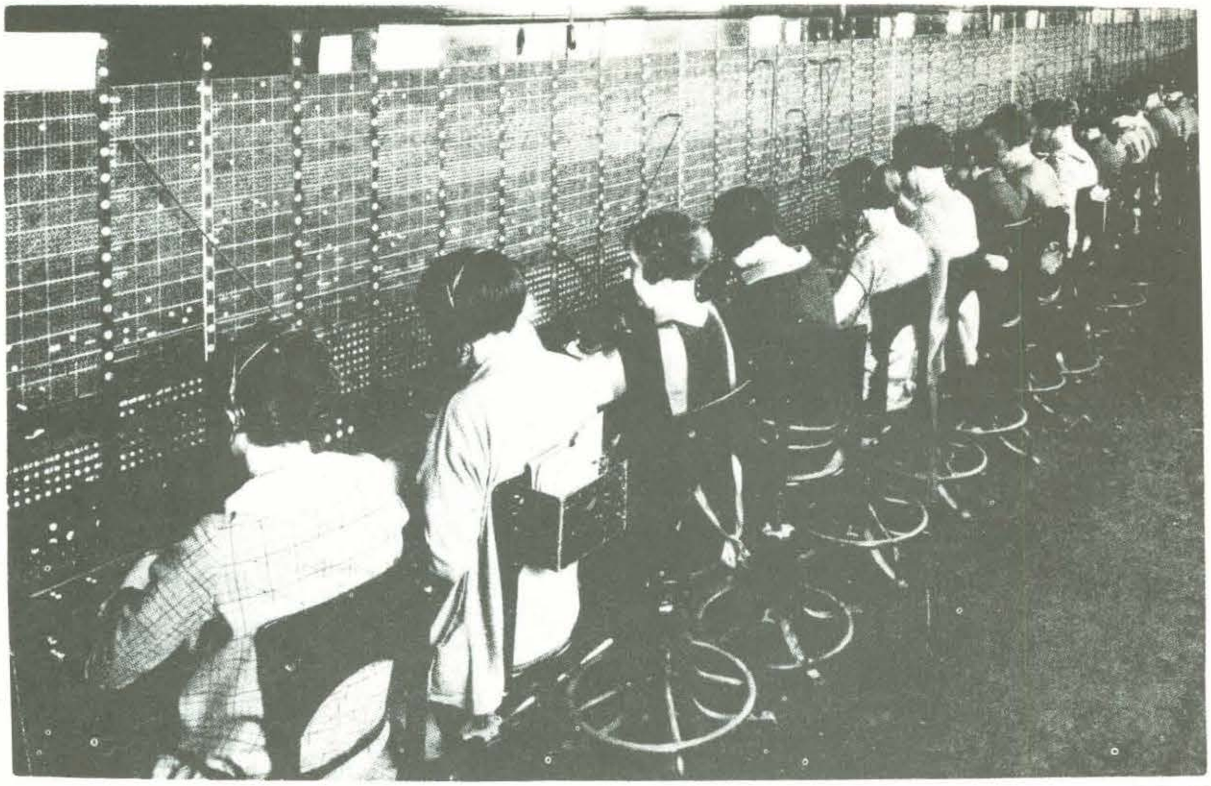


"A" Switchboard Lineup

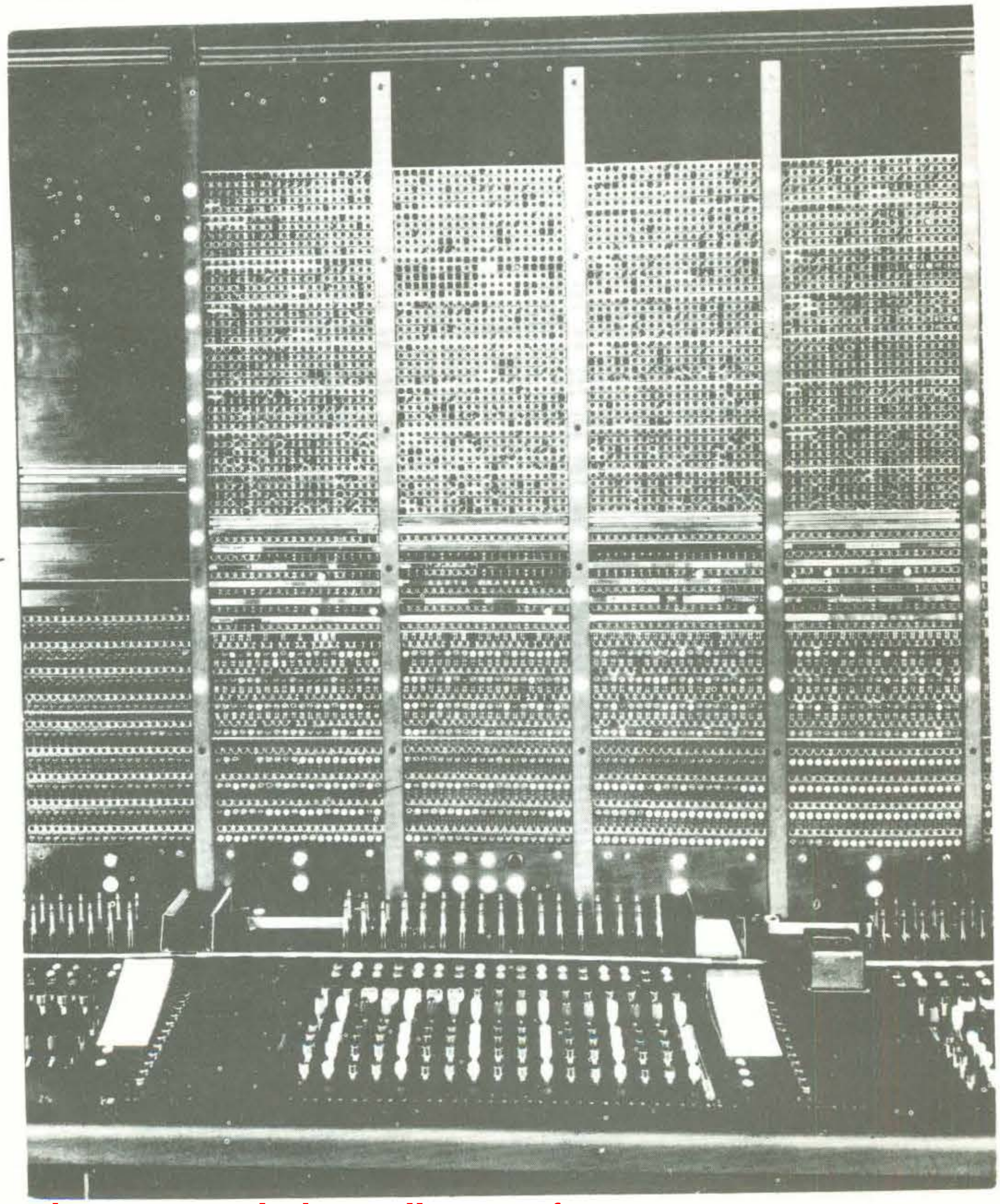


A Portion of a "B" Switchboard Lineup

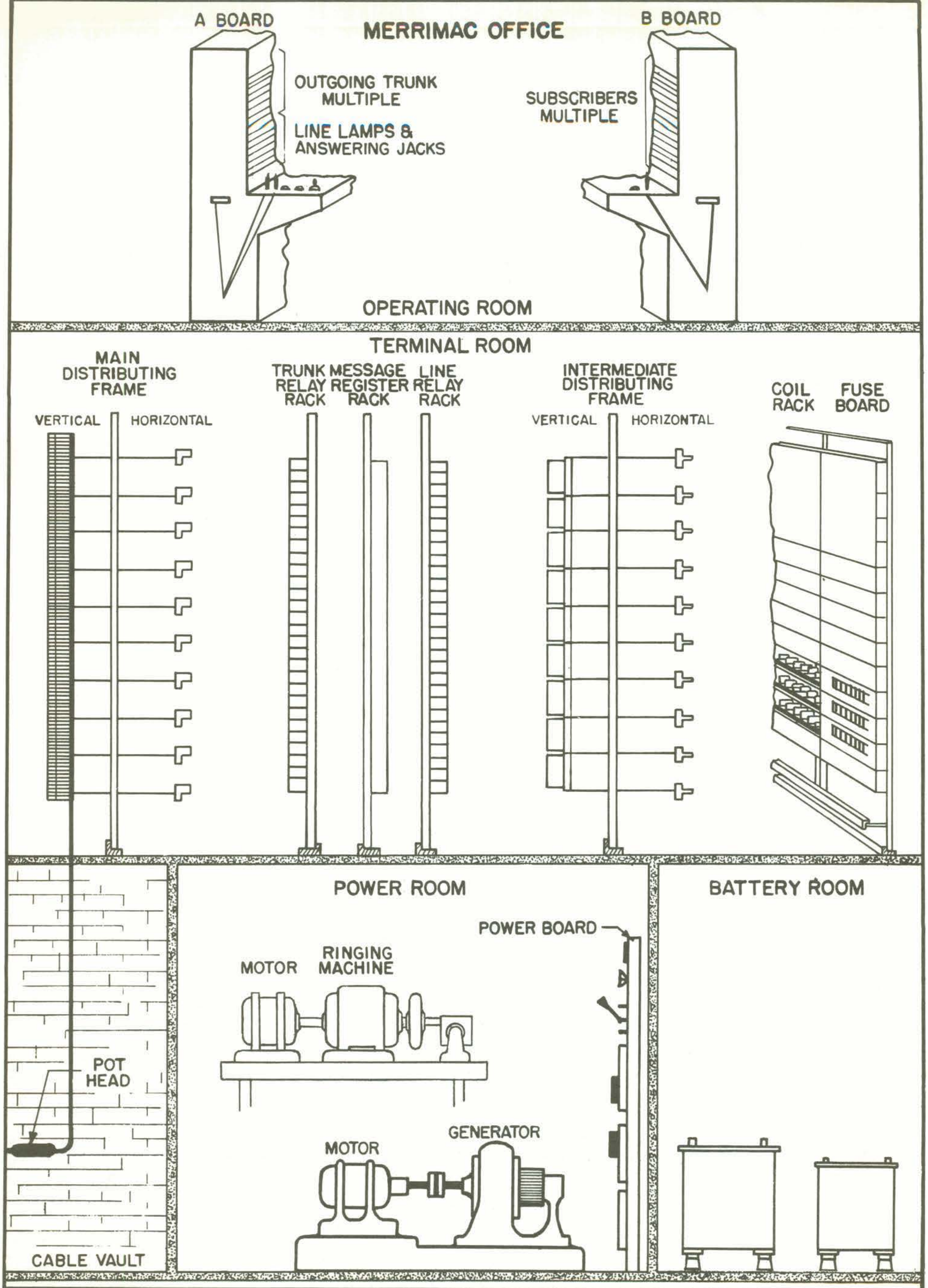
Boys were originally employed as operators; however they would often argue with the subscribers, and sometimes swear at them!

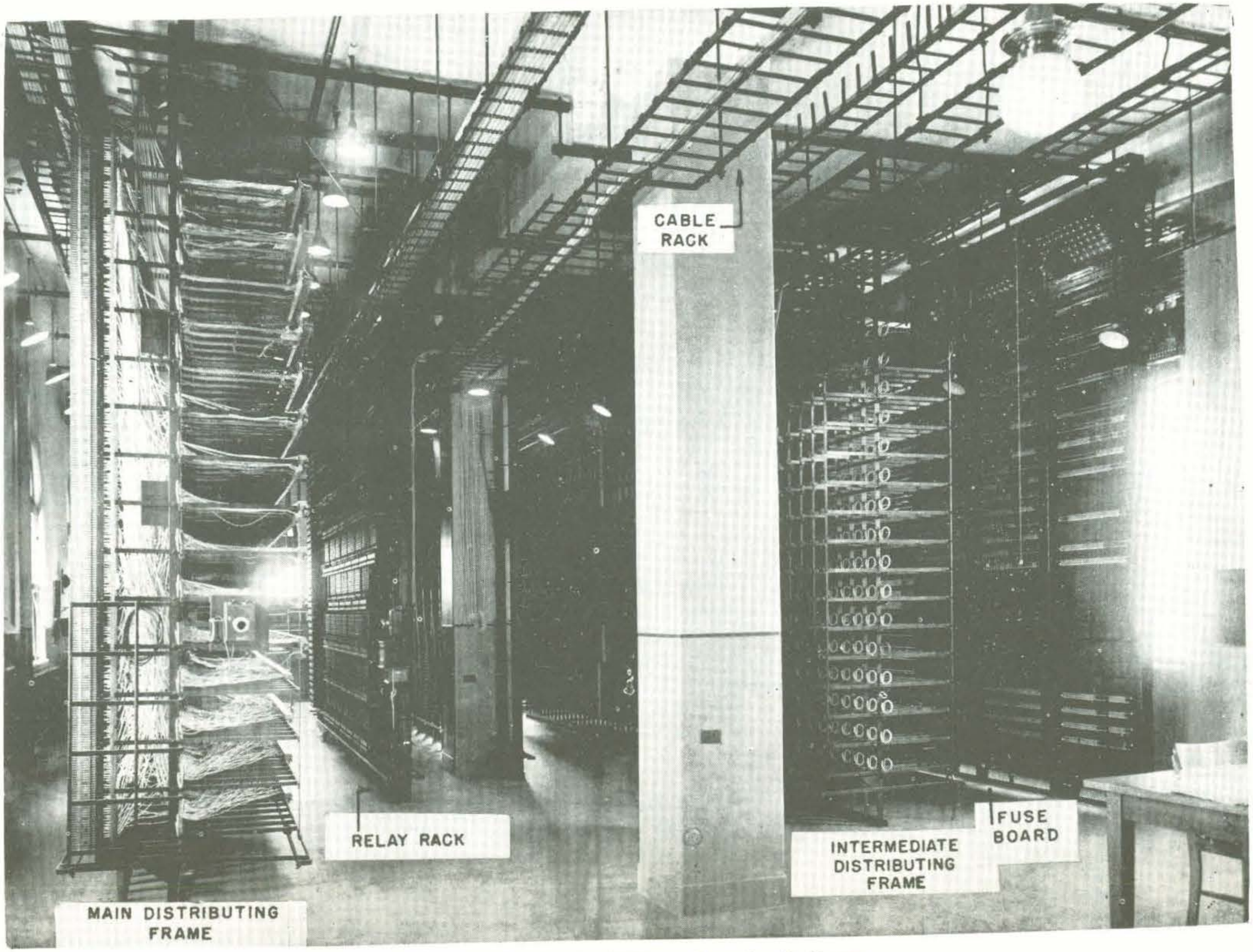


Combination Switchboard Lineup

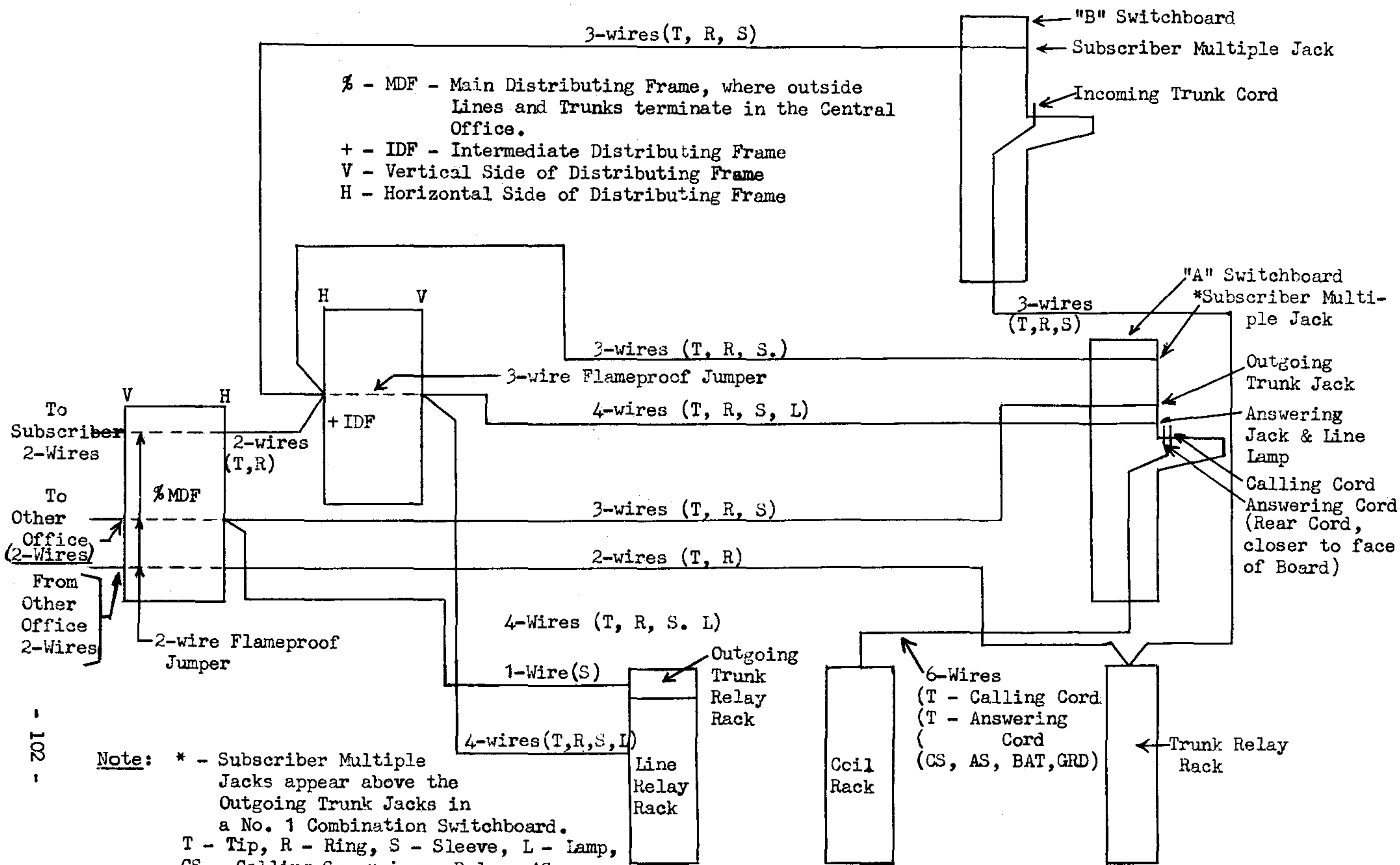


Combination Switchboard Position Equipment


A BOARD
MERRIMAC OFFICE
B BOARD
OUTGOING TRUNK MULTIPLE
LINE LAMPS & ANSWERING JACKS
SUBSCRIBERS MULTIPLE
OPERATING ROOM
TERMINAL ROOM
MAIN DISTRIBUTING FRAME
VERTICAL
HORIZONTAL
TRUNK RELAY RACK
MESSAGE REGISTER RACK
LINE RELAY RACK
INTERMEDIATE DISTRIBUTING FRAME
VERTICAL
HORIZONTAL
COIL RACK
FUSE BOARD
POWER ROOM
BATTERY ROOM
POWER BOARD
MOTOR
RINGING MACHINE
POT HEAD
MOTOR
GENERATOR
CABLE VAULT

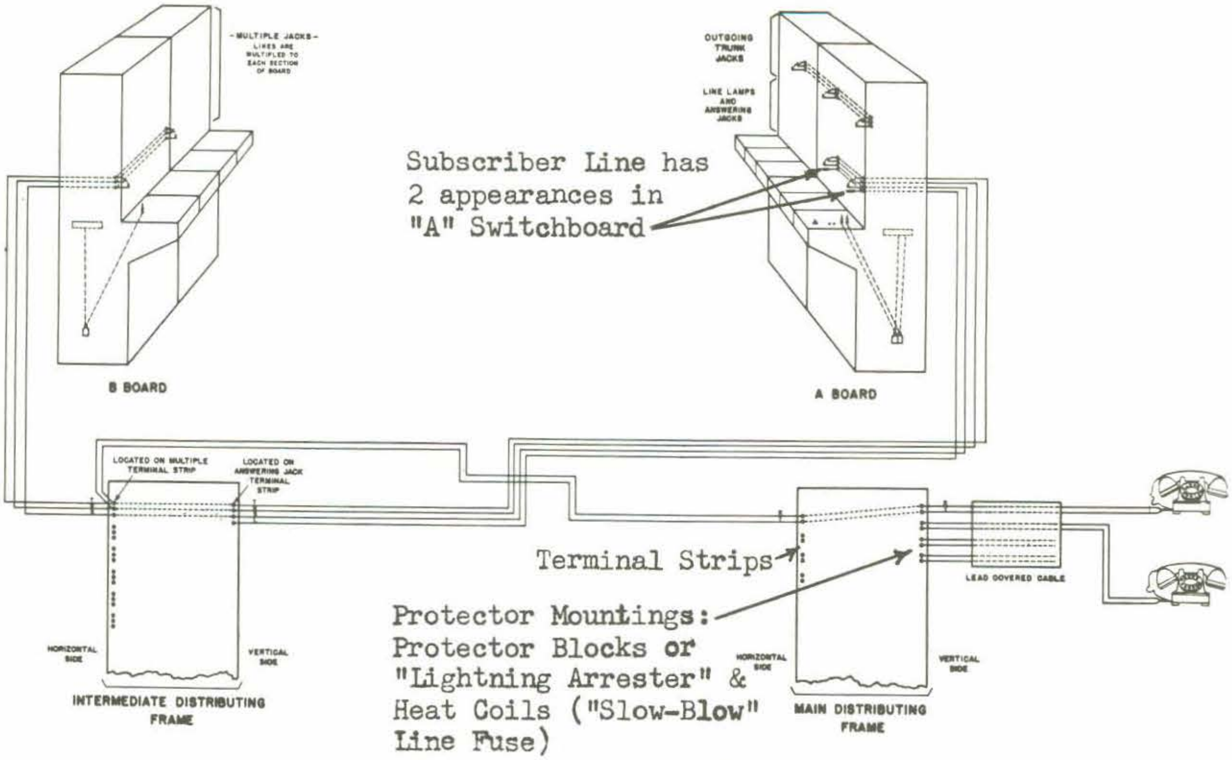


Manual Central Office Terminal Room



Note: * - Subscriber Multiple Jacks appear above the Outgoing Trunk Jacks in a No. 1 Combination Switchboard.
T - Tip, R - Ring, S - Sleeve, L - Lamp, CS - Calling Supervisory Relay, AS - Answering Supervisory) Relay, BAT - Central) Office Battery, GRD-Ground)

Typical Manual Central Office Cable Layout



MANUAL CENTRAL OFFICE
Cabling Between Distributing Frames and Switchboards

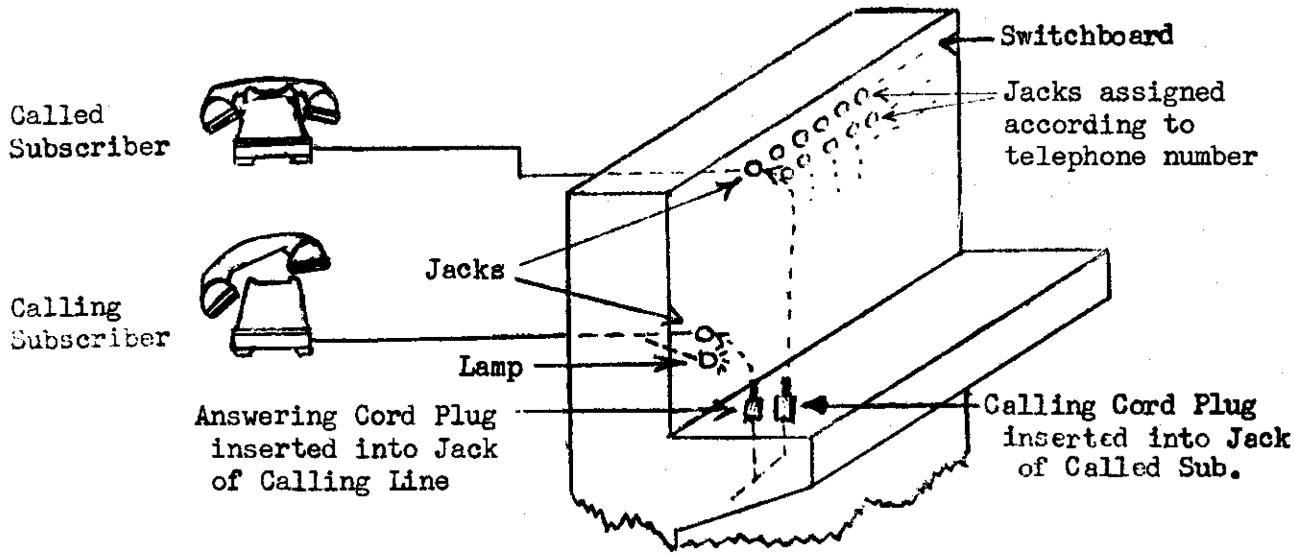
\- - - - - -

LTD - Local Test Desk, for checking outside Subscriber Lines and Trunks that are in trouble.

Repair Service Desk, where Trouble Record Cards are filed. Subscribers report trouble to Repair Service Clerk.

METHODS OF HANDLING CALLS THROUGH THE MANUAL SWITCHING SYSTEM

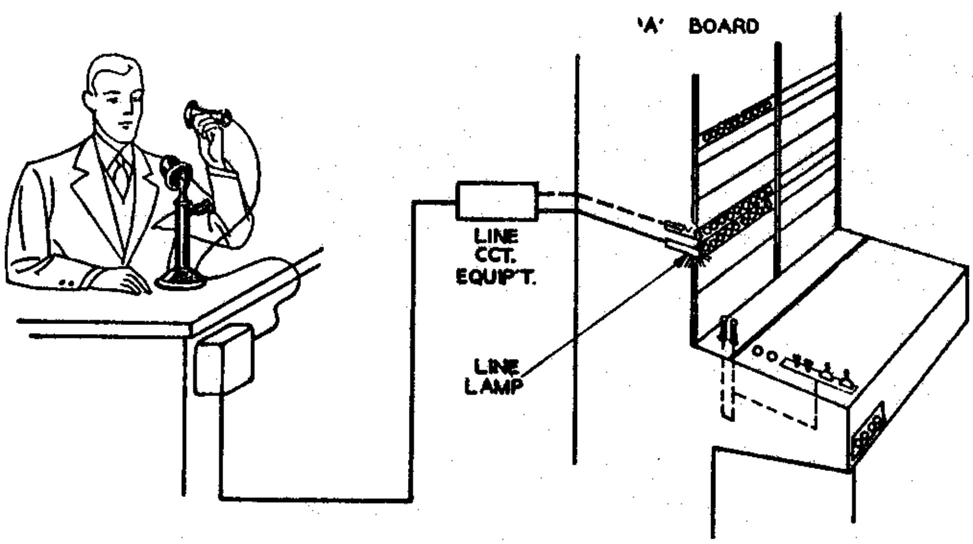
In the Manual Switching System, Subscriber Lines are cabled to Jacks mounted in the face of a Switchboard. Operators temporarily connect two Subscriber Lines together to build up a Talking Path by inserting Plugs on the ends of Cords into Jacks.



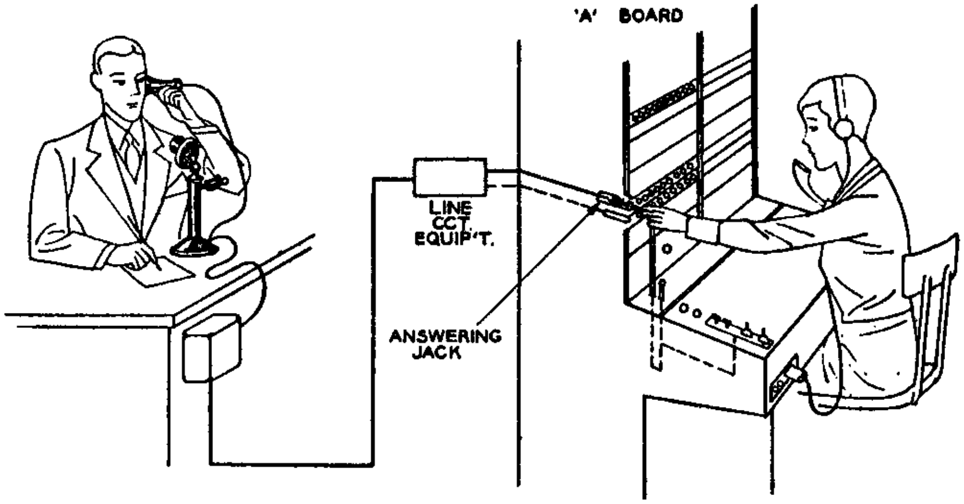
In a Multi-Office Exchange Area, two separate Switchboards are used:

1) The Subscriber or "A" Switchboard, and
2) The Trunk or "B" Switchboard.

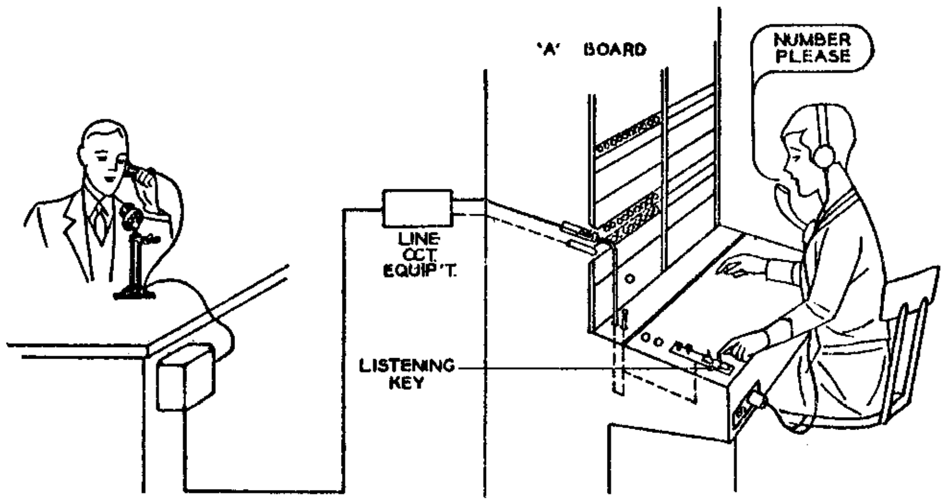
Completion of a Call Between Manual Offices Equipped With No. 1 Type Switchboards



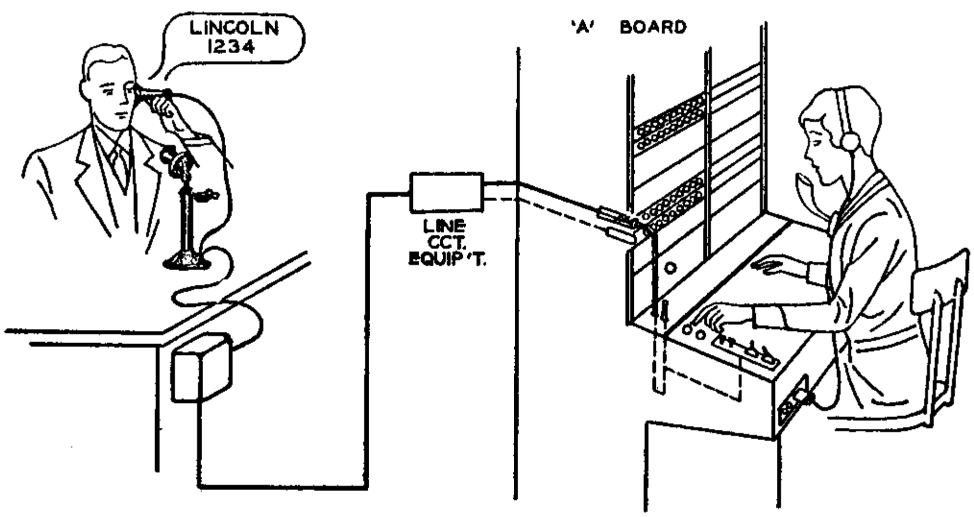
The removal of the Receiver from the Switchhook by the Calling Subscriber lights the Line Lamp in front of the "A" Operator.



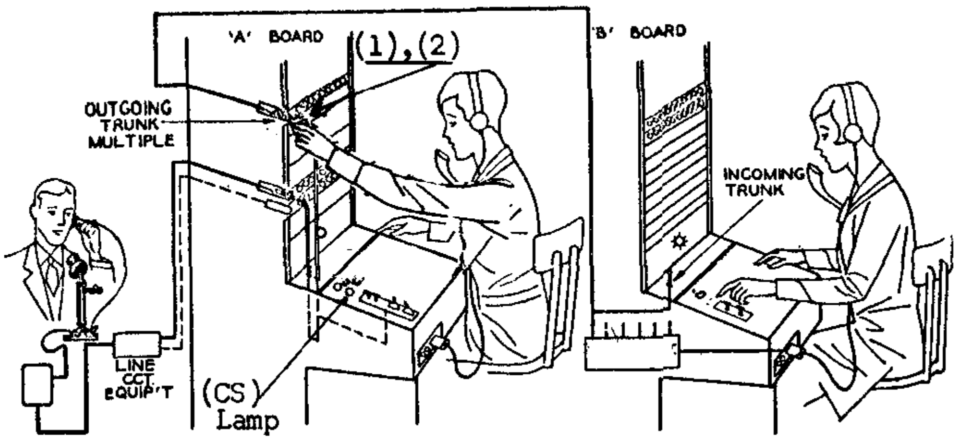
The "A" Operator inserts the Answering Cord Plug in the Calling Subscriber Answering Jack.



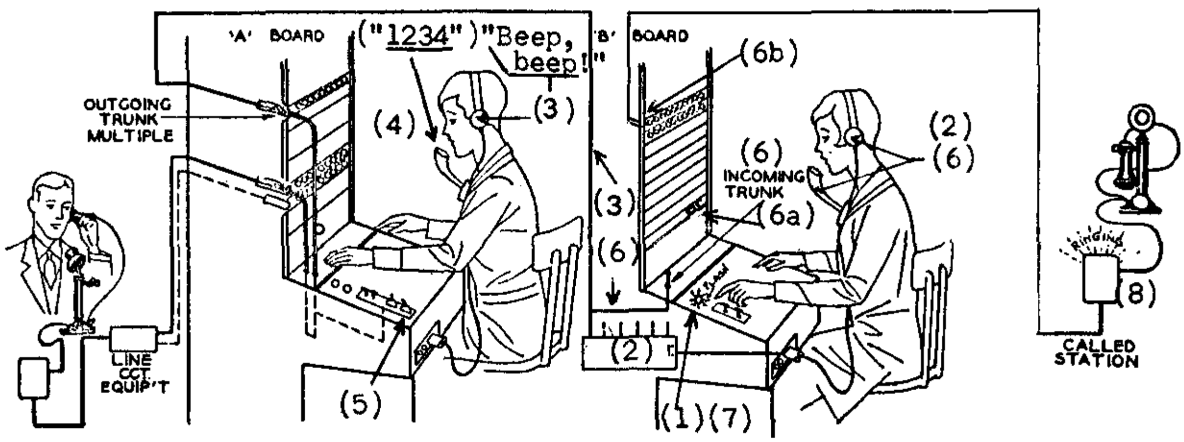
The "A" Operator connects her Telephone Set to the Answering Cord by operating the Listening Key, and challenges on the Line by saying, "Number, please."



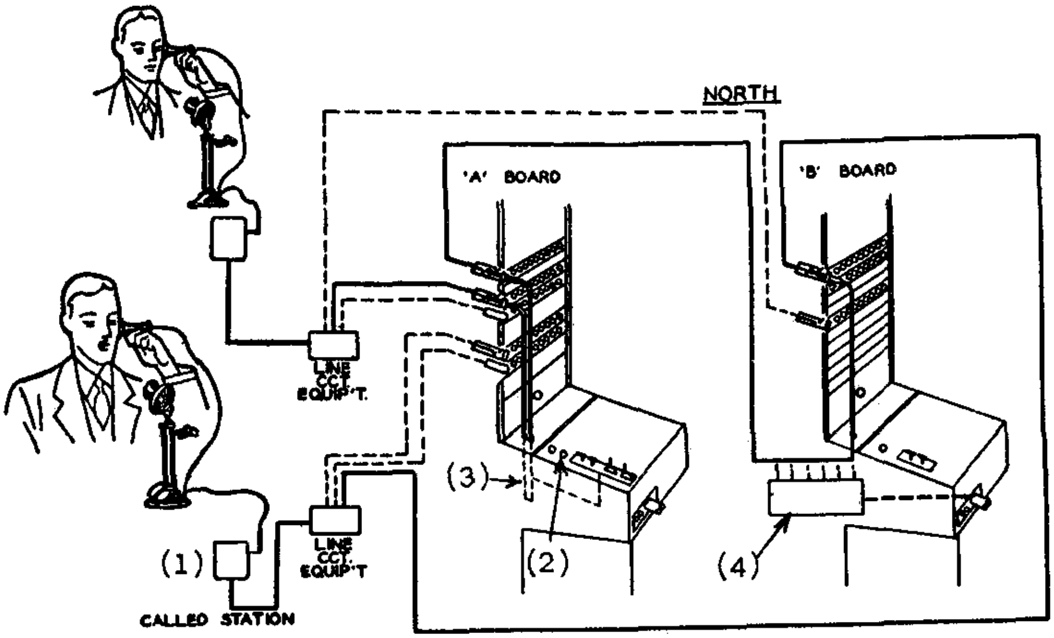
The Calling Subscriber passes the Office Code (Lincoln) and the Called Subscriber Number (4 digits) to the "A" Operator.



1) When the "A" Operator hears the Central Office Name or Code, she tests for an Idle Outgoing Trunk to the "B" Switchboard in the Called Office by touching the Tip of the Calling Cord Plug to the Sleeve of the Outgoing Trunk Jacks:
   a) A "click" in the "A" Operator's Headset indicates a Busy Trunk.
   b) No "click" in the "A" Operator's Headset indicates an Idle Trunk.
2) The "A" Operator inserts the Calling Cord Plug into an Idle Outgoing Trunk Jack, lighting the Calling Supervisory Lamp at the "A" Switchboard.

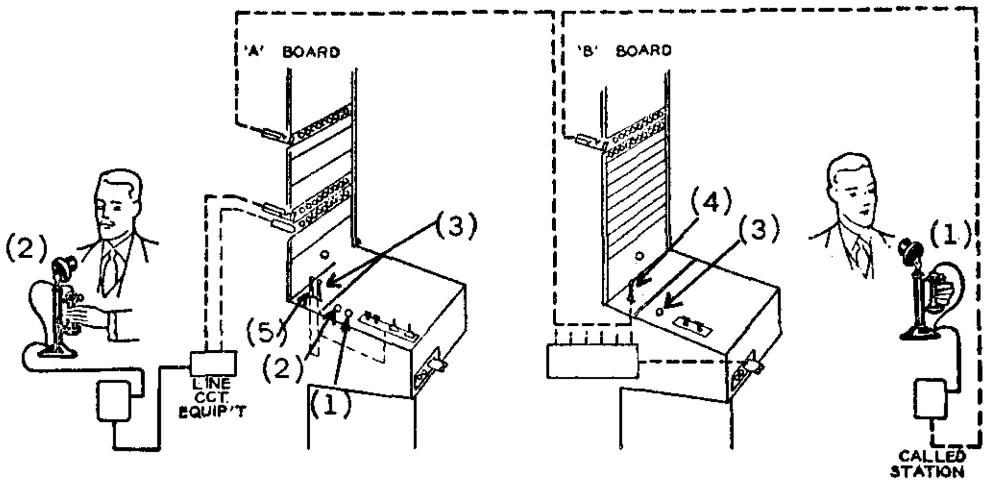


1) When the "B" Operator becomes Idle, the Trunk Supervisory Lamp at the "B" Switchboard flashes 60 times per minute.
2) The "B" Operator's Telephone Set is connected automatically to the Incoming Trunk Cord with the flashing Trunk Supervisory Lamp.
3) Two spurts of Tone (Beep, beep!) are placed on the Trunk.
4) Upon hearing the Order Tones, the "A" Operator repeats the Called Number, "1234," to the "B" Operator.
5) The "A" Operator releases the Listening Key. (The Calling Supervisory Lamp is still lighted.)
6) The "B" Operator makes a Busy Test of Subscriber Multiple Jack "1234."
   a) If the "B" Operator hears a "click" (Called Subscriber Line Busy), she inserts the Trunk Cord Plug into a Busy-Back Jack, transmitting Busy Tone to the Calling Subscriber.
   b) If the "B" Operator hears no "click," indicating the Called Subscriber Line is Idle, she inserts the Trunk Cord Plug into Subscriber Multiple Jack "1234."
7) Plugging up the Call extinguishes the flashing Trunk Supervisory Lamp at the "B" Switchboard.
8) Ringing Current is applied automatically to the Called Subscriber Line.



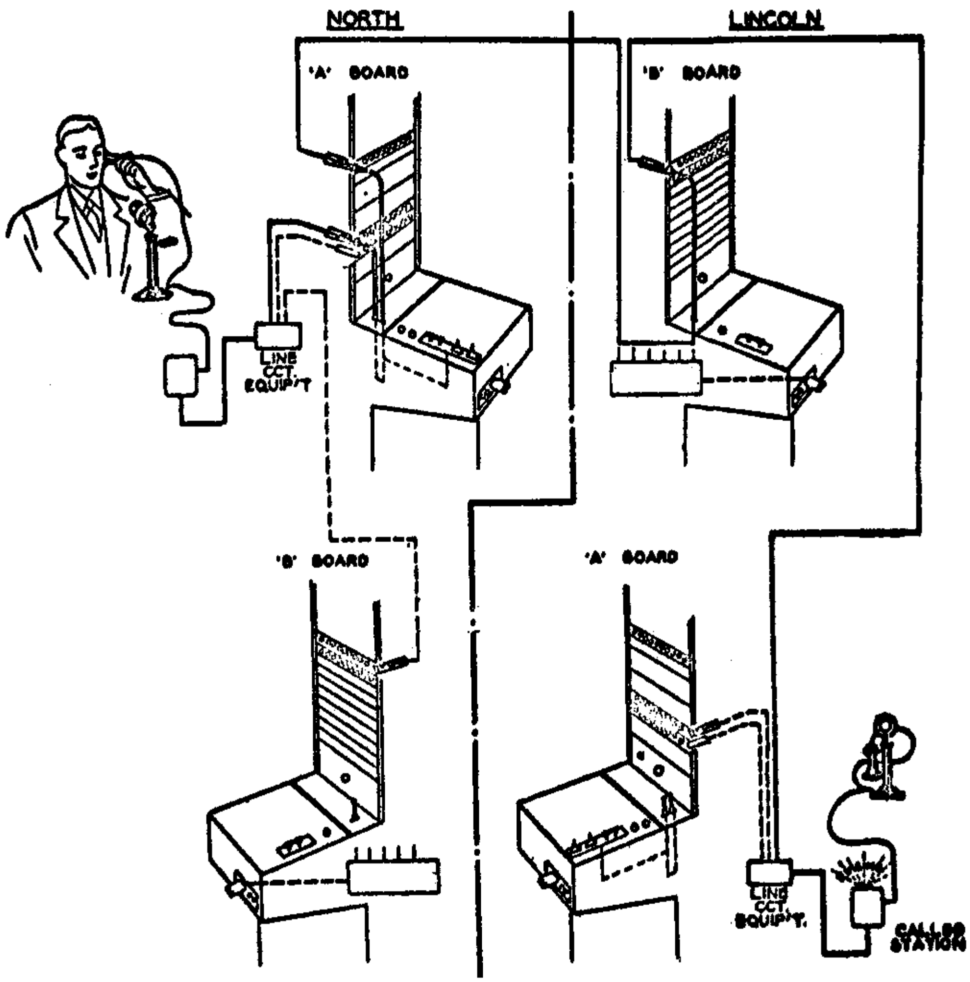
When the Called Subscriber answers (Called Handset OFF Switchhook):

1) Ringing Current is "tripped" (cut-off) automatically.
2) The Calling Supervisory Lamp at the "A" Switchboard is extinguished, signaling the "A" Operator that the Call has been completed.
3) Talking Battery and Ground are supplied to the Calling Subscriber by the "A" Switchboard Cord Circuit.
4) Talking Battery and Ground are supplied to the Called Subscriber by the "B" Switchboard Cord Circuit.

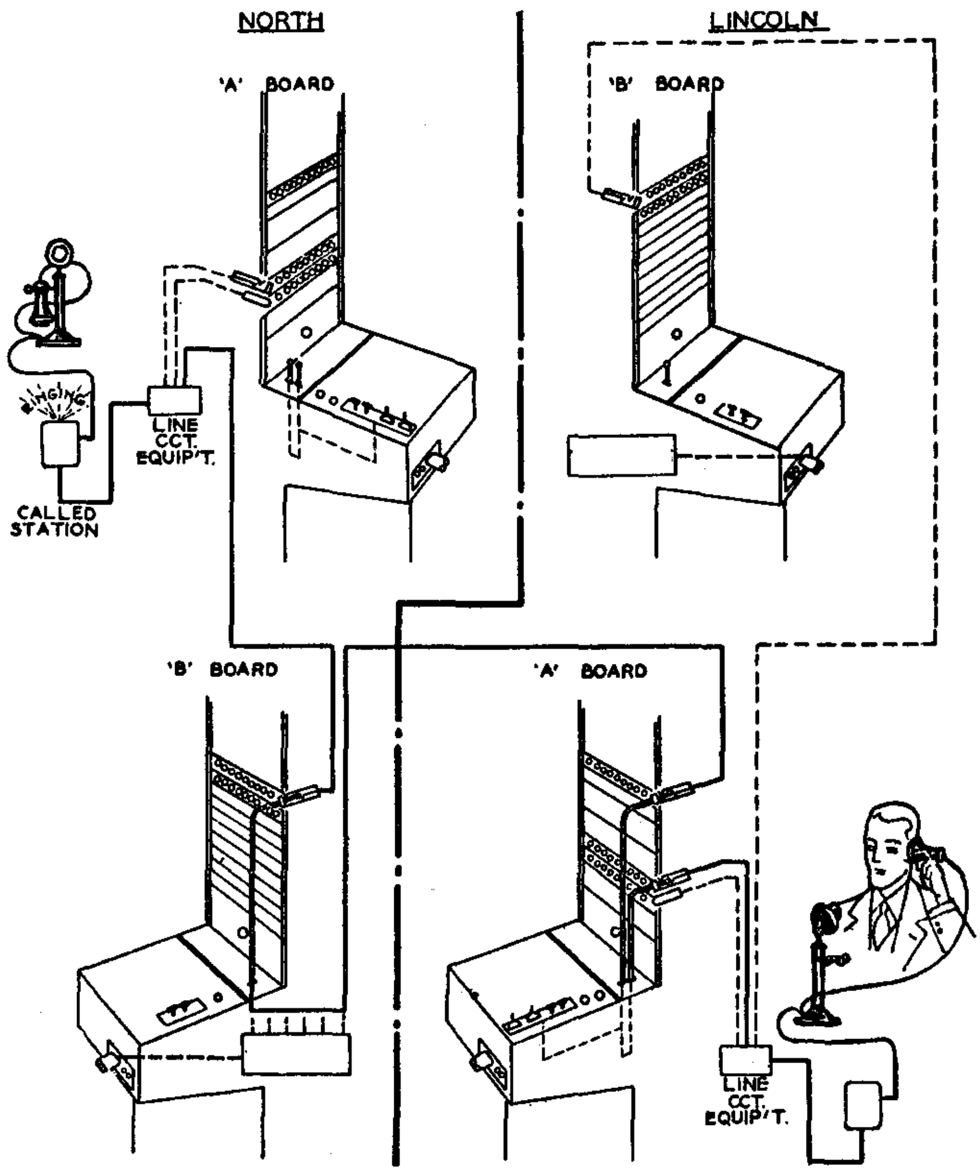


When the Manual Subscribers finish talking and replace their Handsets ON Switchhook, a "double-disconnect" signal appears at the "A" Switchboard.

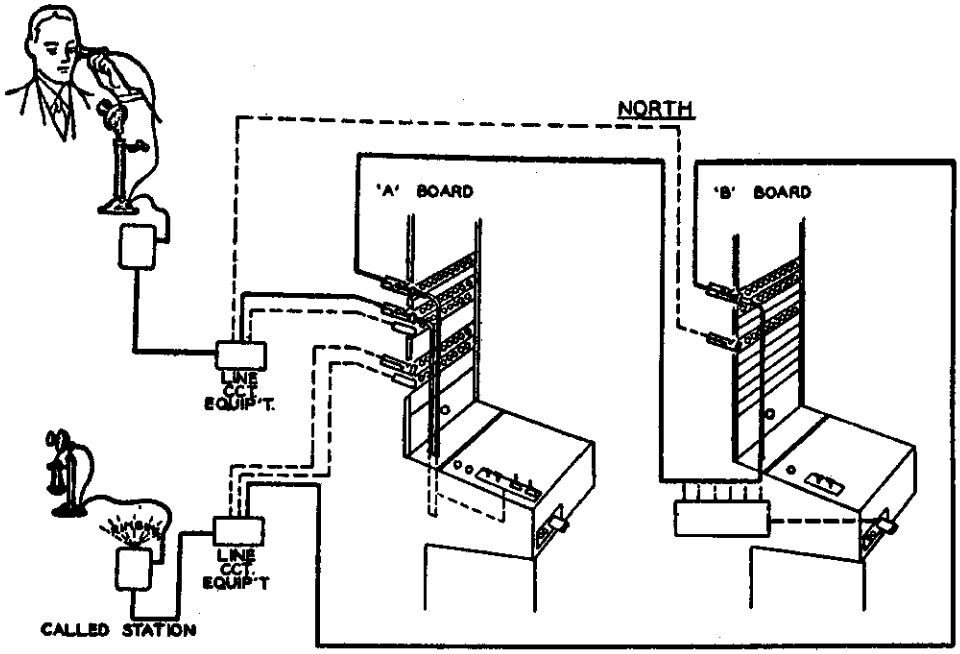
1) The Called Handset ON Switchhook lights the Calling Supervisory Lamp at the "A" Switchboard.
2) The Calling Handset ON Switchhook lights the Answering Supervisory Lamp at the "A" Switchboard.
3) The "A" Operators takes down the Calling Cord at the "A" Switchboard, extinguishing the Calling Supervisory Lamp and lighting the Trunk Supervisory Lamp at the "B" Switchboard.
4) The "B" Operator takes down the Trunk Cord at the "B" Switchboard, extinguishing the Trunk Supervisory Lamp and restoring the "B" Switchboard to normal.
5) The "A" Operator withdraws the Answering Cord Plug from the Answering Jack, extinguishing the Answering Supervisory Lamp and restoring the "A" Switchboard to normal.



A Call from a Subscriber in the North Office to a Subscriber in the Lincoln Office is completed from the North Office "A" Board to the Lincoln Office "B" Board, as shown above.



A Call from a Lincoln Office Subscriber to a North Office Subscriber is set up on the Lincoln "A" Board and the North "B" Board.

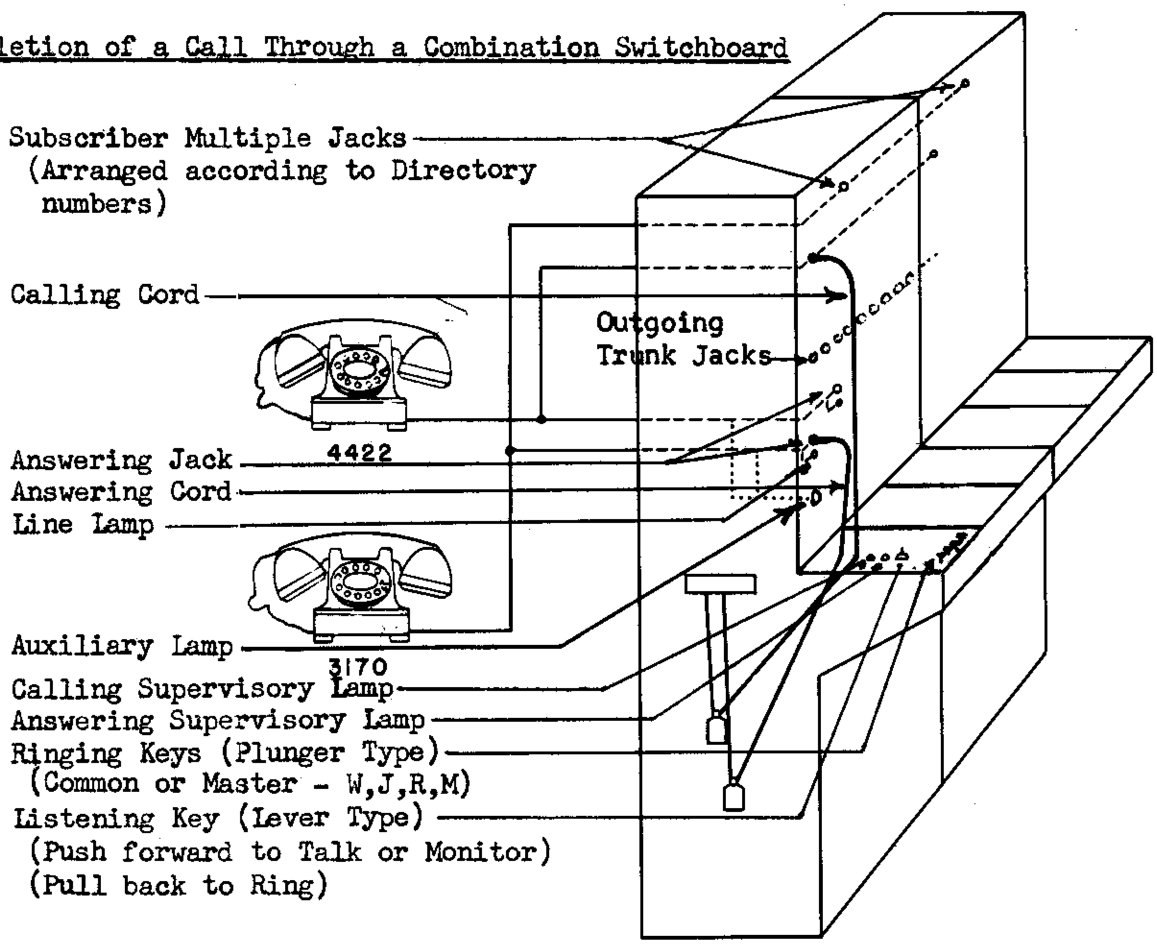


A Call between two North Office Subscribers is completed through the North "A" and "B" Boards.

In a small Exchange Area, a Combination Board combines the functions of the "A" and "B" Boards:

1) Outgoing Trunks to Toll ("Long Distance") and other Local Offices appear directly above the Answering Jacks and Line Lamps.
2) Subscriber Multiple Jacks appear above the Outgoing Trunk Jacks.
3) A single Operator performs all operations in handling a Local Call.

Completion of a Call Through a Combination Switchboard



Steps in Completing a Call Through a Combination Switchboard
(Refer to Drawing on Preceding Page)

1) Subscriber No. 3170 removes his Handset, lighting the Line and Auxiliary Lamps.

2) The Operator inserts the Plug of an Idle Answering Cord into the Answering Jack above the lighted Line Lamp, extinguishing the Line and Auxiliary Lamps.

3) The Operator pushes forward the Listening Key of the selected Cord Circuit and says, "Number, please!"

4) The Calling Subscriber (No. 3170) passes the Called No., "4422," to the Operator.

5) The Operator picks up the Calling Cord of the pair selected for this call and makes a Busy Test of the Called Subscriber Line by touching the Tip of the Calling Cord Plug to the Sleeve of Subscriber Multiple Jack 4422. A "<u>click</u>" in her Telephone Receiver indicates the Called Subscriber Line is <u>Busy</u>--no "click" indicates an Idle Subscriber Line.

6) <u>If the Called Subscriber Line checks Busy</u>, the Operator so advises the Calling Subscriber, who replaces his Handset ON Switchhook. The Operator then takes down the connection.

7) <u>Should the Called Subscriber Line check Idle</u>, the Operator:
   a) <u>If the Switchboard is equipped for MANUAL Ringing</u>:
      1) Inserts the Calling Cord Plug into Subscriber Multiple Jack No. 4422, lighting the Calling Supervisory Lamp.
      2) Pulls back on the Listening Key, applying Ringing to the Called Subscriber Line.
      3) For a Call completed to a Multi-Party Line, the Operator depresses one of the Common or Master Ringing Keys, "W, J, R or M," before operating the Cord Circuit Listening Key to apply Ringing.
   b) <u>If the Switchboard is equipped for MACHINE Ringing</u>:
      1) The Operator inserts the Calling Cord Plug into Subscriber Multiple Jack No. 4422, lighting the Calling Supervisory Lamp.
      2) Ringing is applied automatically to the Called Subscriber Line.

8) The Called Handset OFF Switchhook extinguishes the Calling Supervisory Lamp, signaling the Operator that the Call has been completed. In the case of MACHINE Ringing, Ringing is tripped automatically by the Called Handset OFF Switchhook.

9) The <u>Called</u> Handset ON Switchhook, following completion of conversation, relights the <u>Calling Supervisory</u> Lamp.	) - "Double-Disconnect" Signal
10) The <u>Calling</u> Handset ON Switchhook lights the <u>Answering Supervisory</u> Lamp.	)

11) The Operator takes down both Cords, extinguishing the Cord Supervisory Lamps, restoring the Switchboard to normal.

Lesson No. 1

FUNDAMENTALS OF TELEPHONY

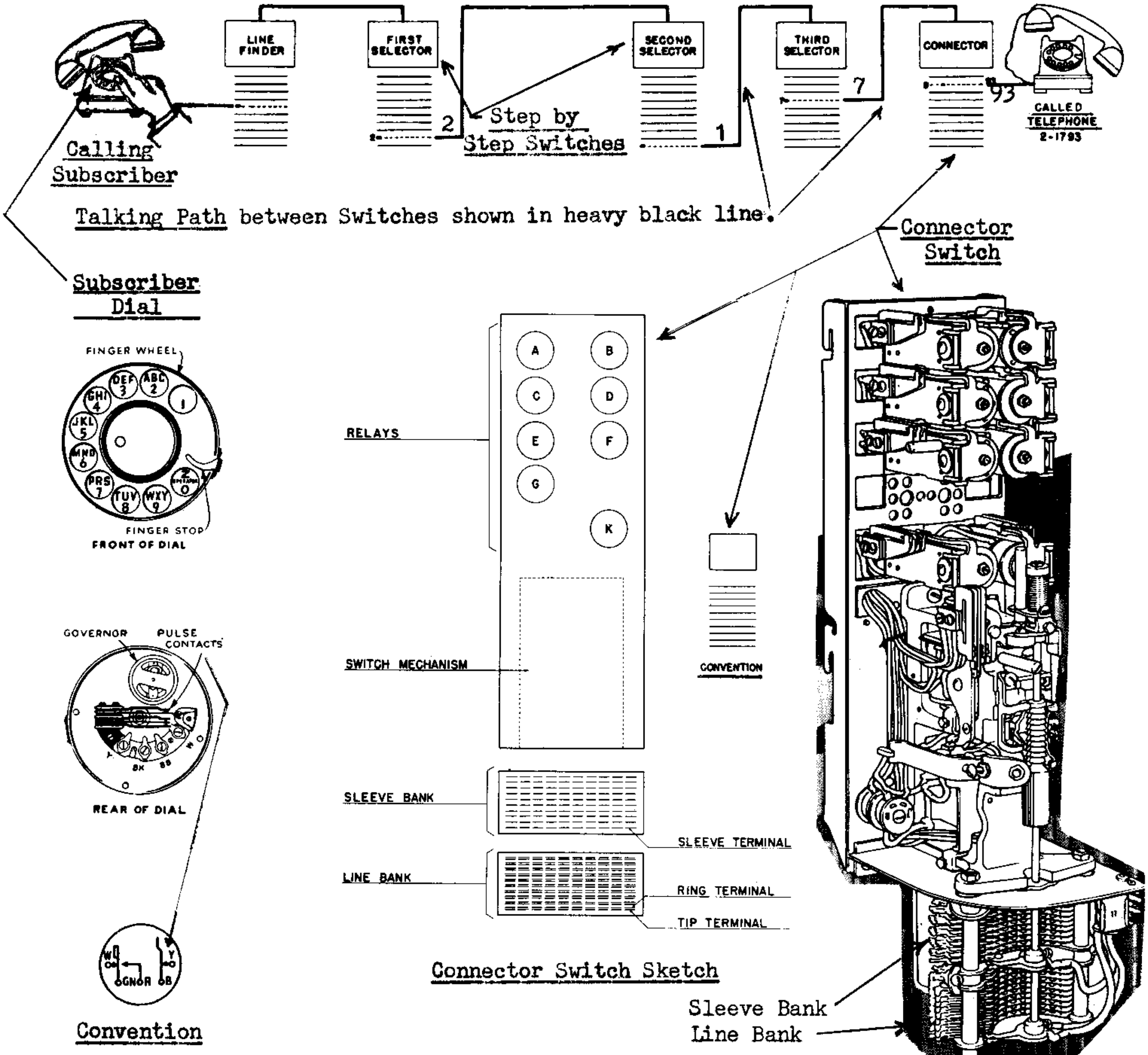
Section 9

The Step by Step Dial Switching System

CONTENTS

THE STEP BY STEP DIAL SWITCHING SYSTEM

In the Step by Step System, a telephone call progresses, a "step-at-a-time," through a series of Switches in the Central Office. Each step is taken under direct control of the Subscriber Dial, as the Calling Subscriber dials the Called Telephone Number.



Convention

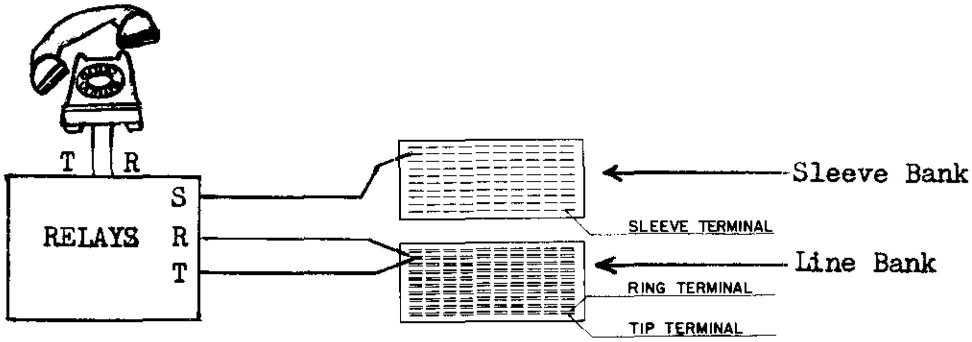
Connector Switch Sketch

Connector Switch Drawing.

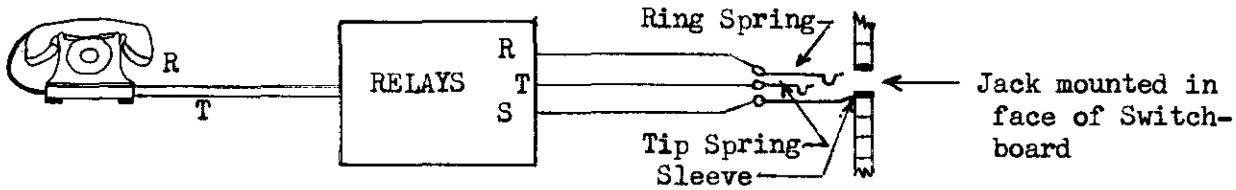
Subscriber Dial - A device for opening and closing the circuit between the Subscriber Station and the Dial Central Office Equipment at a normal rate of 10 times per second.

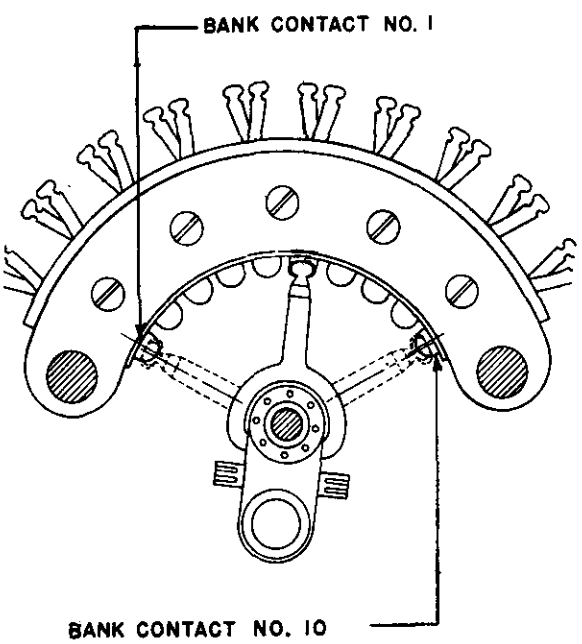
A series of Step by Step Switches replaces the Manual Switchboard in that a Talking Path is built up on them.

Step by Step Subscriber Lines are wired to Switch Bank Terminals.

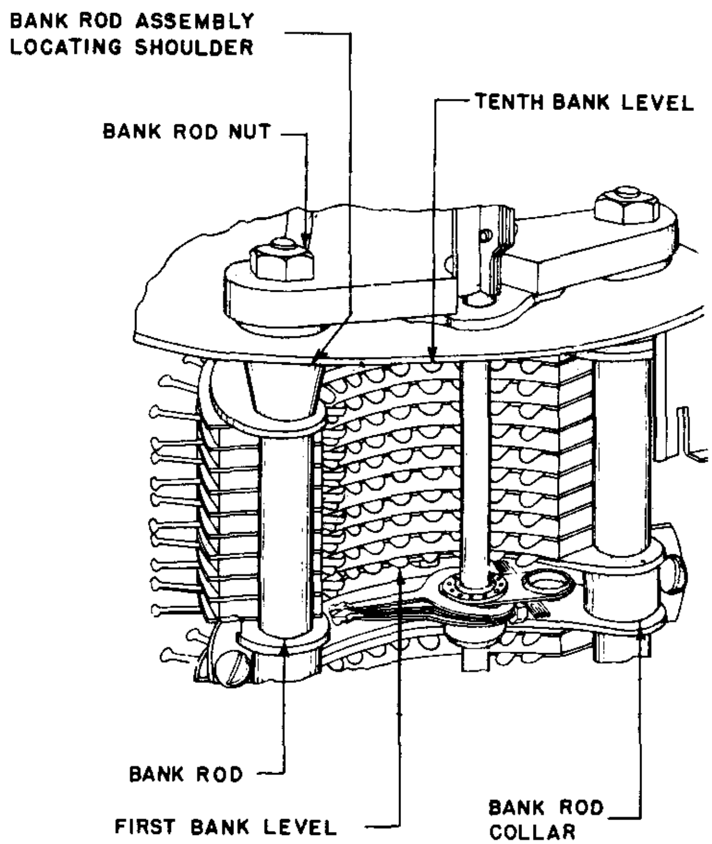


Manual Subscriber Lines are wired to Jacks mounted in the Face of a Switchboard.



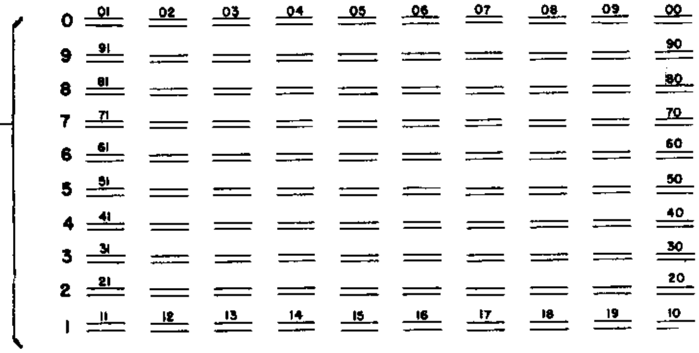


Switch Bank Terminals are mounted in Horizontal Rows or Levels; 10 sets per Level.

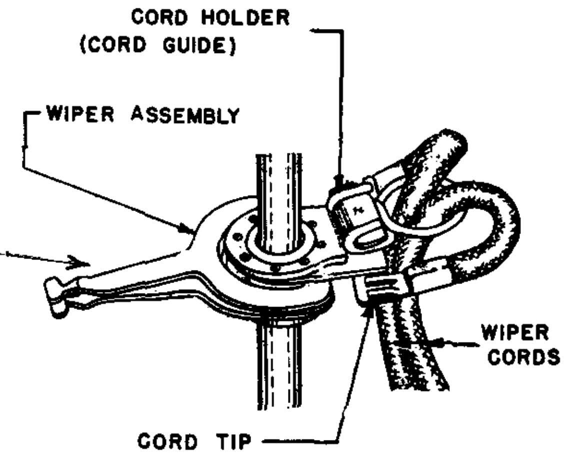


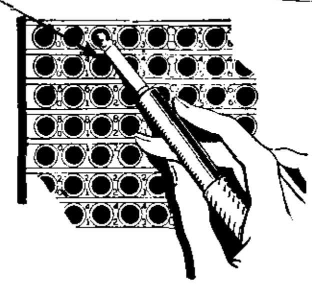
10 Horizontal Rows or Levels make up a Switch Bank.

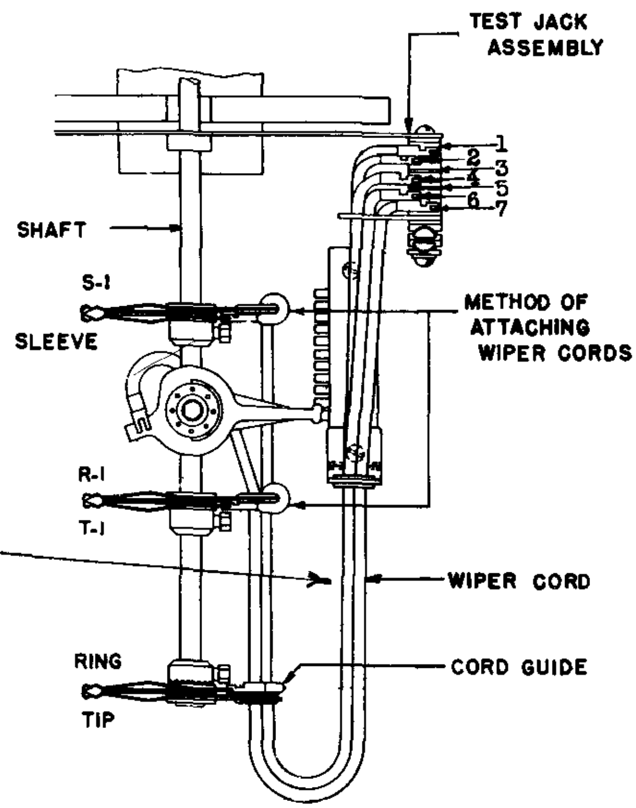
Line Bank Numbering, necessary in the case of Selectors and Connectors, which are dial-controlled, to conform to the numbering plan followed on the Subscriber Dial.



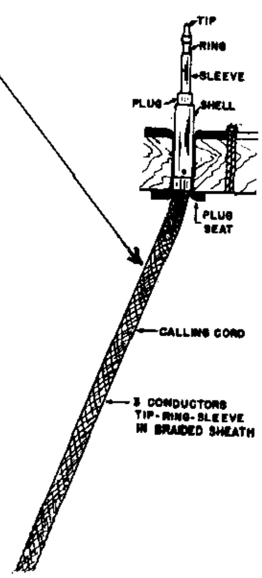
The Step by Step Wiper replaces the Manual Plug in making a connection.

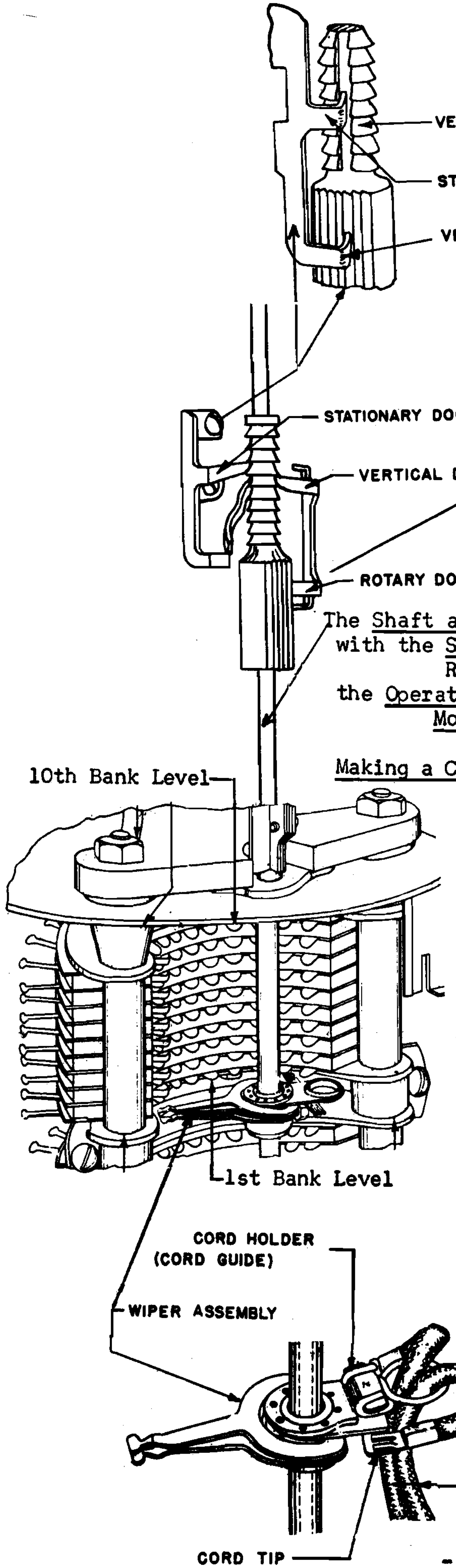


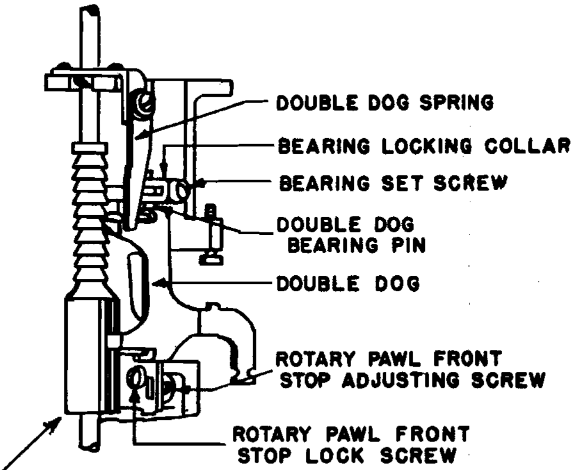




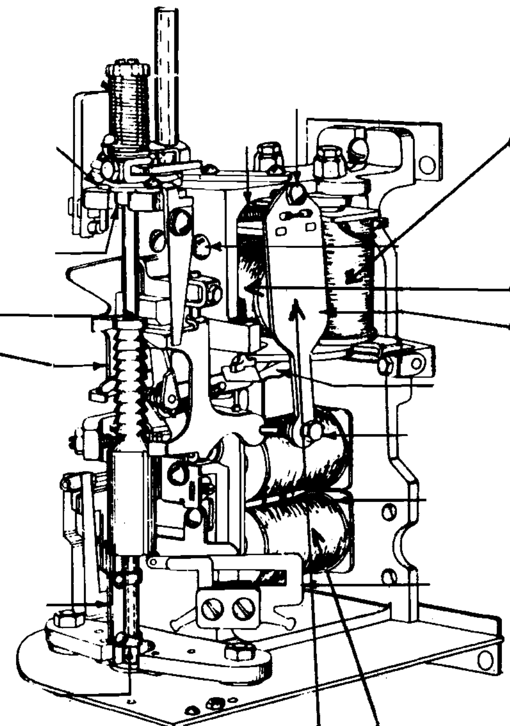
The Step by Step Wiper Cord replaces the Manual Cord.



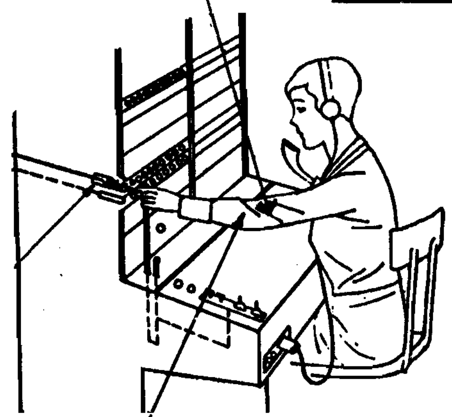




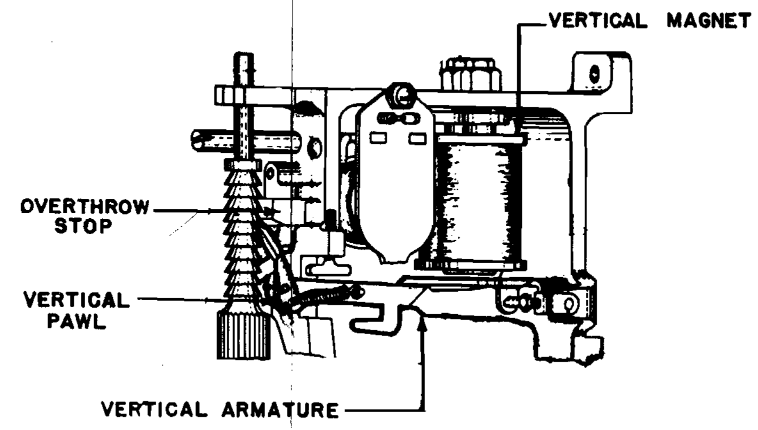
The Shaft and Wiper Assembly, with the Stepping Mechanism Replaces the Operator's Hand and Arm Movements in Making a Connection



Switch Mechanism

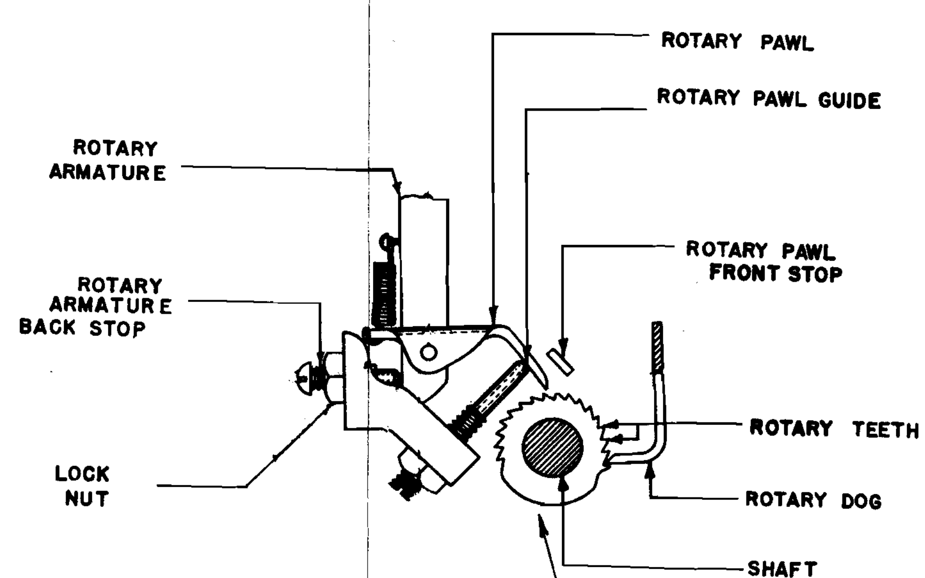


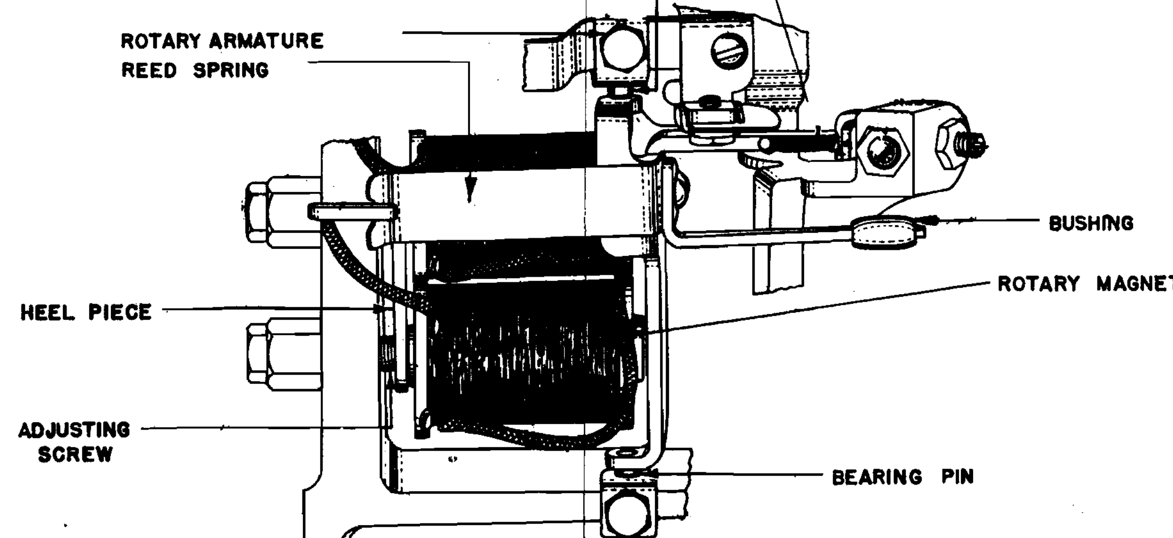
The Release Mechanism Replaces the Operator's Hand and Arm Movements in Taking Down a Connection



Vertical Stepping Mechanism

The Shaft and Wipers are stepped first vertically by the Vertical Magnet which thrusts the Vertical Pawl into the Vertical Ratchet, forcing the Shaft upward. The Vertical Dog engages the Vertical Ratchet to prevent the Shaft restoring to Vertical Normal.



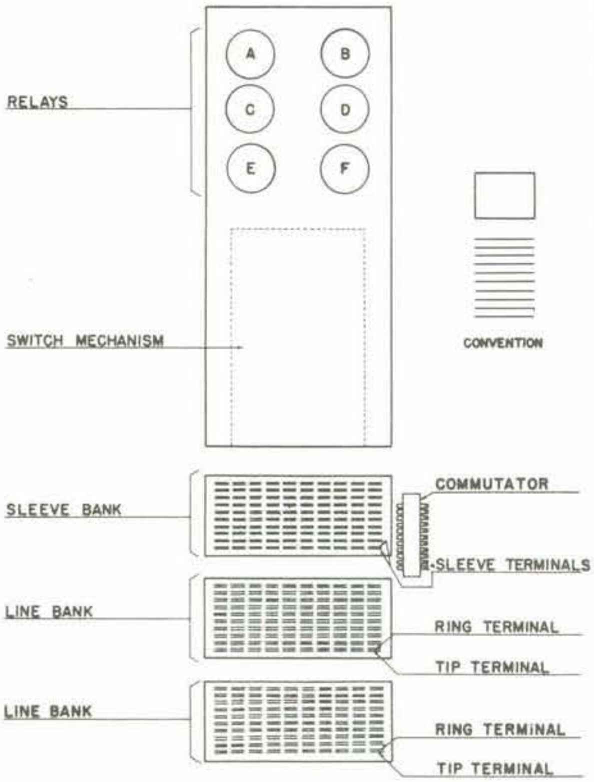


Rotary Stepping Mechanism

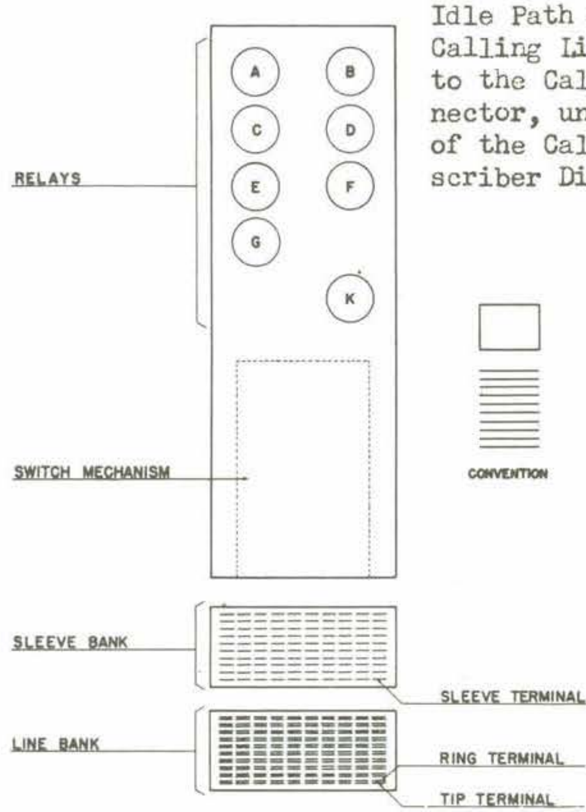
The Rotary Magnet thrusts the Rotary Pawl into the Rotary Ratchet, rotating the Shaft, causing the Wipers to rub or "wipe" over the terminals in one of the Horizontal Rows or Levels. The Stationary Dog prevents the Shaft restoring to Vertical Normal, while the Rotary Dog engages the Rotary Ratchet to prevent the Shaft restoring to Horizontal Normal.

Three types of Step by Step Switches are used in handling a Call:

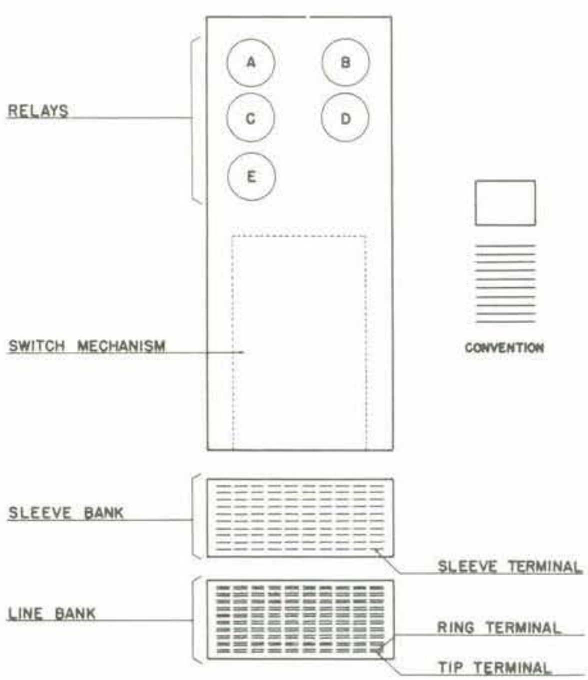
1) Line Finder - First Switch used in handling a Call - Finds the Calling Line when the Calling Subscriber lifts his Handset.
2) Connector - Last Switch used in handling a Call - Finds the Called Line under control of the Calling Subscriber Dial.
3) Selector - One or more Intermediate Switches used in handling a Call - Finds an Idle Path from the Calling Line Finder to the Called Connector, under control of the Calling Subscriber Dial.



200 POINT LINE FINDER SWITCH



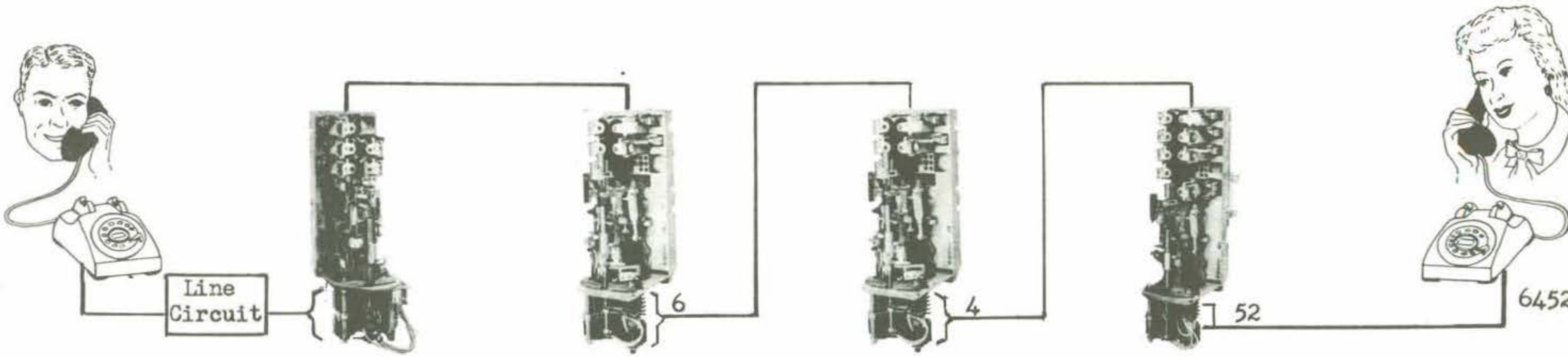
CONNECTOR SWITCH



SELECTOR SWITCH

SWITCHES USED IN HANDLING A STEP BY STEP CALL

MAKING A CALL THROUGH A STEP BY STEP OFFICE



Line Finder

When you pick up your Handset, an Idle Line Finder in your Group performs its job: locates the Terminals of your Line, connects you with an Idle "Selector" Switch, and you hear Dial Tone ("Number, Please!"). The Line Finder is similar in operation to the Connector Switch, but does its work automatically.

First Selector

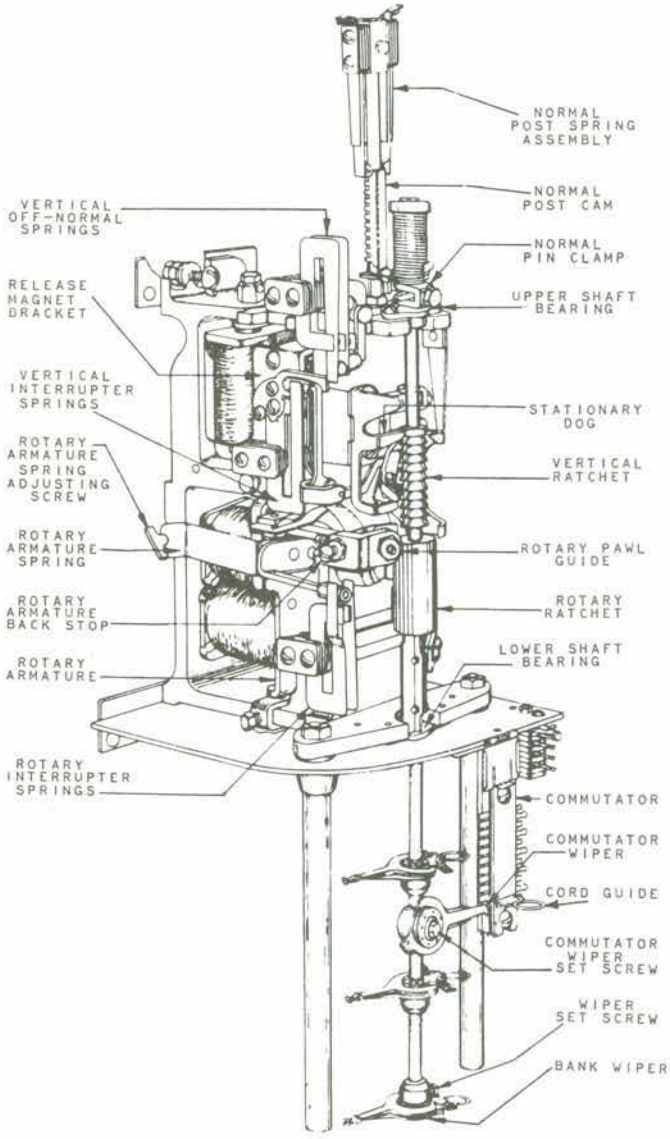
You dial the first number, "6." The First Selector Shaft and Wipers step up to the 6th Level. The 10 Sets of Terminals on this Level are wired to 10 other Selector Switches affording access to all numbers beginning with "6" - 6000 to 6999. The Selector Shaft and Wipers rotate automatically until an Idle Set of Terminals is found, and you're connected to a Second Selector.

Second Selector

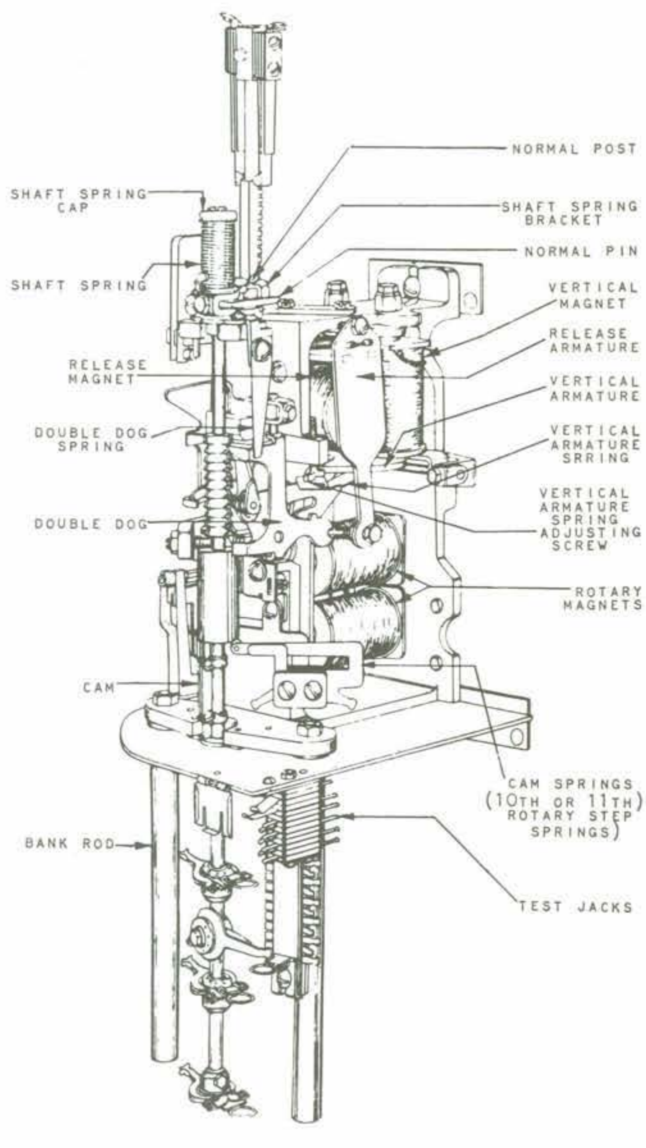
As you dial "4," the second number, the Second Selector Shaft and Wipers step up to the 4th Level. The 10 Sets of Terminals on this Level are wired to 10 Connector Switches, each of which has connected to it 100 telephones - those with numbers from 6400 to 6499. The Selector Shaft and Wipers rotate automatically until an Idle Set of Terminals is found, and you are connected to an Idle Connector Switch.

Connector

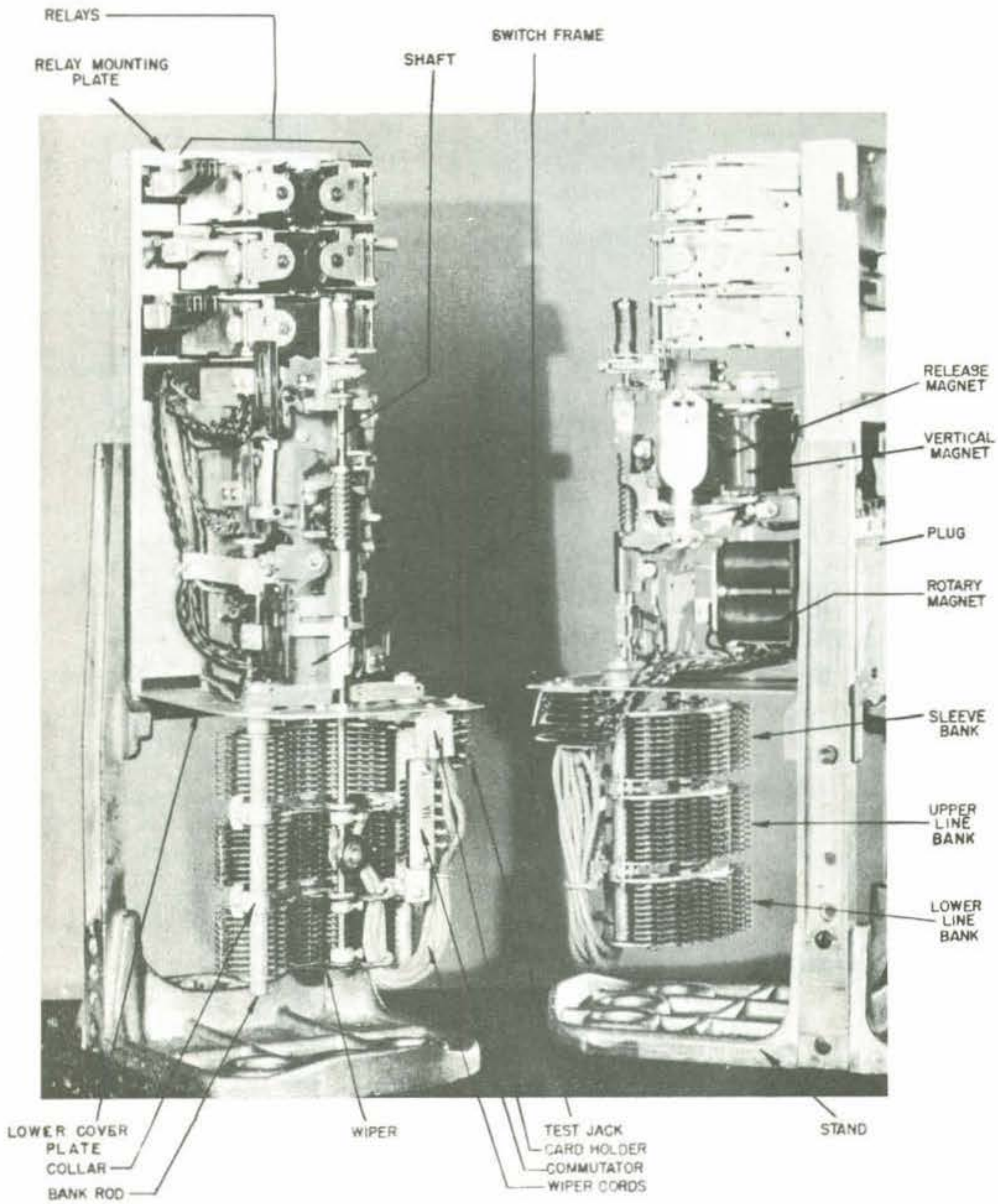
You dial "5," and the Connector Switch Shaft and Wipers step up to the 5th Level. You dial "2," and the Shaft and Wipers move around on the 5th Level to the second Set of Terminals. At this point, you've reached the Terminals of Line "6452." The Called Party's Bell rings until the telephone is answered, or until you hang up.



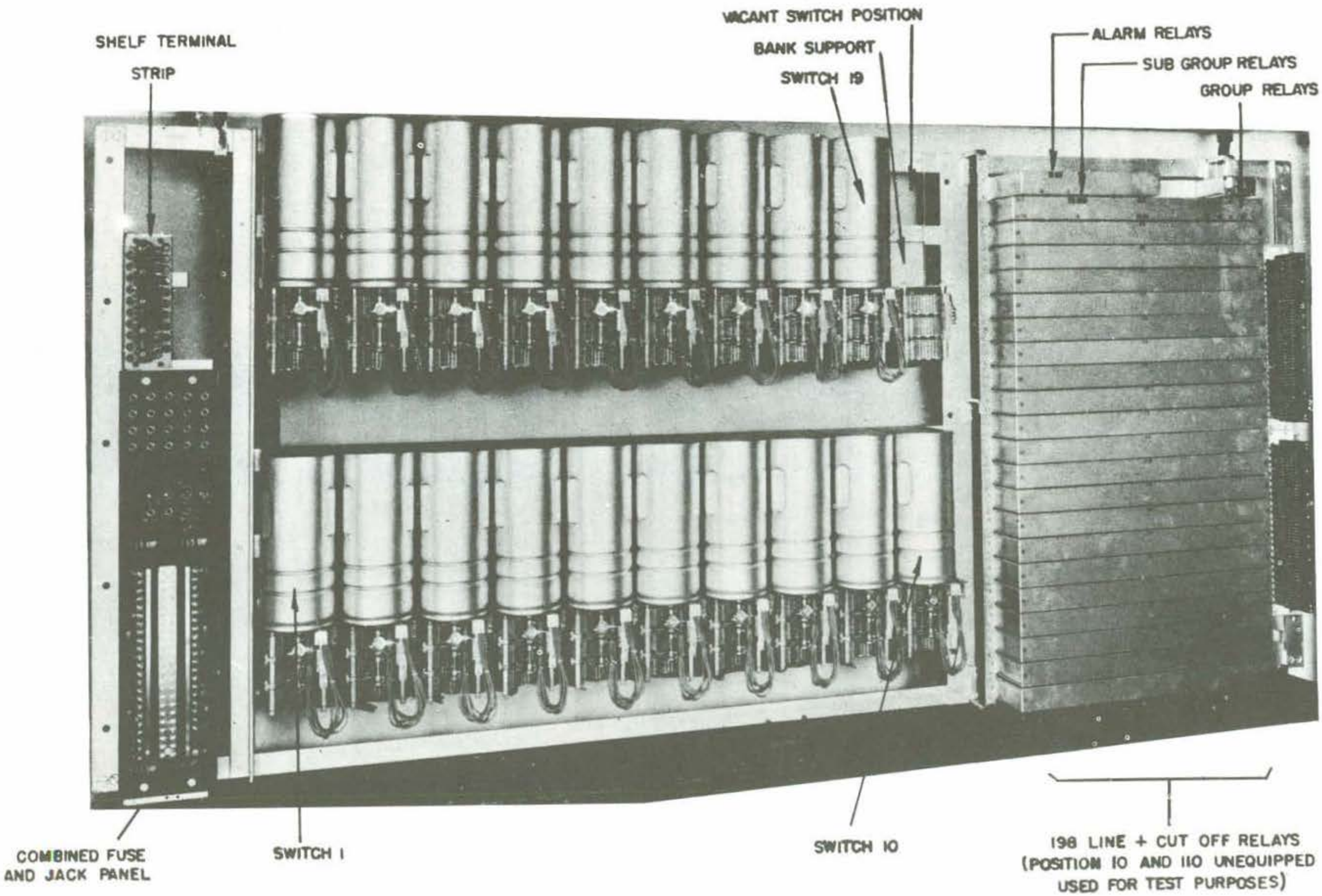
PARTS OF 197 TYPE SWITCH AS VIEWED FROM THE LEFT SIDE



PARTS OF 197 TYPE SWITCH AS VIEWED FROM THE RIGHT SIDE

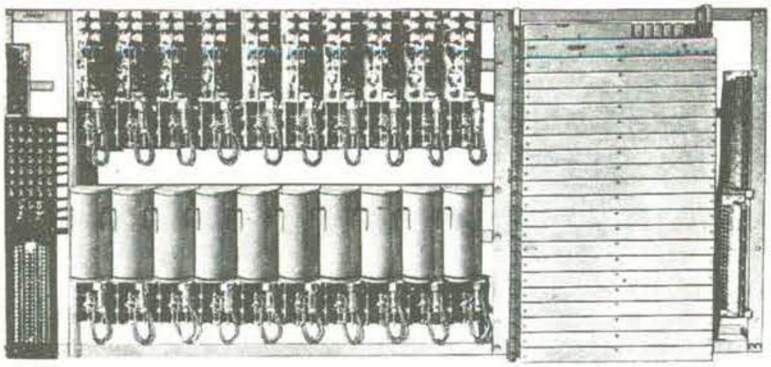


200 Point Line Finder Switch and Banks



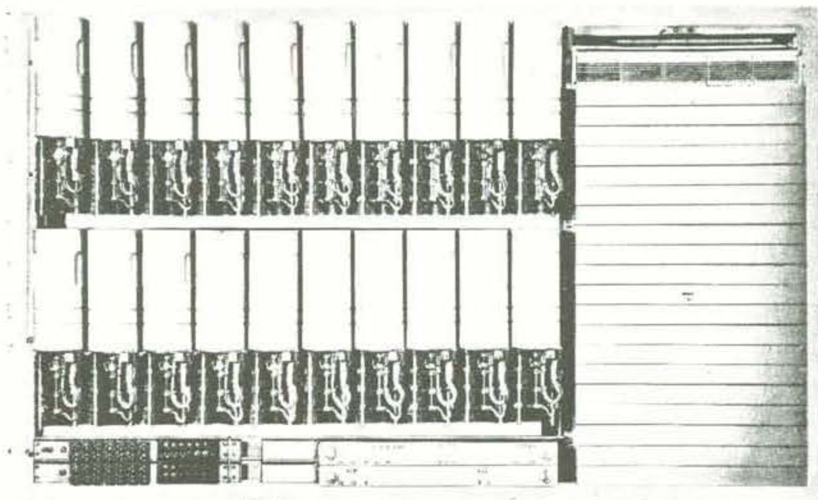
200 Point Line Finder Unit - 20 Switch Capacity

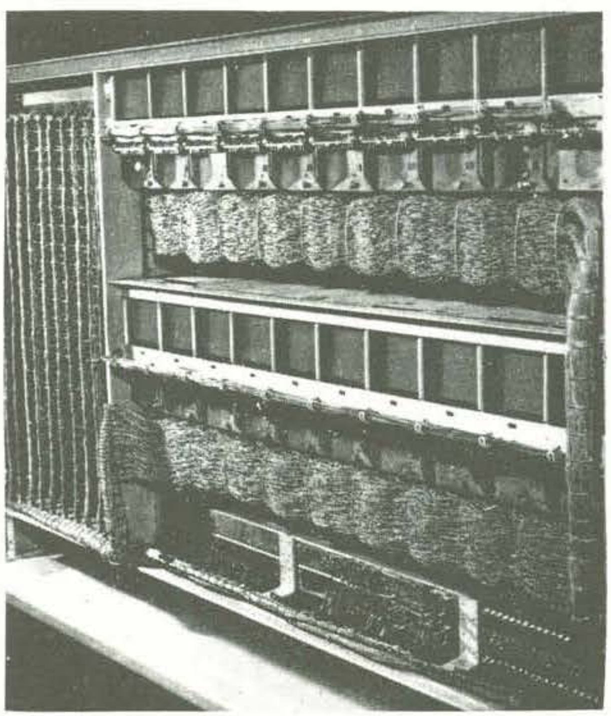
LINE FINDER UNITS



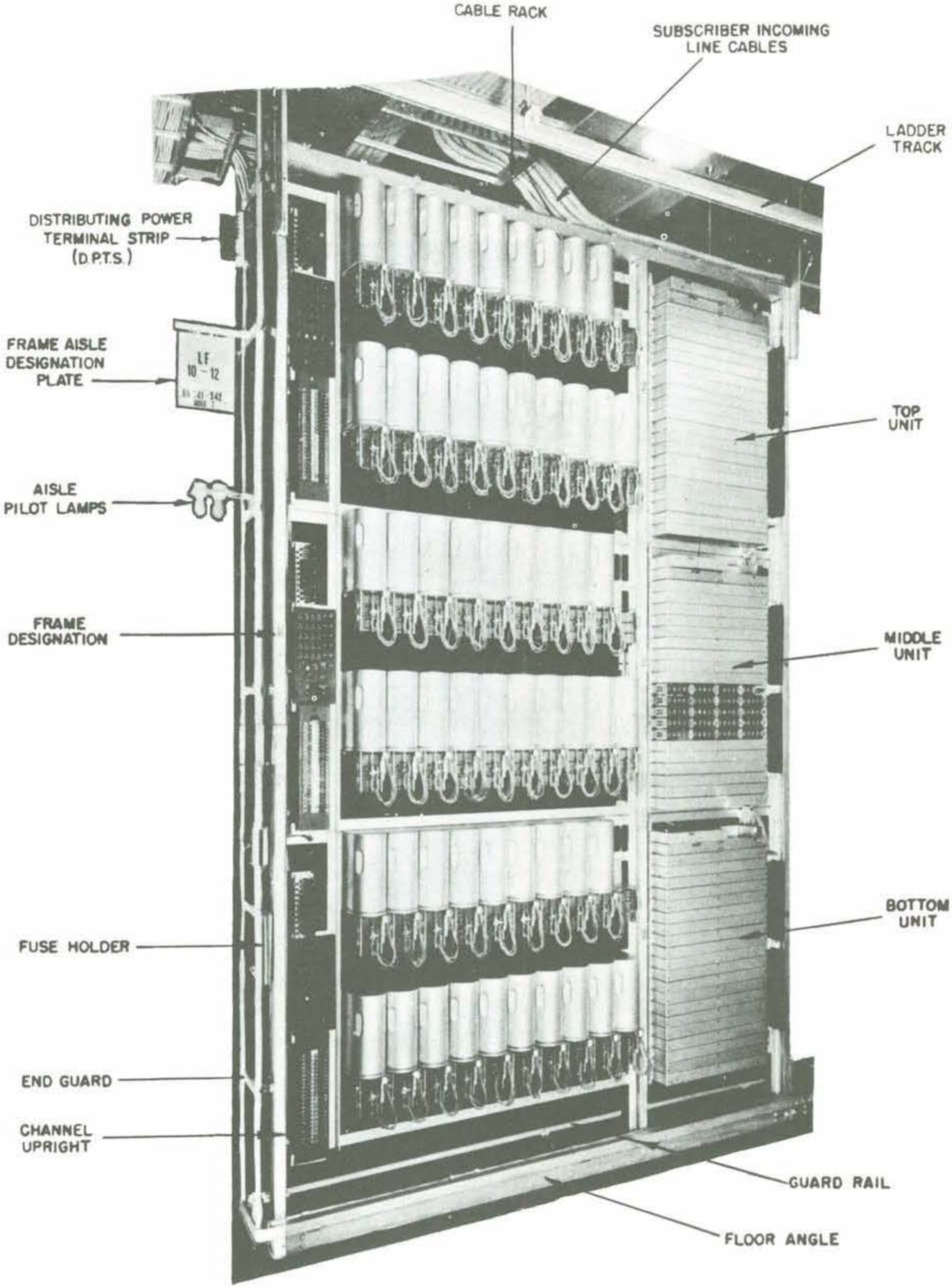
Older Type

Newer Type

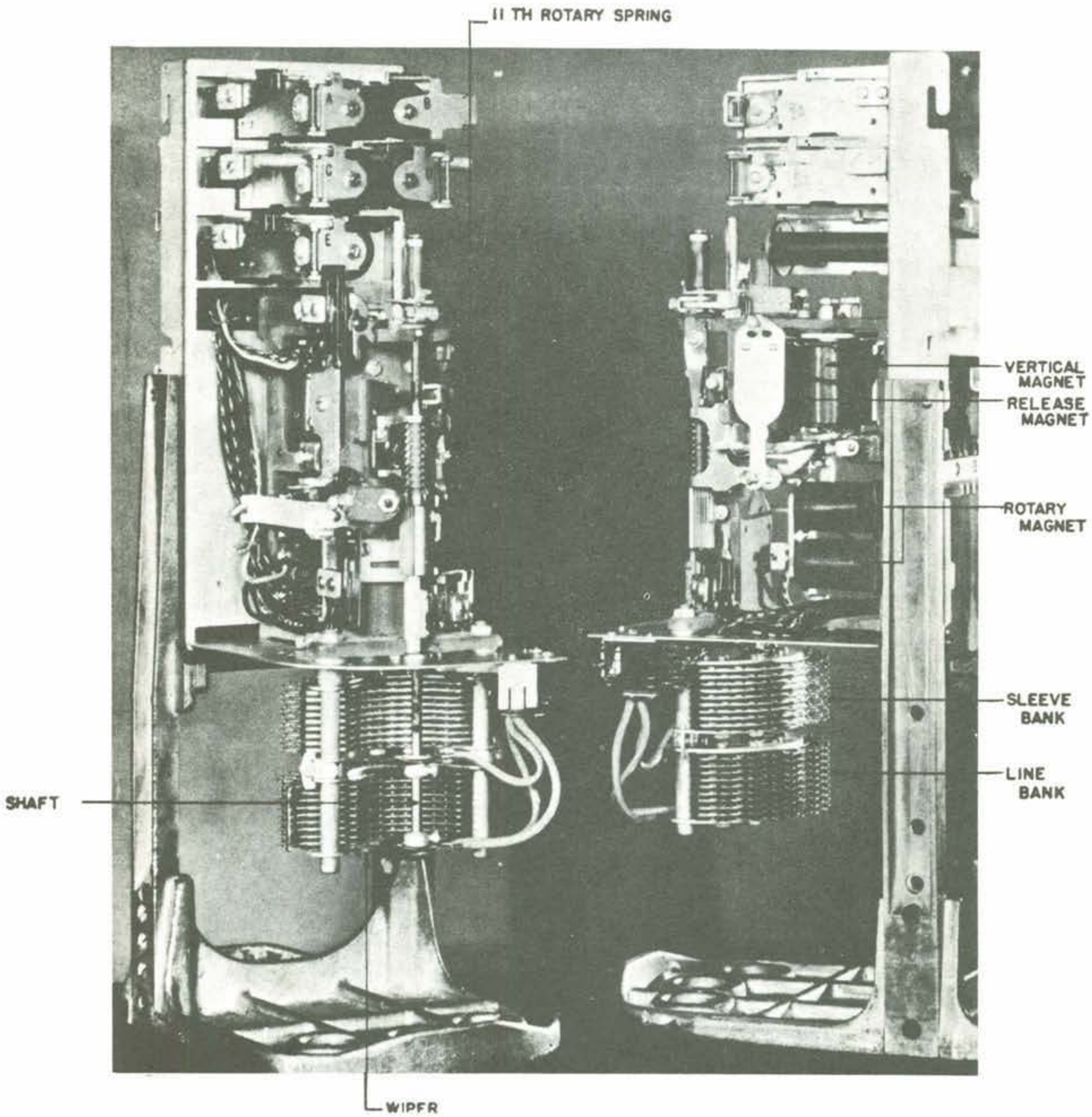




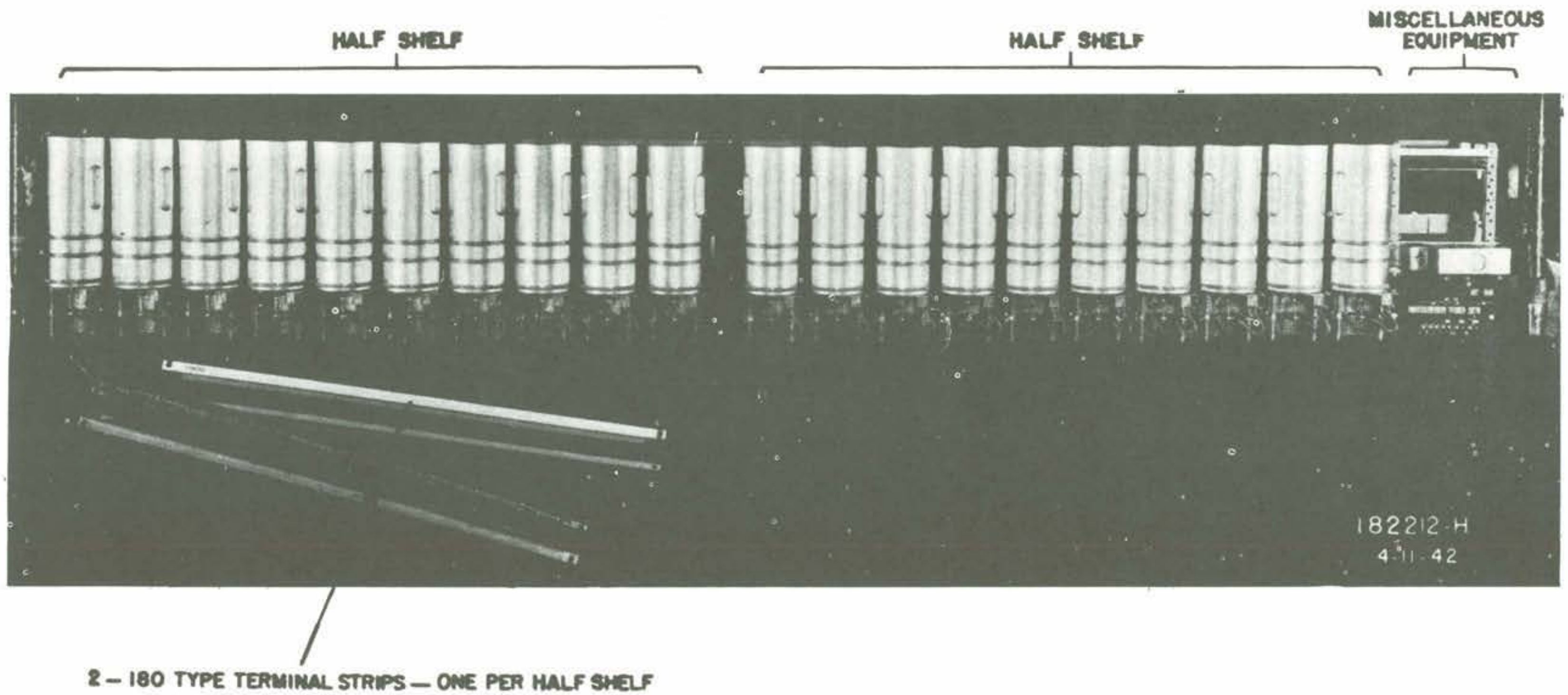
Line Finder Bank Multiple



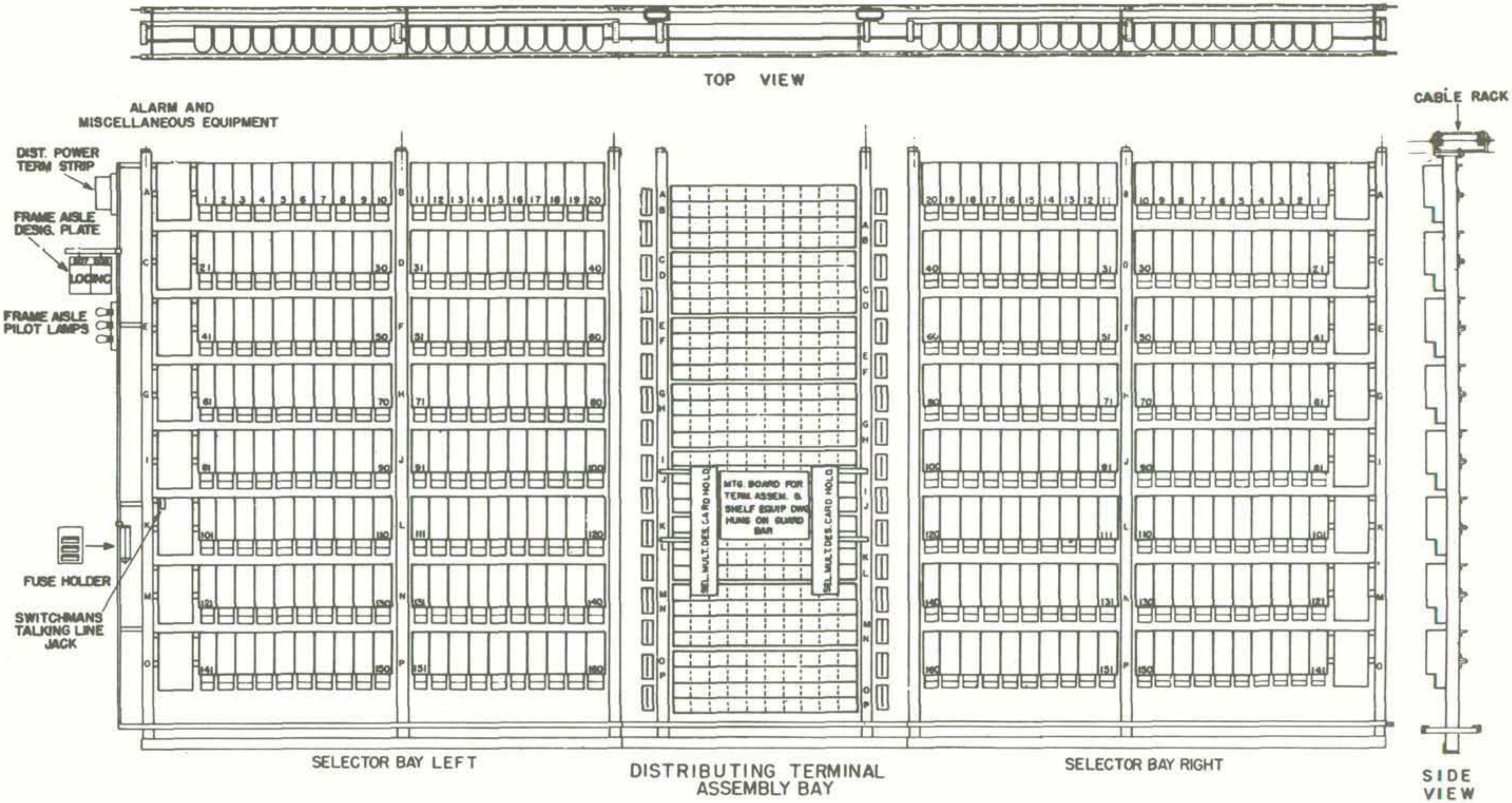
Line Finder Frame



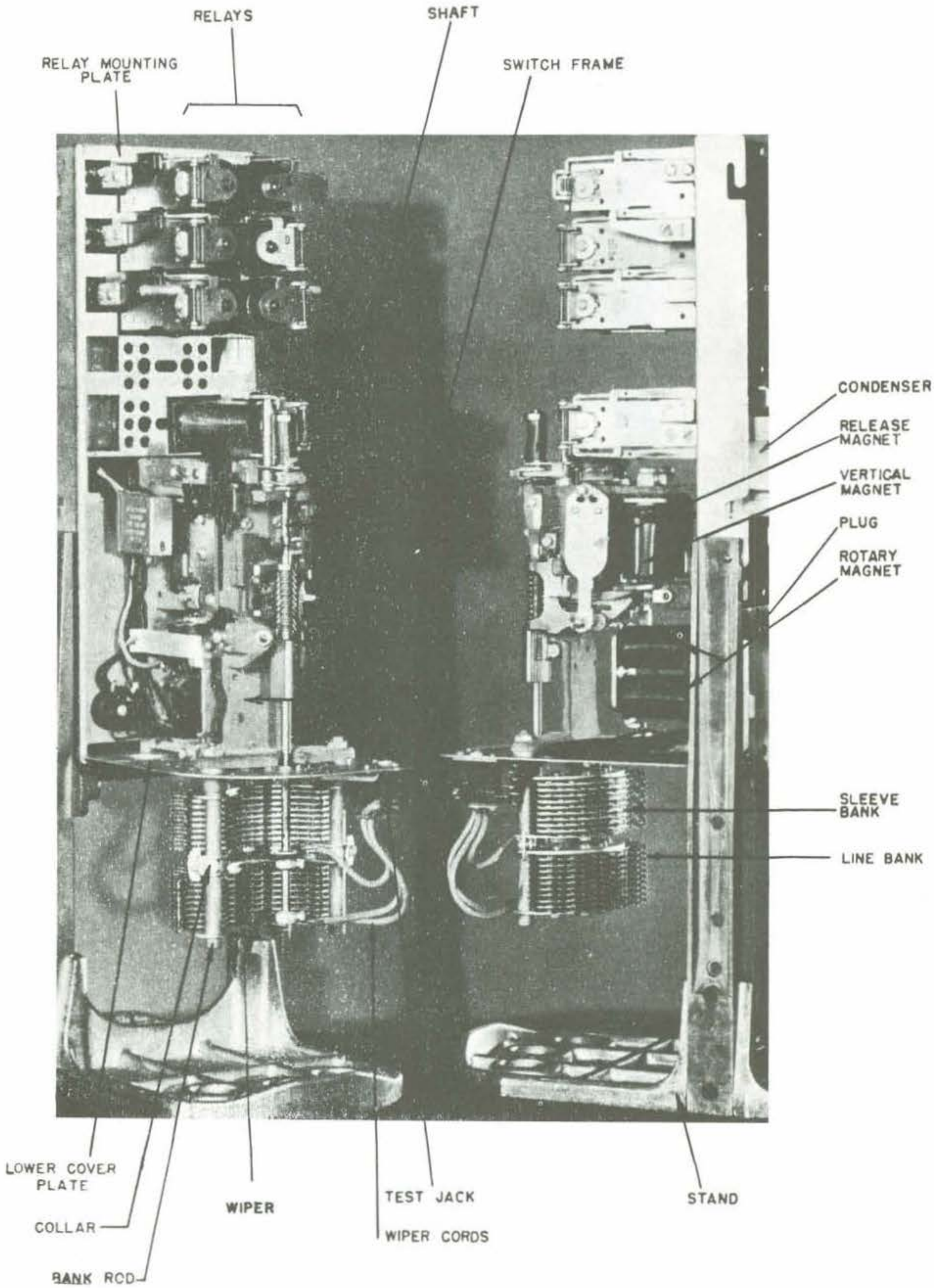
Selector Switch and Banks



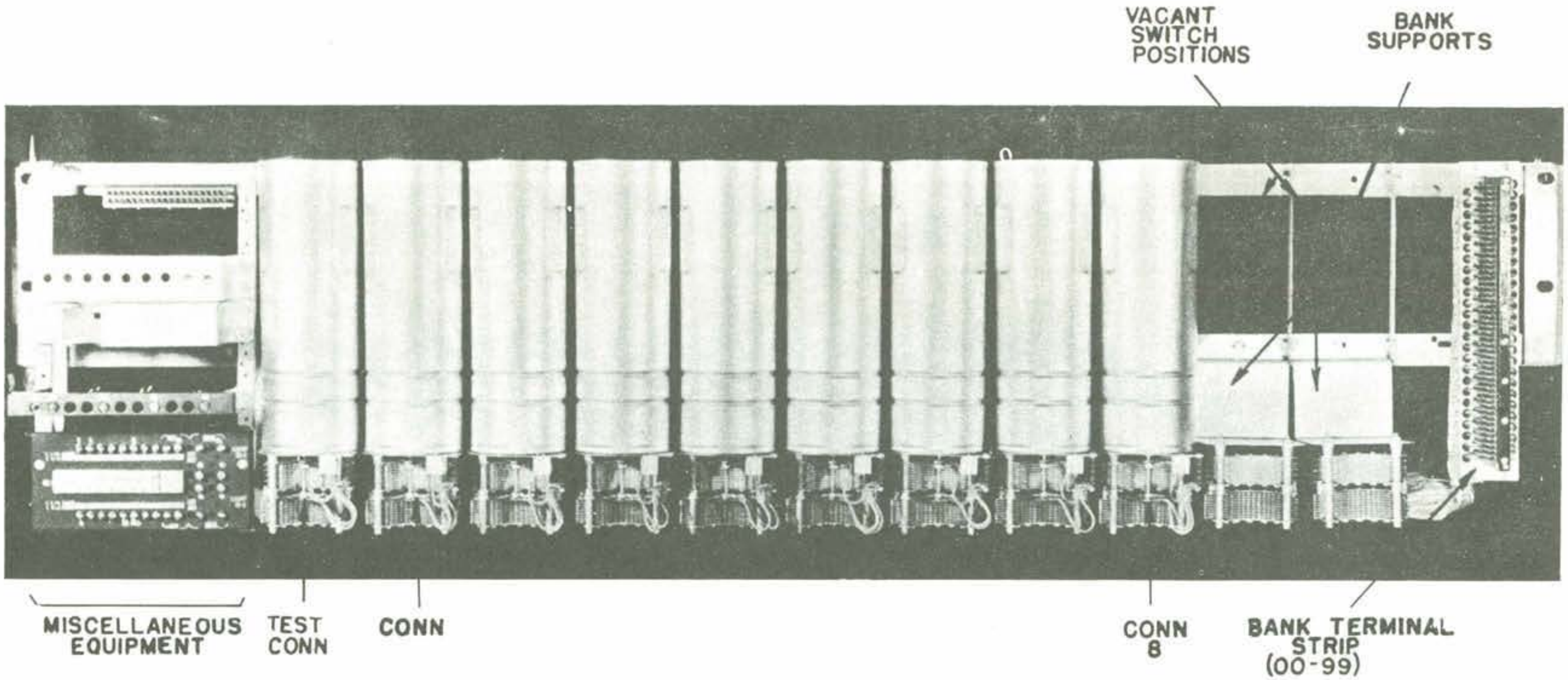
Selector Shelf



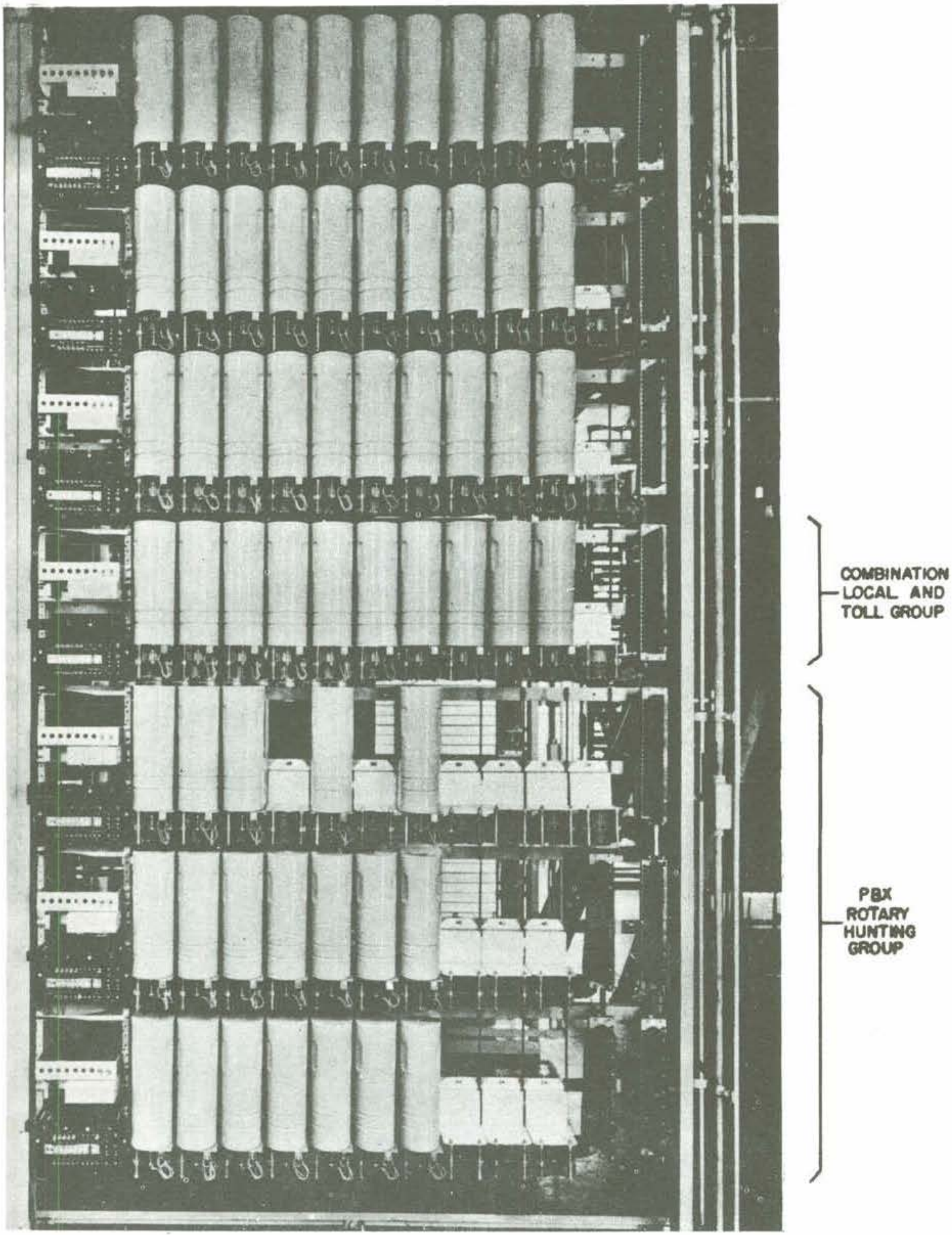
Selector Frame Sketch



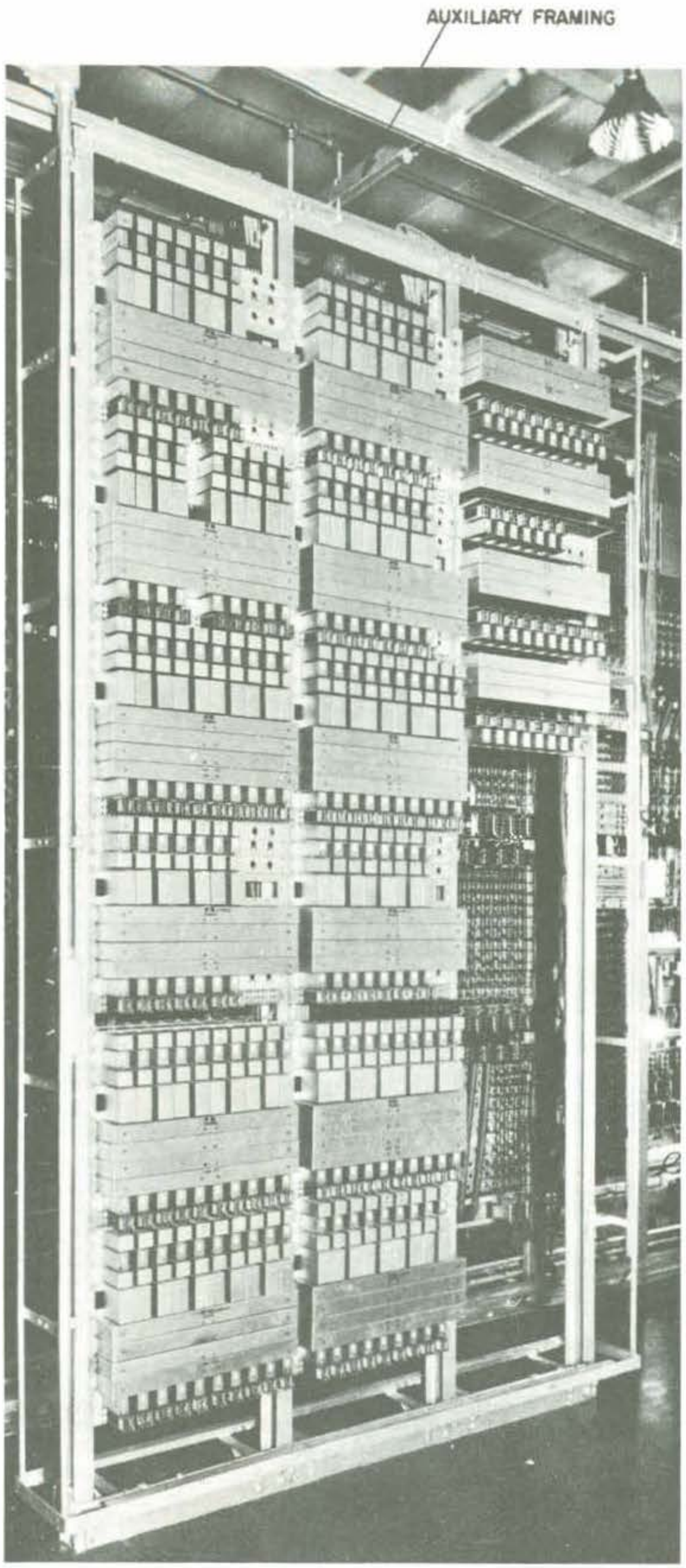
Connector Switch & Banks



Connector Shelf - 11 Switch



Connector Frame



Relay Racks

Western Electric Company, Inc.
Equipment Engineering - Area "B"
Engineering Personnel Relations

For Training Purposes Only

Lesson No. 1

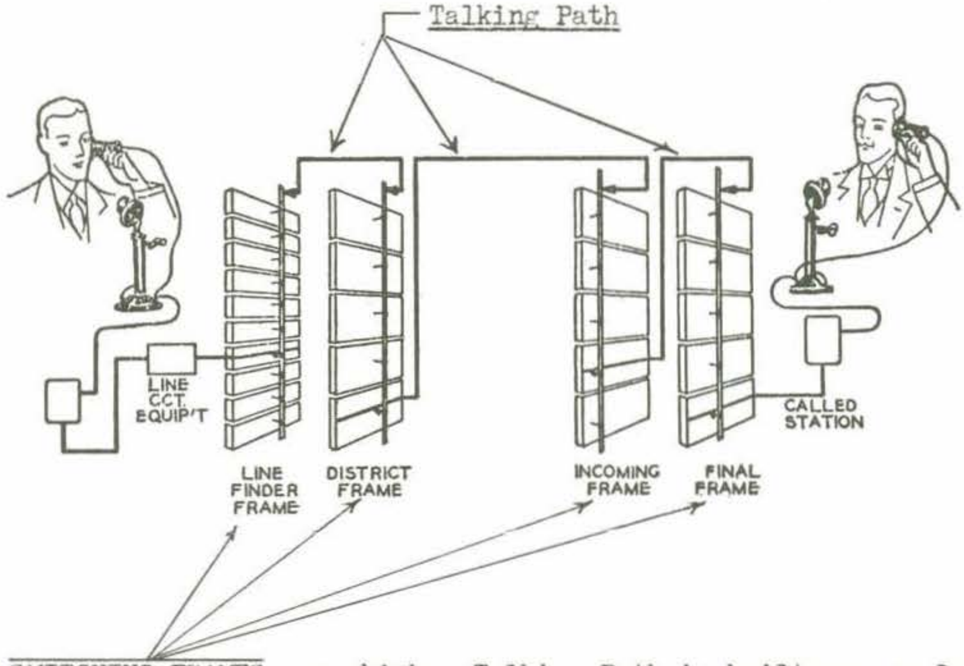
FUNDAMENTALS OF TELEPHONY

Section 10

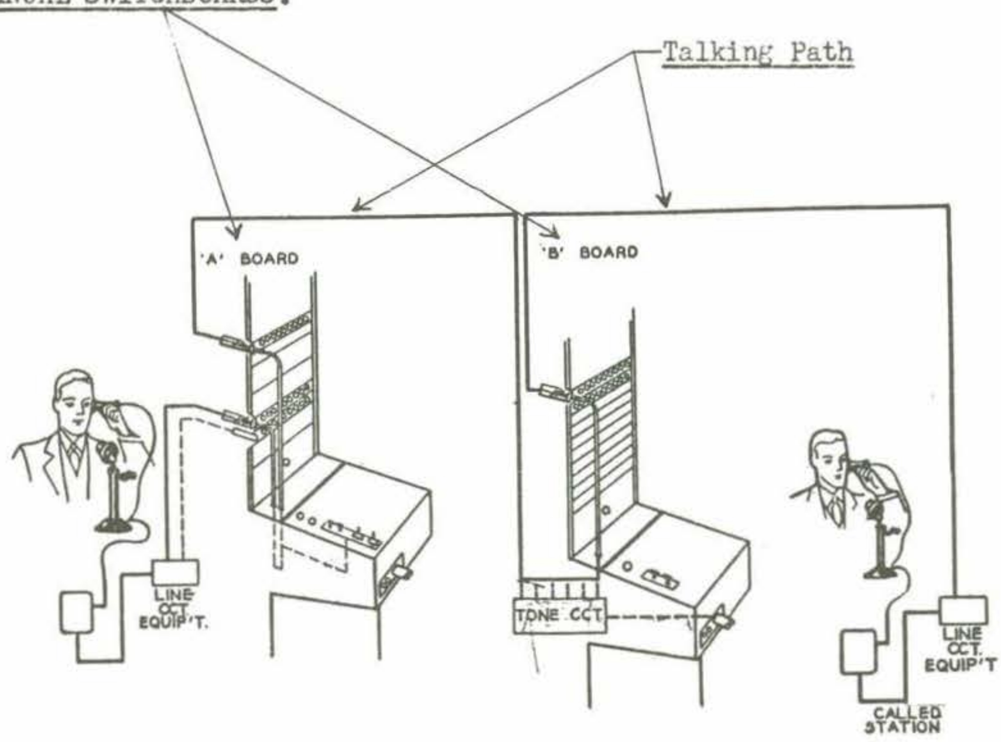
The Panel Dial Switching System

CONTENTS

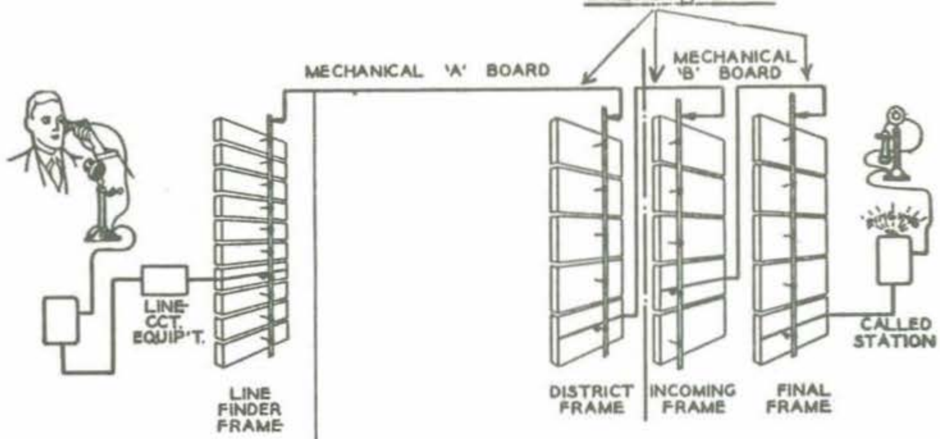
Panel Dial Subscriber Lines and Trunks connect to flat "panel-shaped" Multiple Banks, resembling door panels. Multiple Brushes mounted on Elevator or Brush Rods move vertically over vertical rows of Bank Terminals. Brush Rods are driven up and down by electric motors (1/16 horsepower). The Panel Dial Subscriber dials into a register and control device called a SENDER, which controls the upward movement of the Brush Rods on the various Switching Frames.

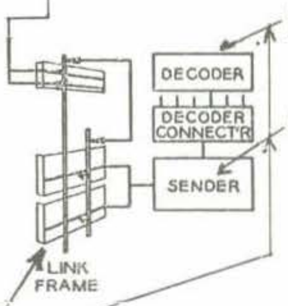


Panel Dial SWITCHING FRAMES, on which a Talking Path is built up, replace the MANUAL SWITCHBOARDS.



Talking Path



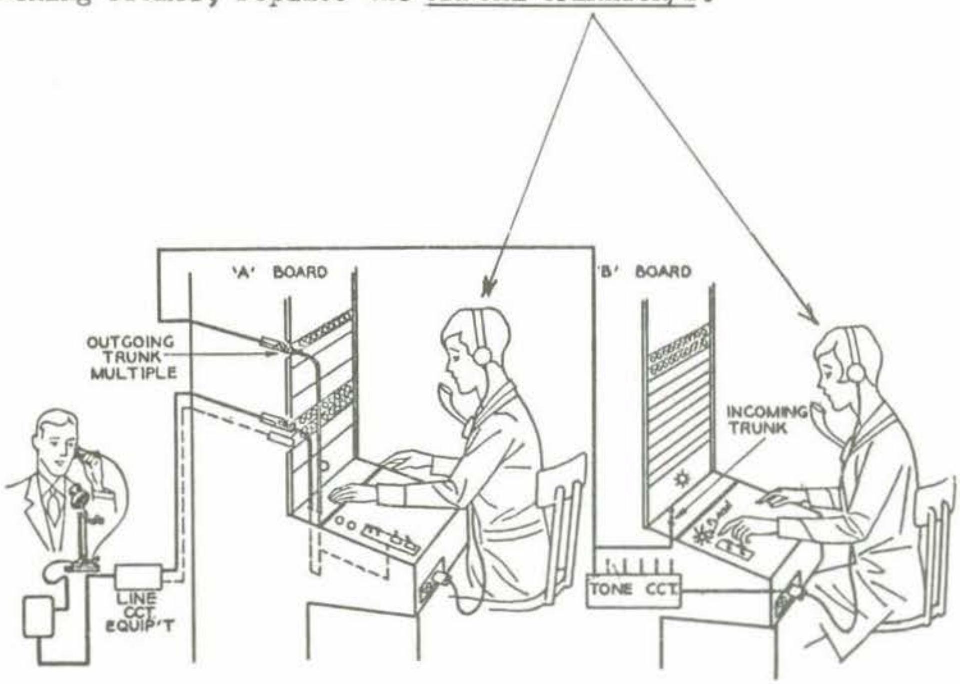


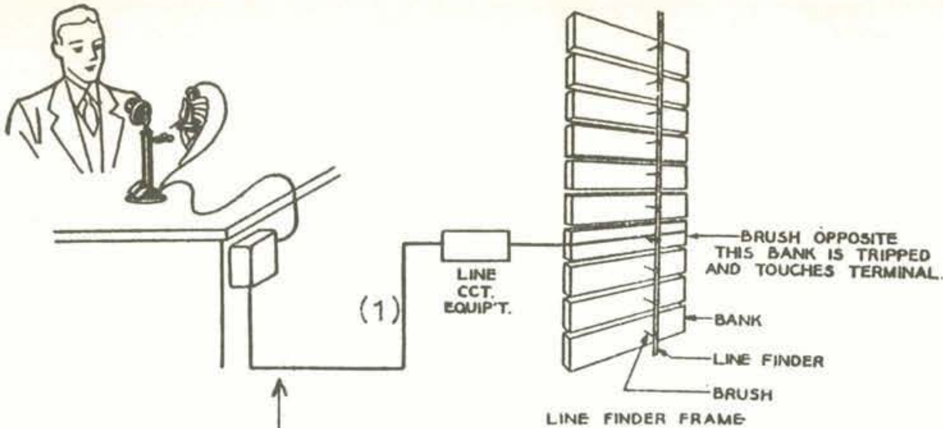
Decoder - Informs the Sender where to locate Outgoing Trunks to the Office (Exchange) dialed.

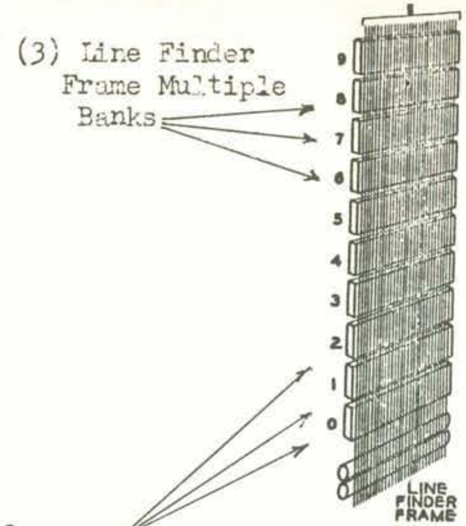
Sender - 1) Furnishes Dial tone, ("Number, please!").
2) Registers digits dialed by the Subscriber.
3) Directs or Controls the Brush Rods in "build-up" of the Talking Path.

Link Frame - Connects the Sender into the Switching Frames to set up the Talking Path, then releases the Sender for use on other Calls.

Panel Dial COMMON CONTROL FRAMES, which set up the Talking Path on the Switching Frames, replace the MANUAL OPERATOR/S.

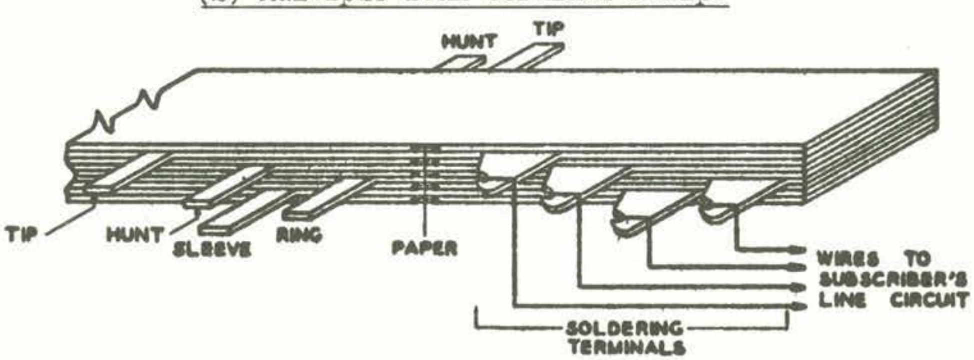


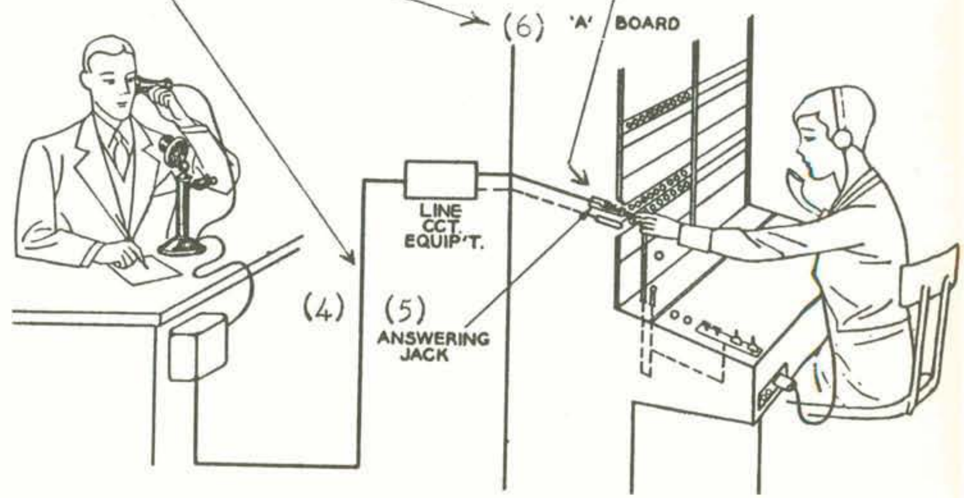


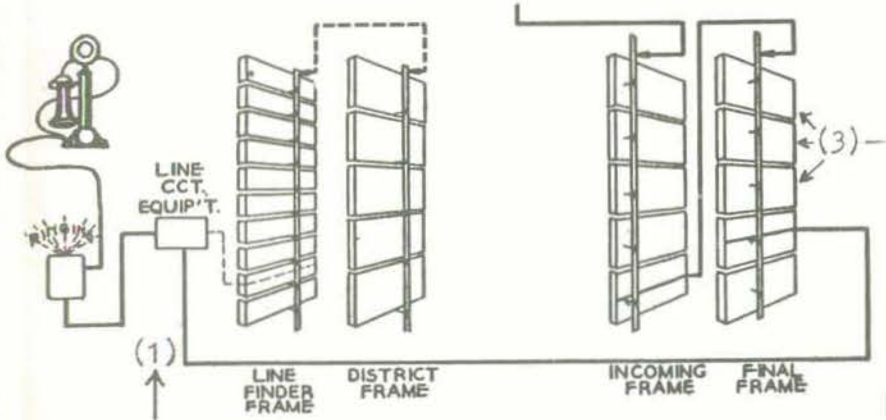


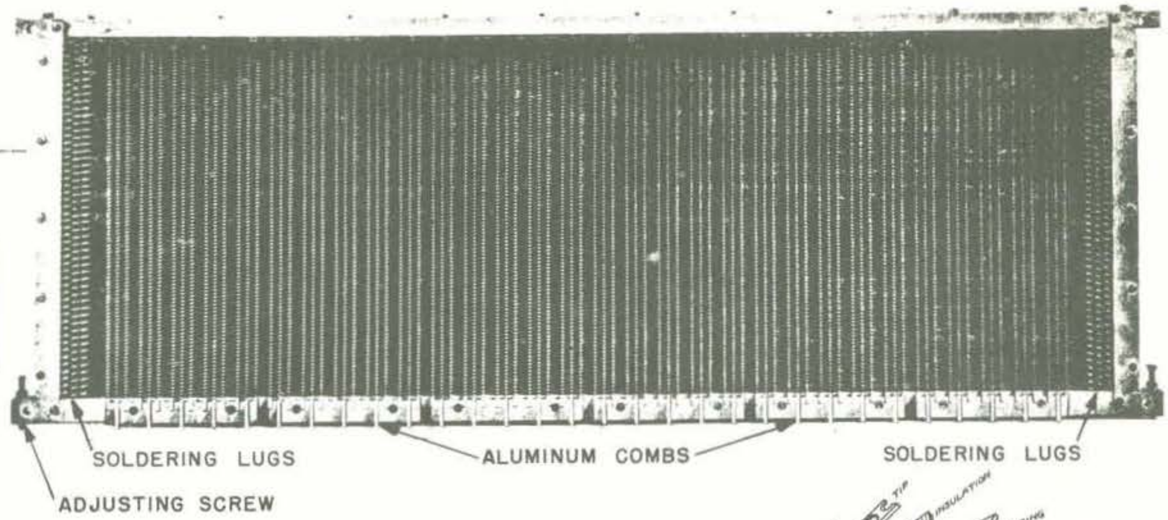
A Panel Dial Subscriber Line (1) is cabled to a set of Multiple Bank Terminal Strips (2)(T, R, S and H), in a Line Finder Frame Multiple Bank (3), corresponding to a Manual Subscriber Line (4), which is cabled to an Answering Jack (5) in the face of an "A" Switchboard (6).

(2) Multiple Bank Terminal Strips

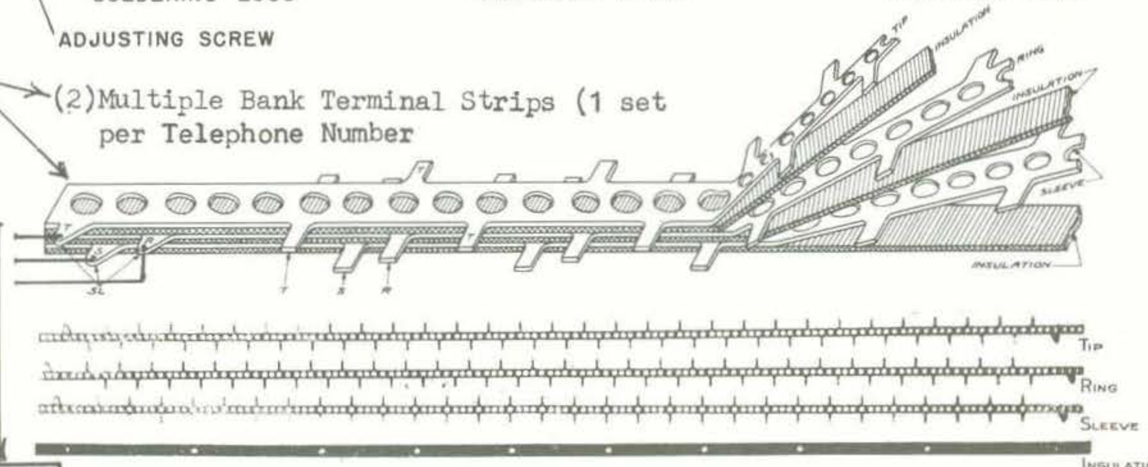




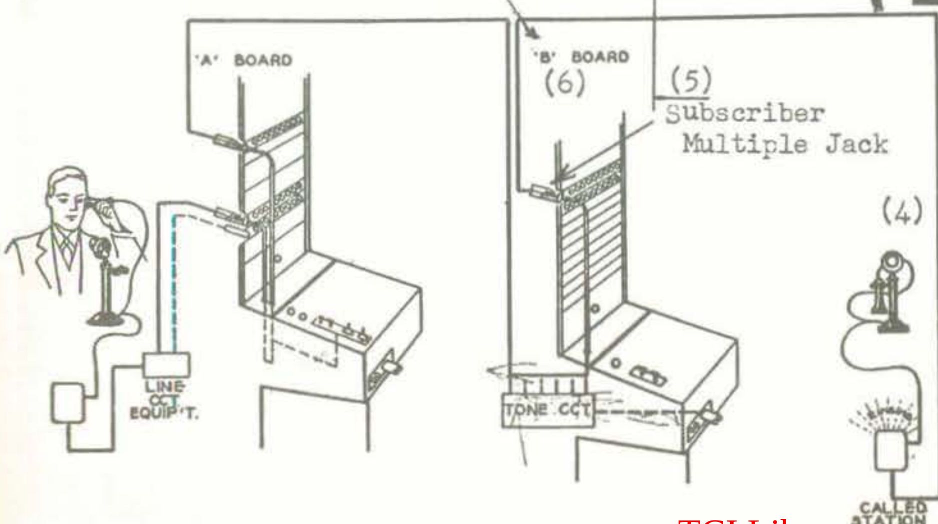


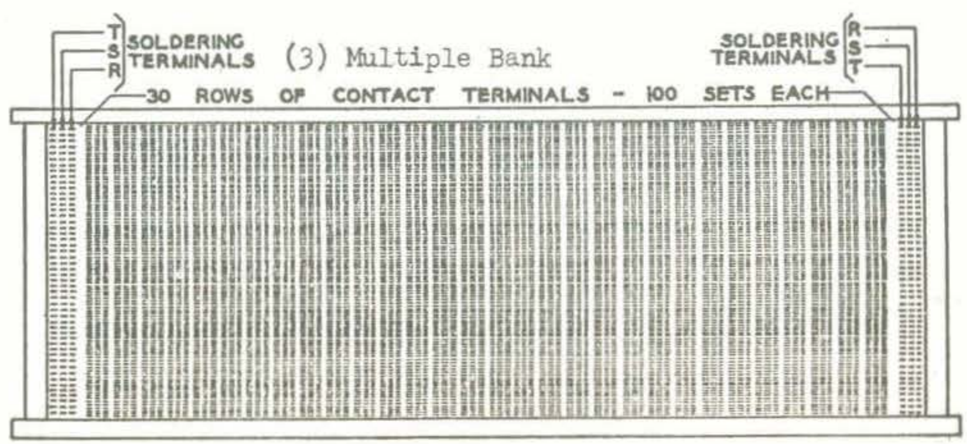


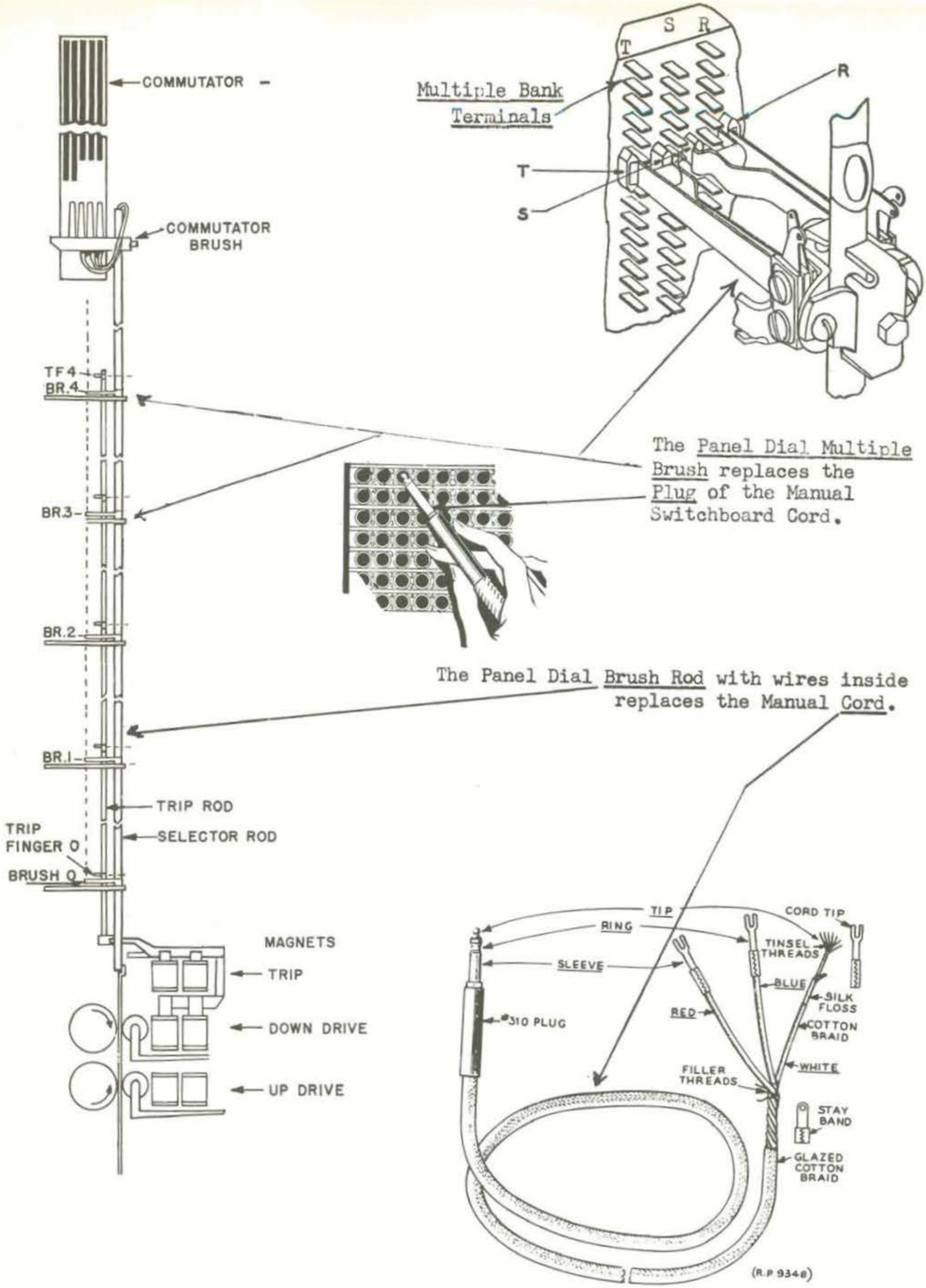
A Panel Dial Subscriber Line (1) also cables to a set of Multiple Bank Terminal Strips (2)(T, R, S) in a Final Selector Frame Multiple Bank (3), corresponding to the Manual Subscriber Line (4), which cables to a Subscriber Multiple Jack (5) in the face of the "B" Switchboard(6).



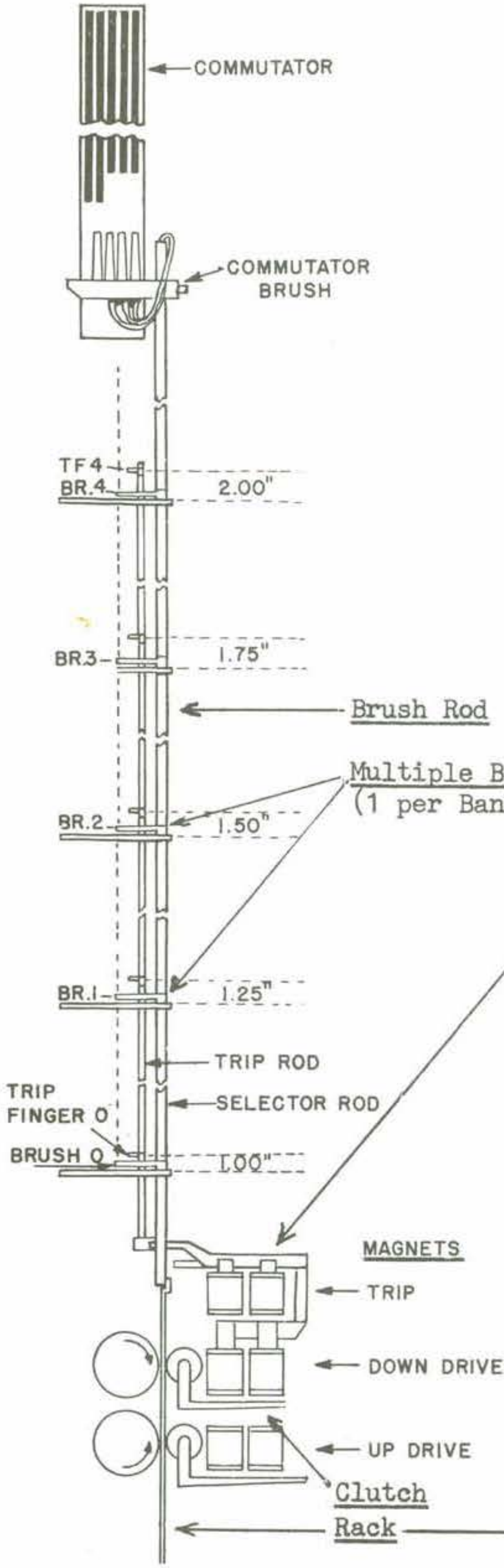
- 135 -



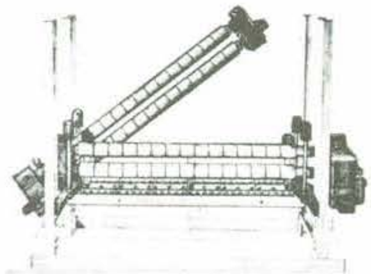


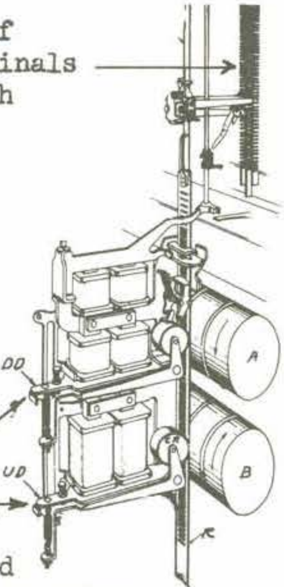


SWITCHBOARD CORD



Vertical Column of Multiple Bank Terminals (T, S & R) for each Brush Rod.

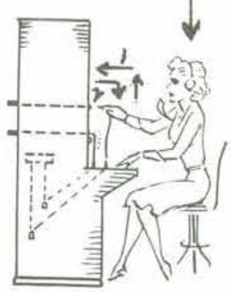




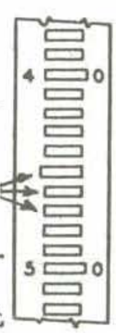
Down Drive
Up Drive

Clutch, mounted on Friction Roll Drive Unit.

The Panel Dial Friction Roll Drive Unit and an Electrically Operated Clutch for each Brush Rod replace the Manual Operator in putting up (making a connection) and taking down (disconnecting) Cords.



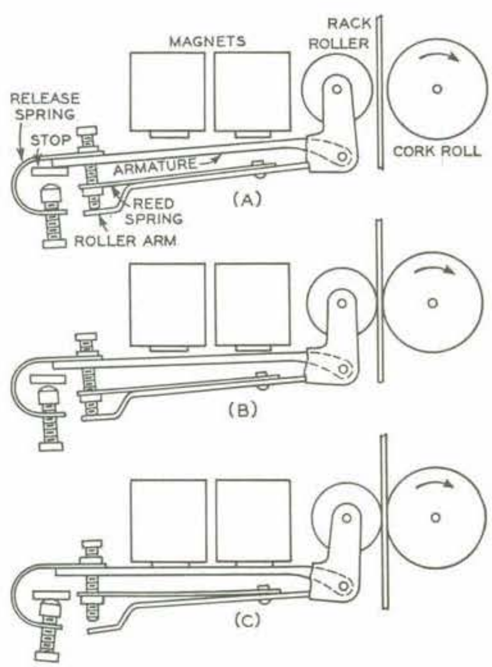
1 Making a Connection
2 Disconnecting



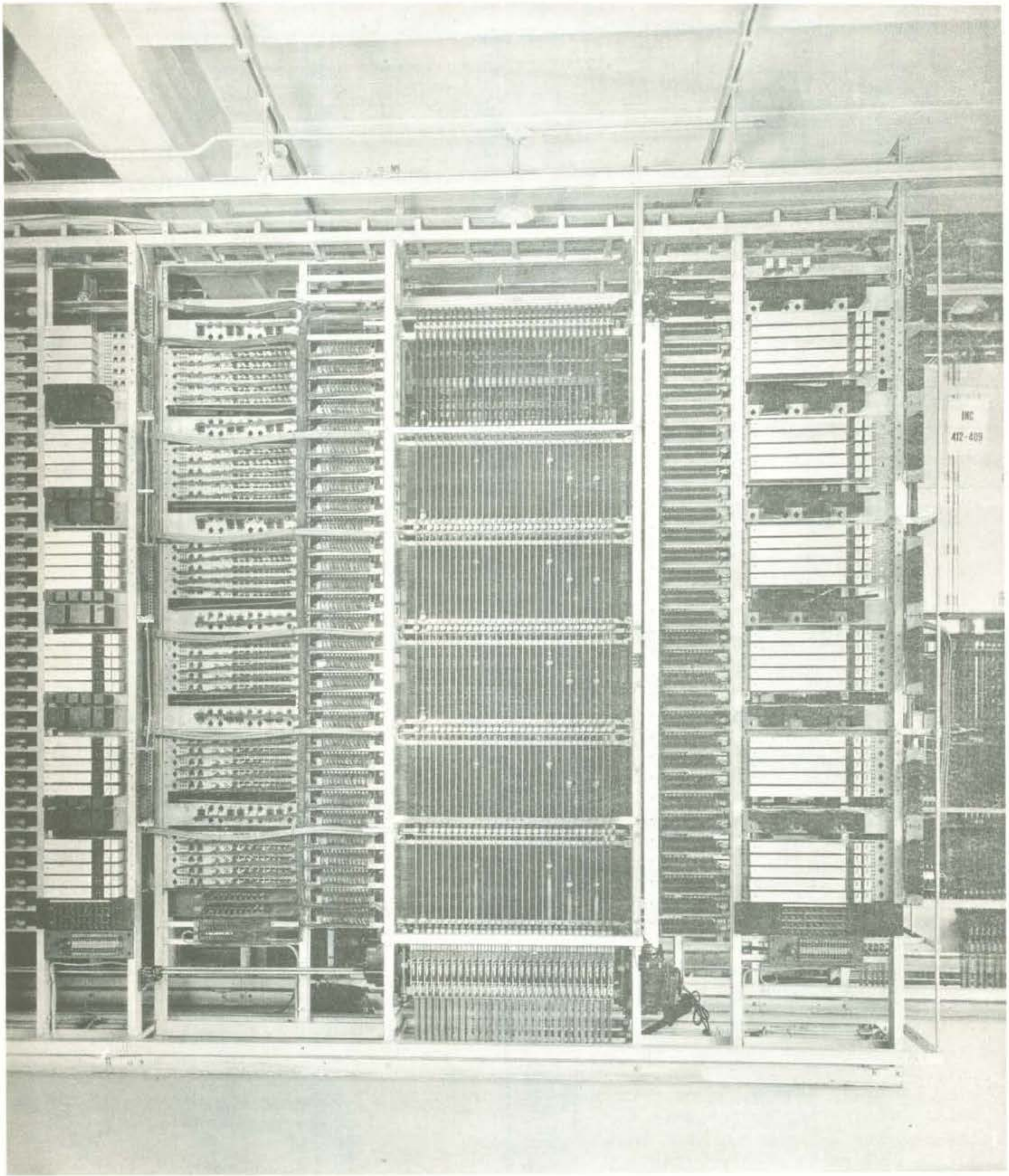
SECTION OF RACK FRONT VIEW

Rack Slots

Rack Slot spacing corresponds to the spacing between adjacent Multiple Bank Terminals (approximately 1/8-inch vertical spacing), so that the Pawl drops into the Rack Slot to position the tripped Multiple Brush Shoes directly opposite that set of Bank Terminals in any one of the Multiple Banks.

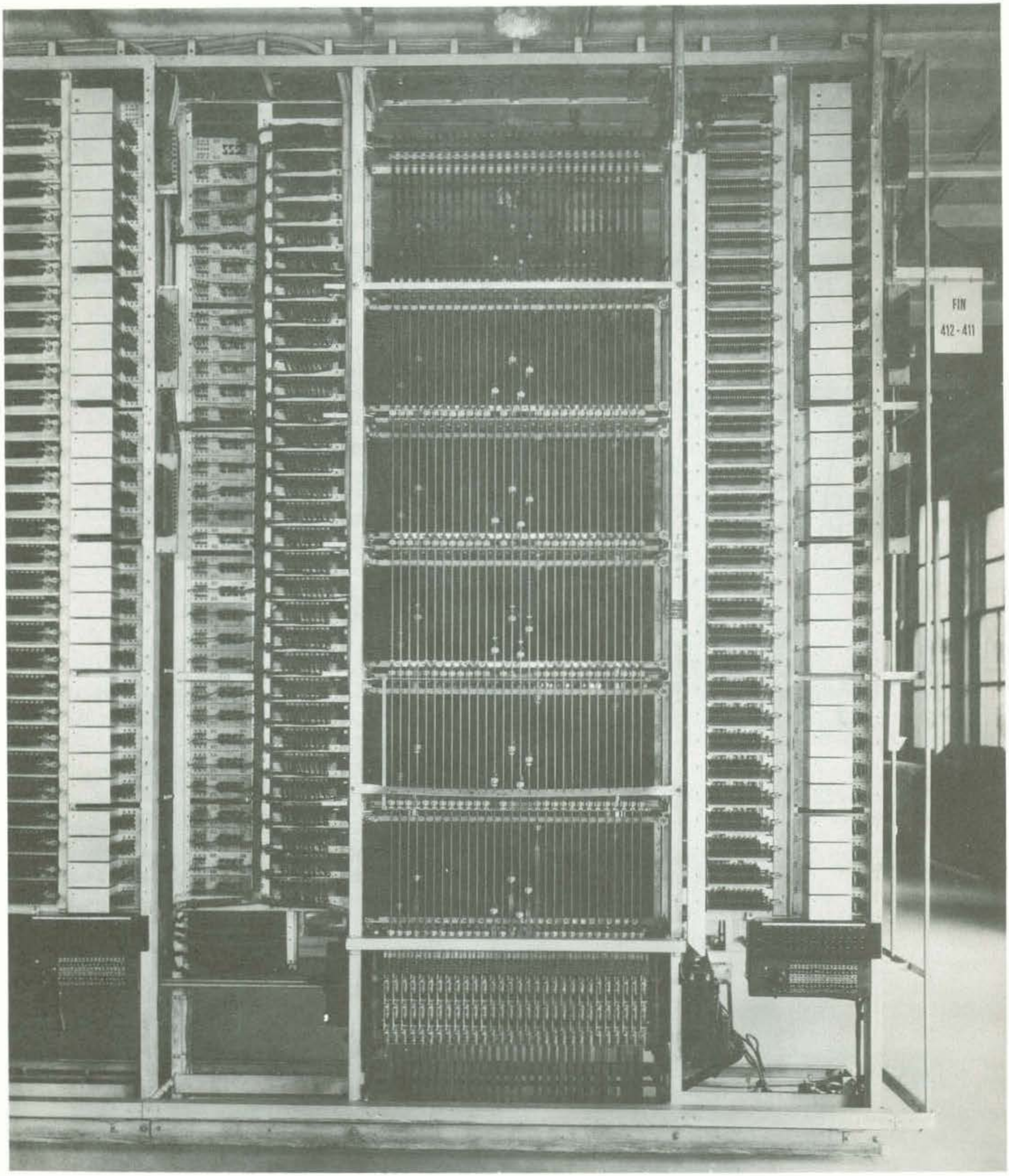


Clutch Magnet
(A) Normal
(B) Partially Operated
(C) Fully Operated



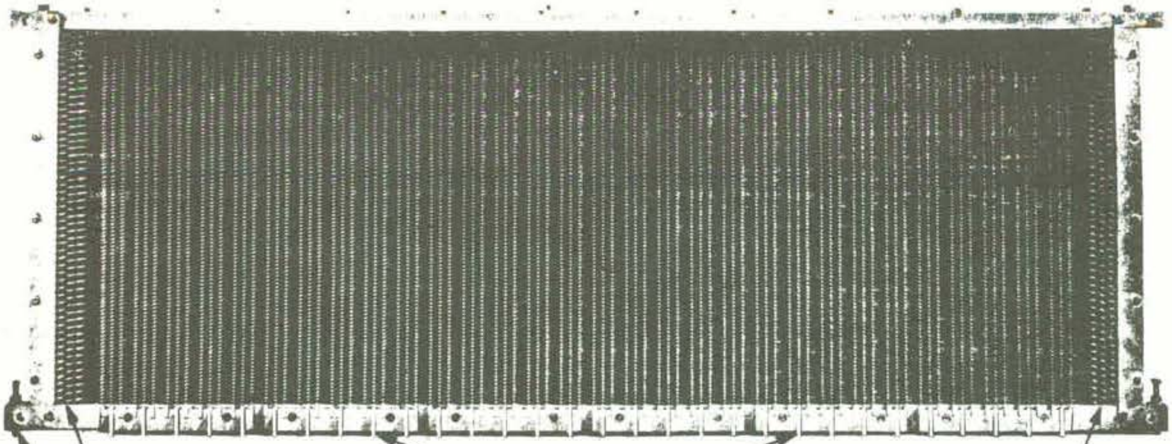
INCOMING SELECTOR FRAME - WABASH OFFICE

166322

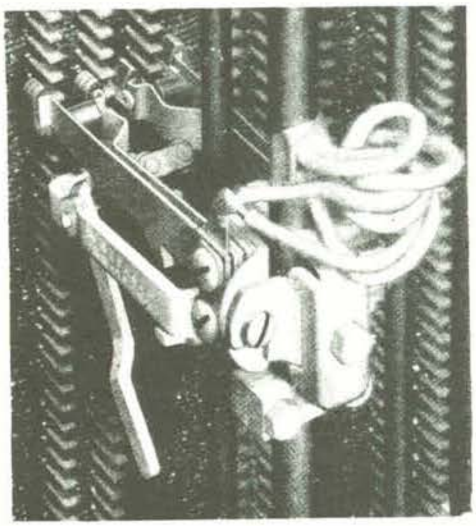


FINAL SELECTOR FRAME-WABASH OFFICE

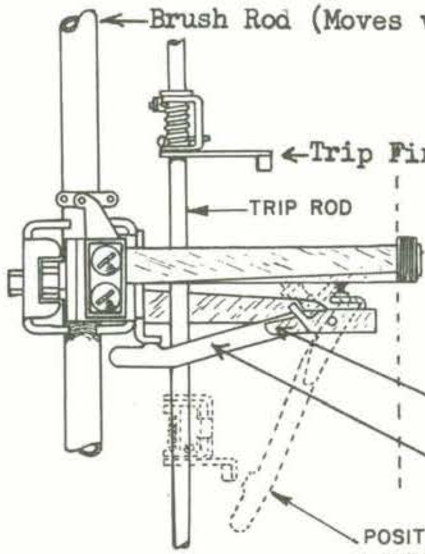
166320



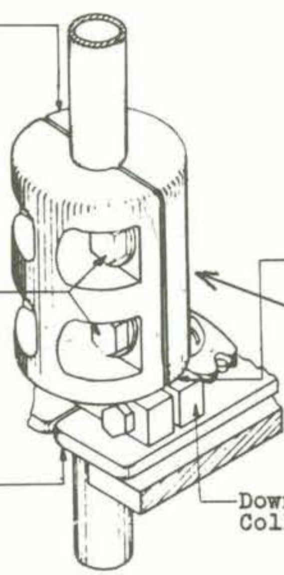
Multiple Bank (10 per Line Finder, 5 per other Selector Frames)



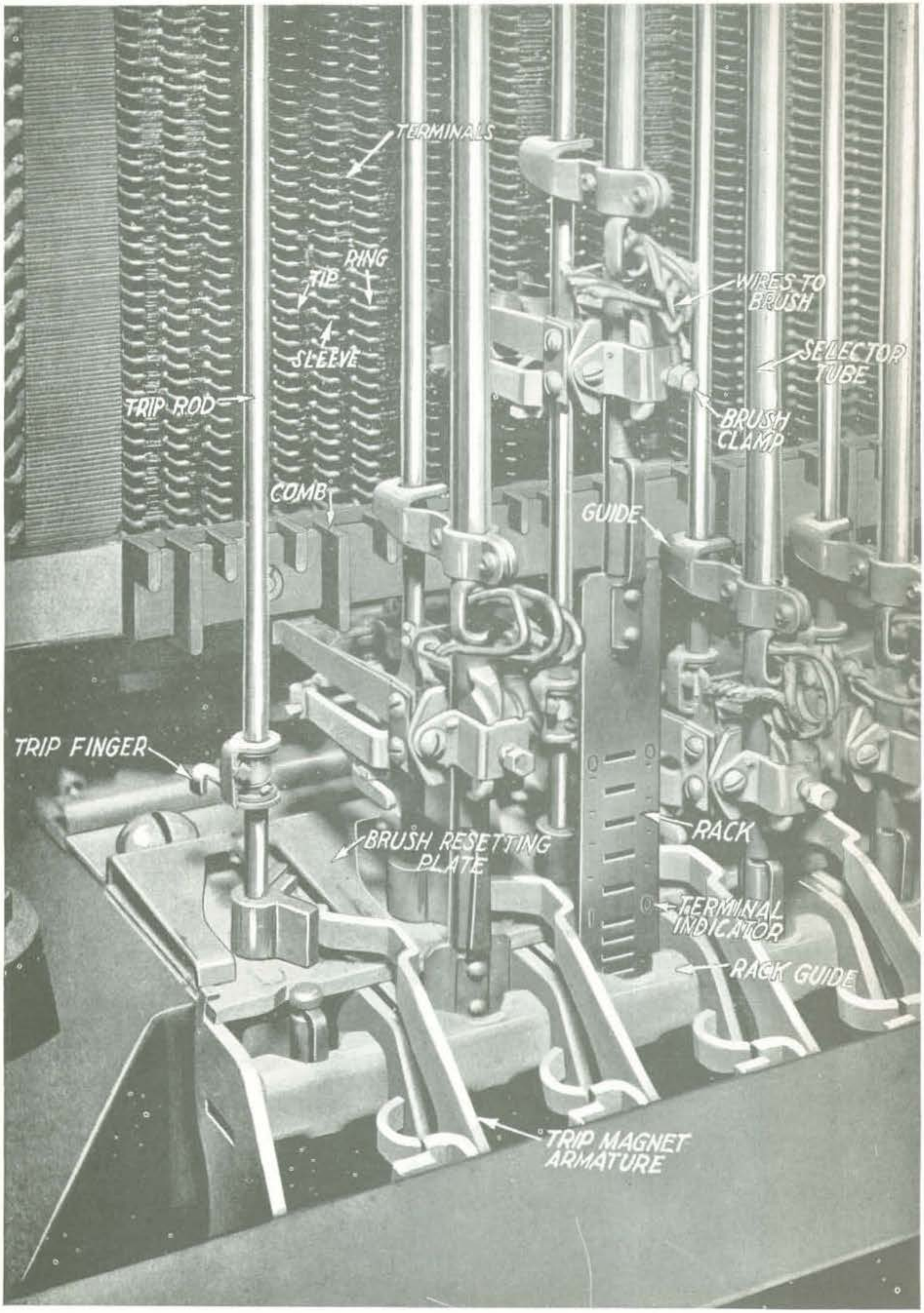
Multiple Brush (1 per Bank, per Brush Rod)



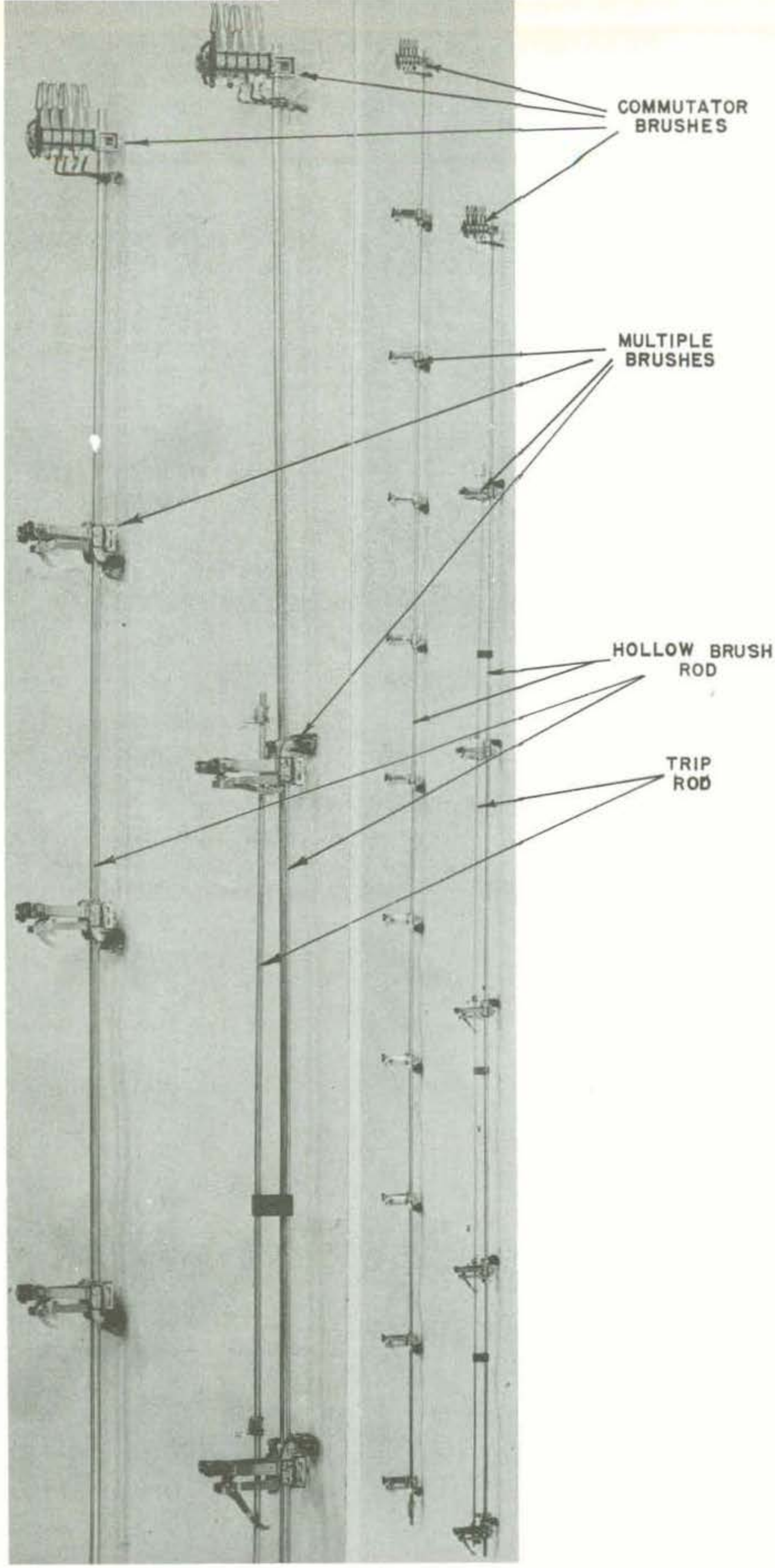
Tripping Mechanism - Trip Rod rotated by Trip Magnet so that Trip Finger engages Trip Lever as Brush Rod moves upward.



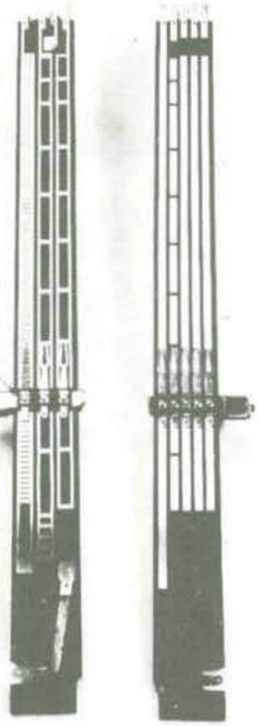
Compensating Weight - Used on Link Frame short Brush Rods, and Brush Rods with less than normal number of Multiple Brushes.



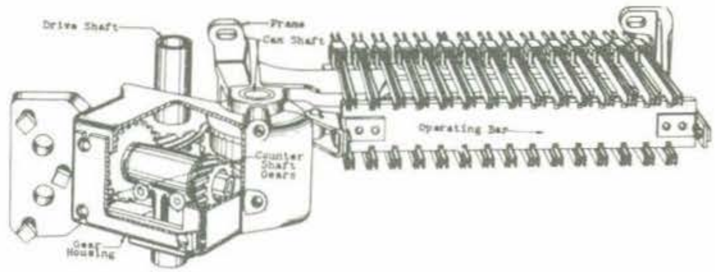
Panel Type Selecting Mechanism



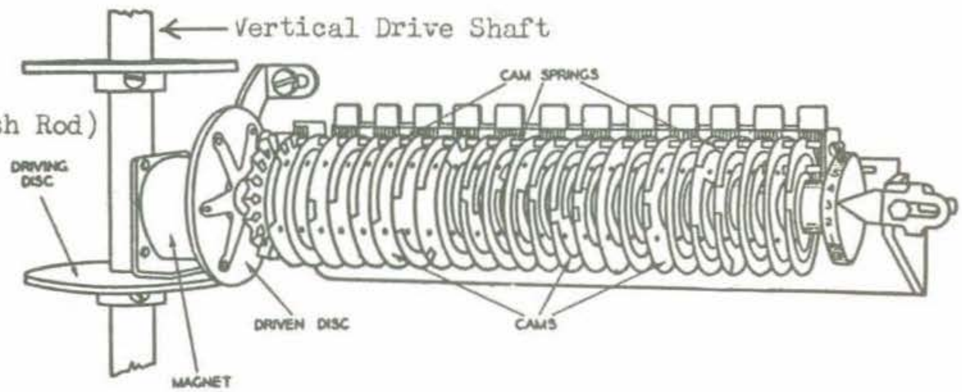
BRUSHES AND BRUSH RODS

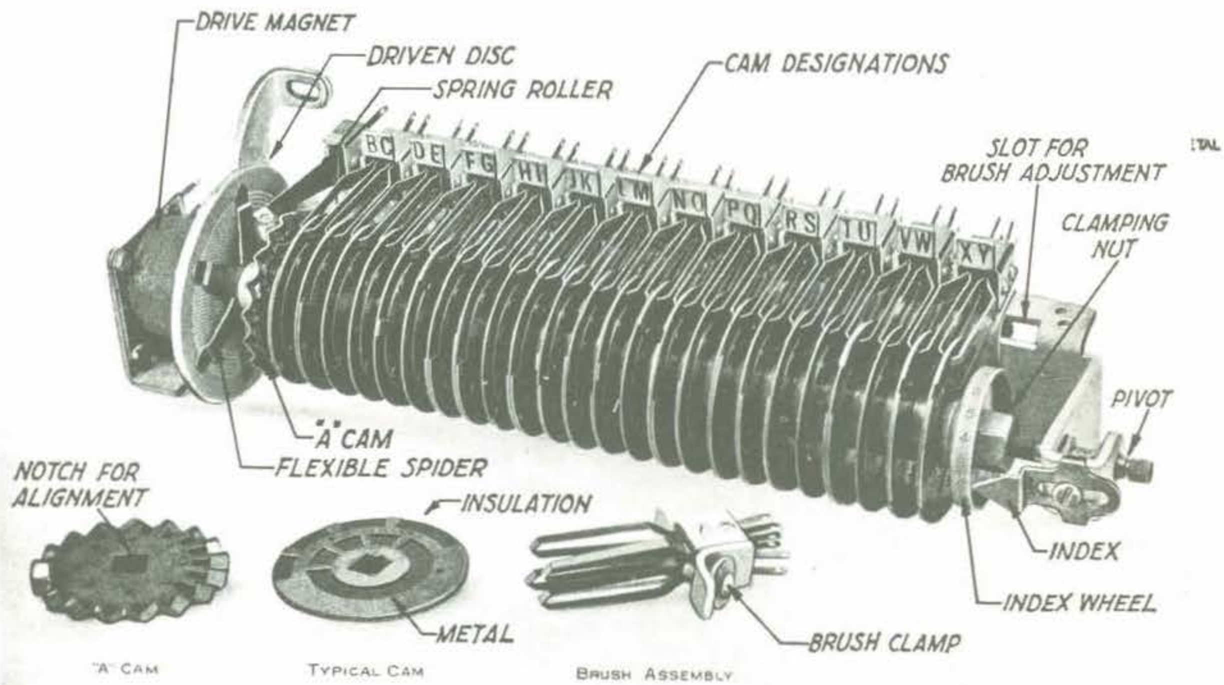


Commutator (1 per Brush Rod)



Reciprocating Bar Interrupter (Timer) - For opening and closing circuits, such as interrupting Dial Tone to make Busy Tone





Sequence Switch (Power Driven Relay, driven off Vertical Drive Shaft)

METHOD OF HANDLING A CALL BETWEEN TWO MANUAL SUBSCRIBERS

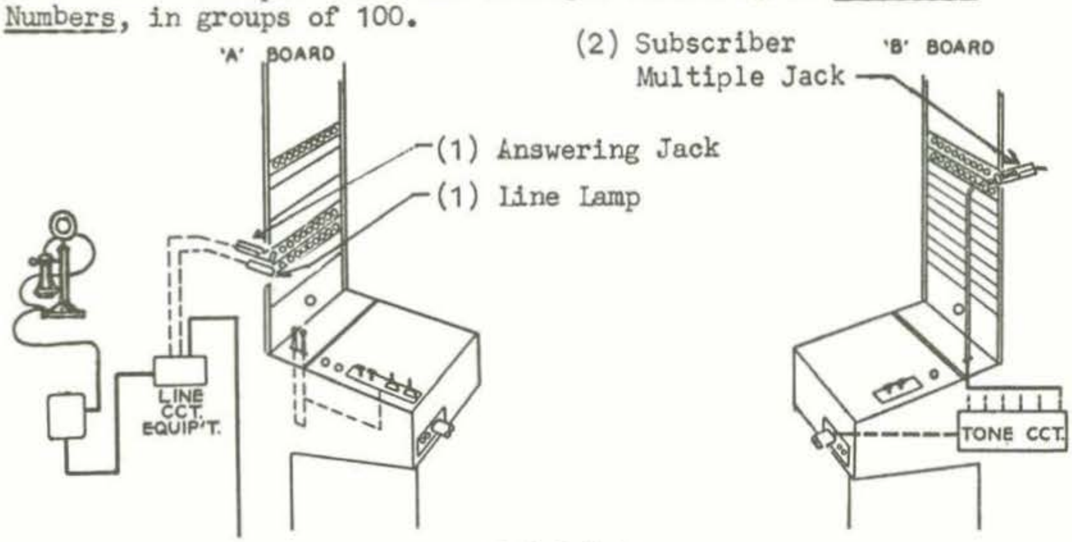
In the Manual System, a Subscriber Line is cabled to:

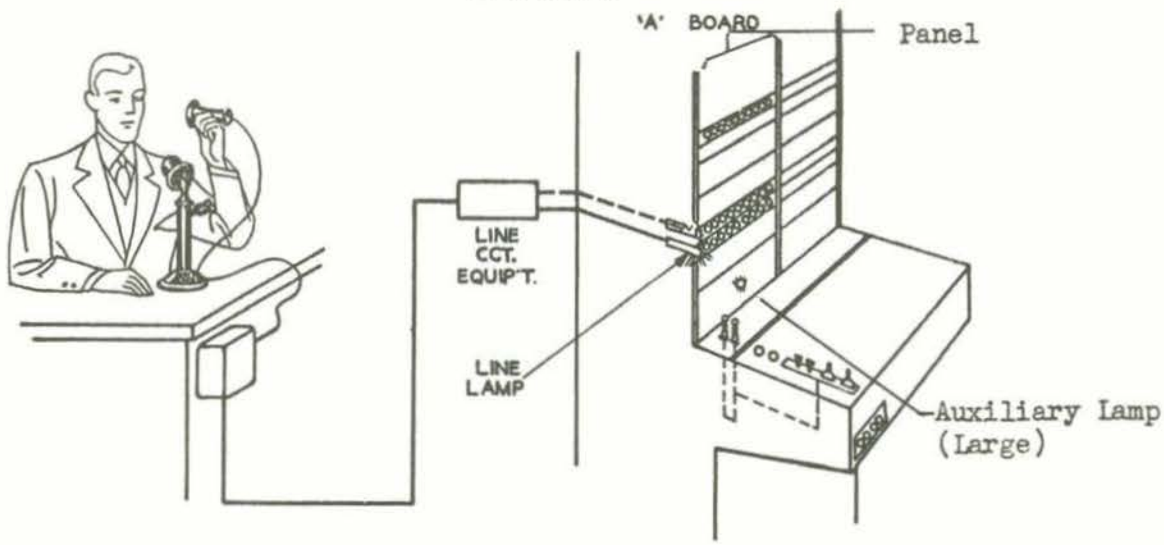
1) An Answering Jack and Line Lamp in the face of the "A" Switchboard for originating calls.

2) A Subscriber Multiple Jack in each Section of the "B" Switchboard Lineup for terminating calls.

   a) A separate Switchboard Lineup is furnished for each Exchange or Office Unit (Lincoln, Metropolitan, North, etc.).

   b) Subscriber Multiple Jacks are arranged according to Directory Numbers, in groups of 100.



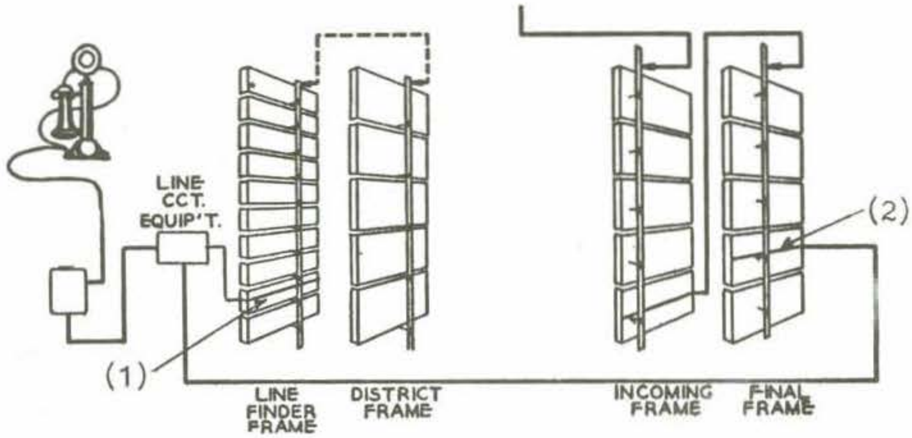


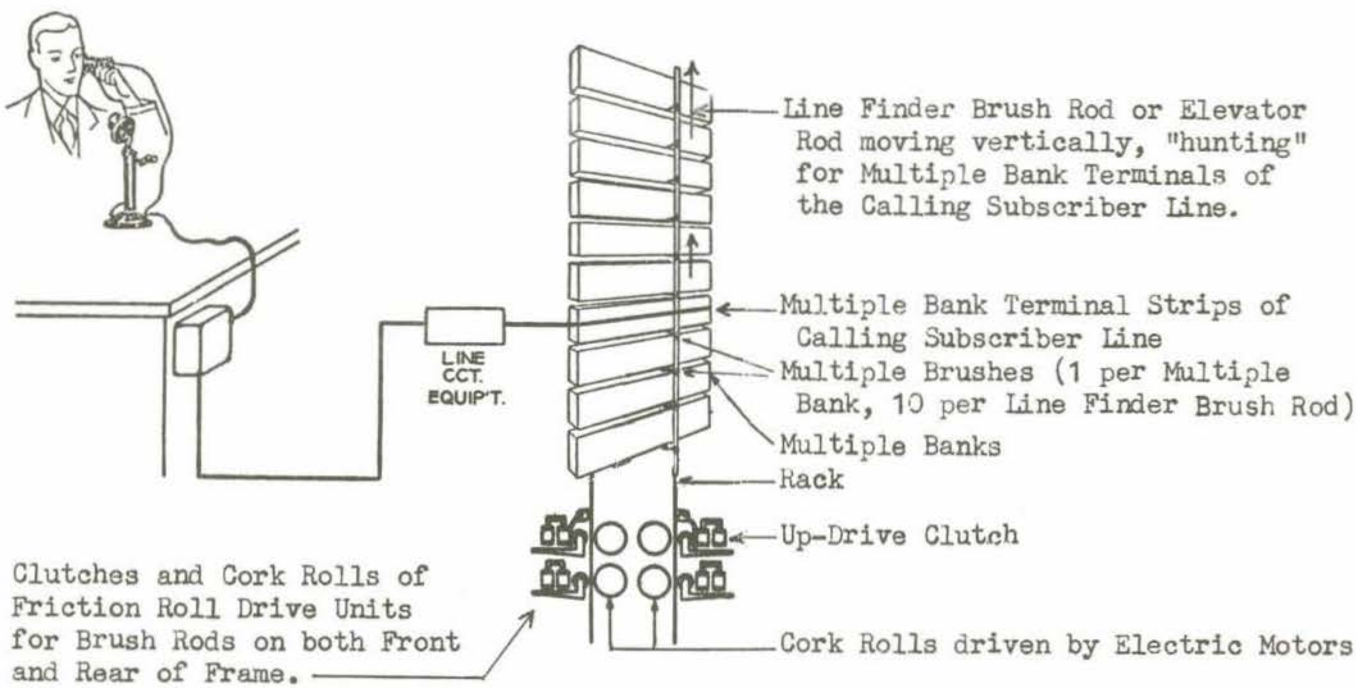
The removal of the Receiver (or Handset) from the Switchhook by the Manual Subscriber lights the Line Lamp at the "A" Switchboard, attracting the "A" Operator's attention. The Auxiliary Lamp also lights to indicate the Panel in which the lighted Line Lamp is located.

METHOD OF HANDLING A CALL BETWEEN TWO PANEL DIAL SUBSCRIBERS

In the Panel Dial System, a Subscriber Line is cabled to:

1) A Set of Multiple Bank Terminal Strips (T, R, S and H - "Hunt") in a Line Finder Frame for originating Calls.
2) And a Set of Multiple Bank Terminal Strips (T, R, S) in a Final Selector Frame for terminating Calls. Subscriber Line appearances on Final Selector Frames are arranged according to Directory Numbers.





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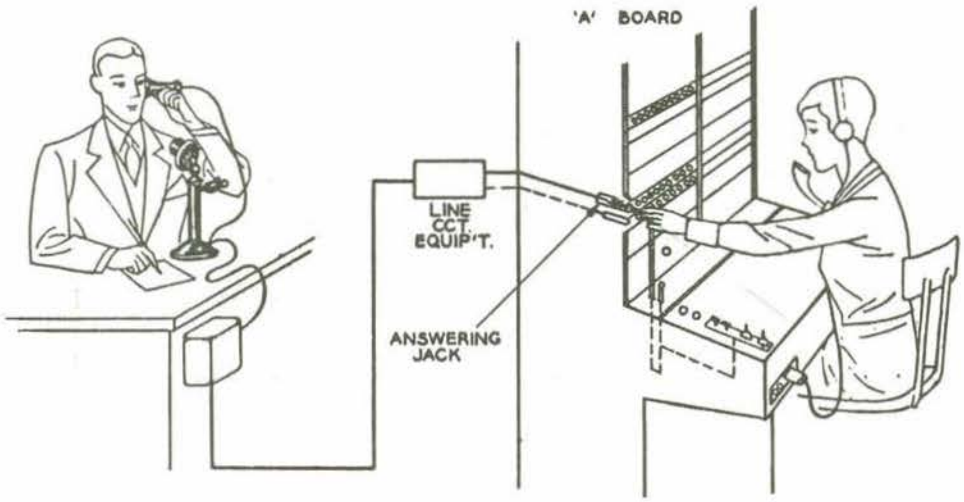
The removal of the Receiver or Handset from the Switchhook (Handset OFF Switchhook) by the Panel Dial Subscriber:

1) Energizes the Up-Drive Clutch of one of the Idle Line Finder Brush Rods on his Line Finder Frame, and
2) Trips the Multiple Brush (one of 10) for the Multiple Bank in which the Calling Subscriber Line appears.

- - - - -

The Line Finder Brush Rod corresponds to the Manual "A" Switchboard Answering Cord. The Panel Dial Multiple Brush replaces the Answering Cord Plug.

The "A" Operator connects to ("finds") the Calling Subscriber Line by selecting an Idle Cord Circuit, and inserting the Answering Cord Plug into the Answering Jack, extinguishing the Line Lamp and Auxiliary Lamp.



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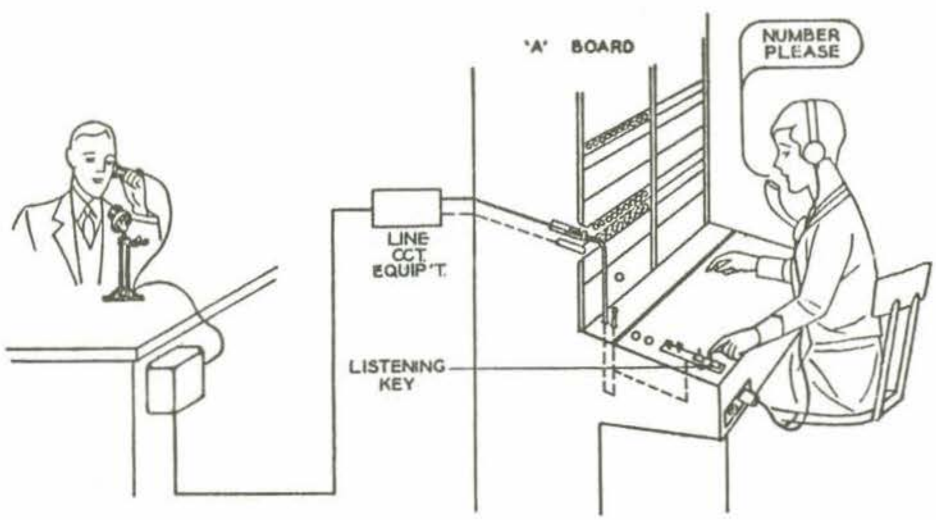
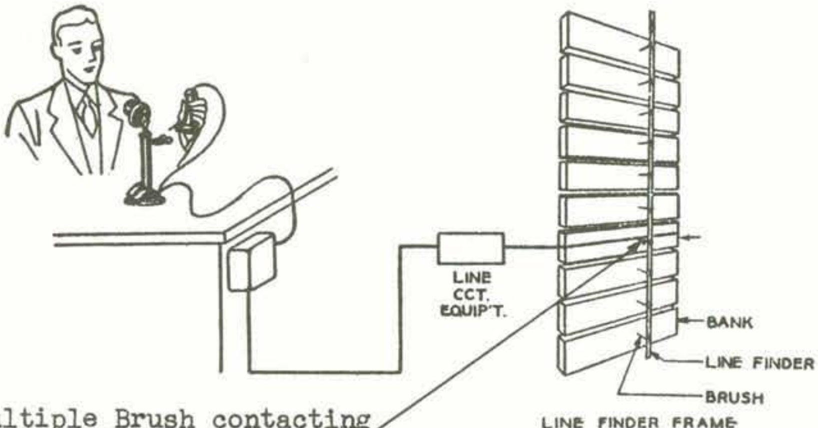
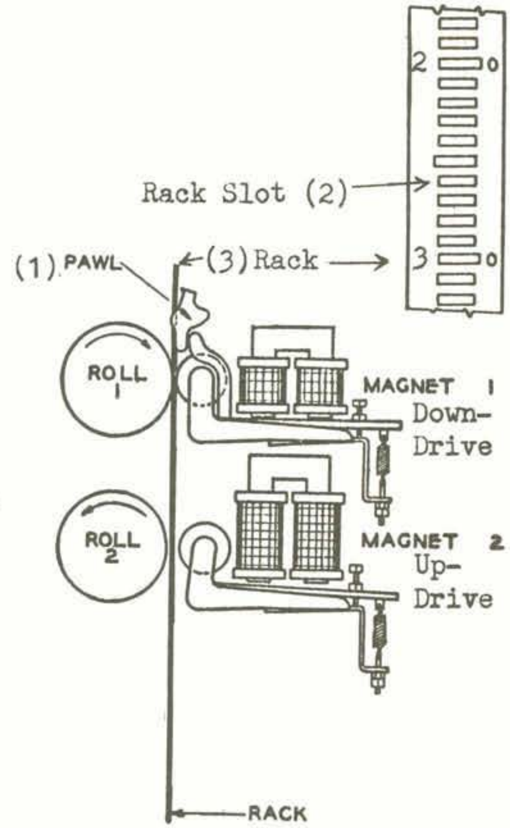


The "A" Operator connects her Telephone Set to the Answering Cord by operating the Listening Key, and says, "Number, please!"





Multiple Brush contacting Multiple Bank Terminals, corresponding to Manual Answering Cord Plug inserted in Answering Jack of the "A" Switchboard

The Up-Drive Clutch of the Line Finder Brush Rod is de-energized when the Multiple Brush Shoes contact ("find") the Multiple Bank Terminals of the Calling Subscriber Line.

A Pawl (1) engages a Slot (2) in the Rack (3) to hold the Brush Rod in position.

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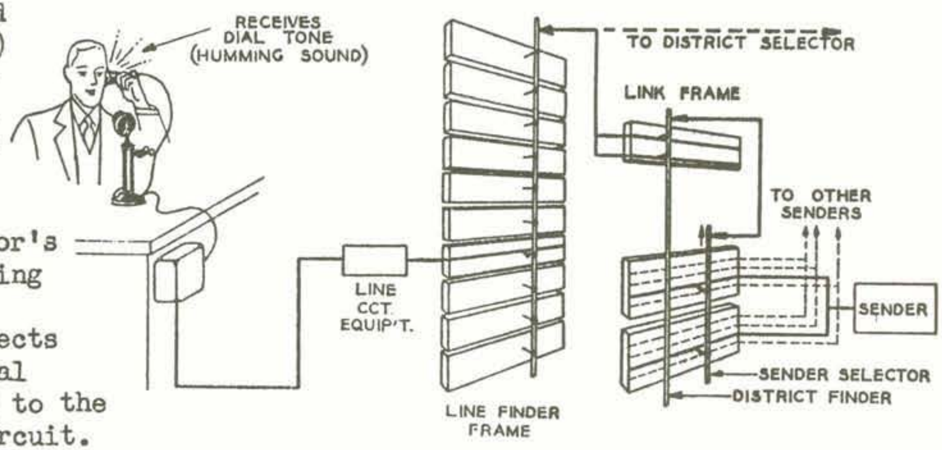

1) The Line Finder Brush Rod (Mechanical Cord Circuit) has been pre-selected by the District Finder of a Link Circuit on the Link Frame.
2) The Link Circuit corresponds to the "A" Operator's Telephone Set and Listening Key.
3) The Link Circuit now selects an Idle Sender (Mechanical Operator), connecting it to the Line Finder Brush Rod Circuit.
4) The Sender transmits Dial Tone ("Number, please!") to the Calling Subscriber, indicating the Sender (Mechanical Operator) is ready to receiver the Called Subscriber Number.
5) Each Line Finder Brush Rod is permanently cabled to a mate Brush Rod on a District Selector Frame; the combination is known as a "Line Finder-District Selector."

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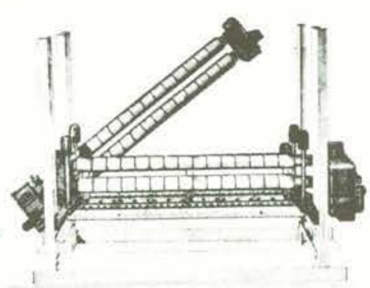
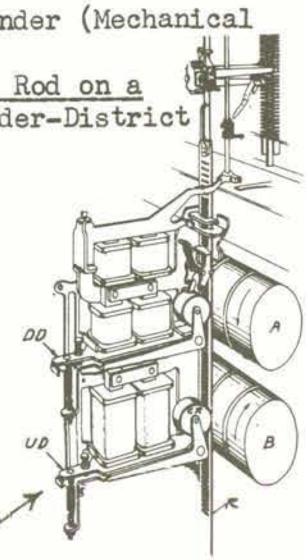
The Friction Roll Drive Unit and Electrically operated Clutches replace the Manual Operator's Hand and Arm movements in putting up and taking down connections at the Switchboards.

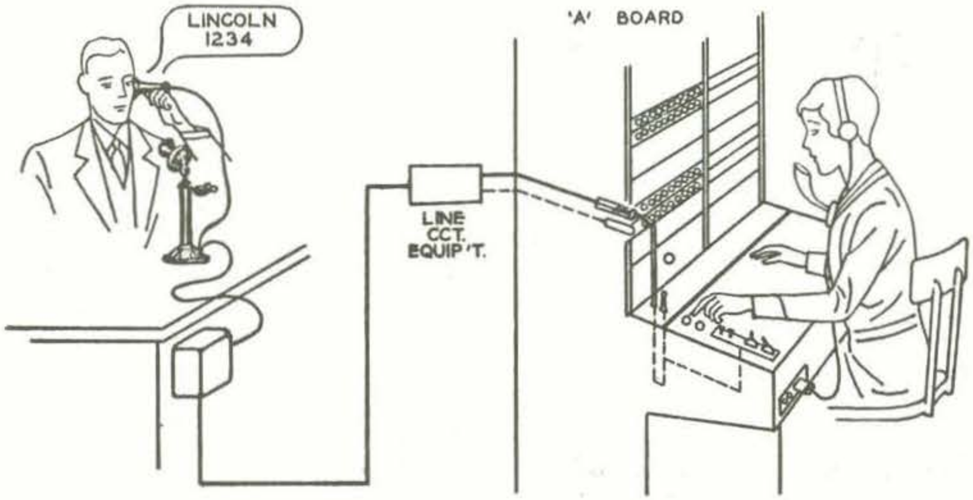


Friction Roll Drive Unit



Electrically Operated Clutch

The Manual Calling Subscriber passes verbally to the "A" Operator the Central Office Name or Code and the 4-digit Called Subscriber Number (0000 to 9999 - 10,000 Telephone Numbers or Subscriber Terminals).



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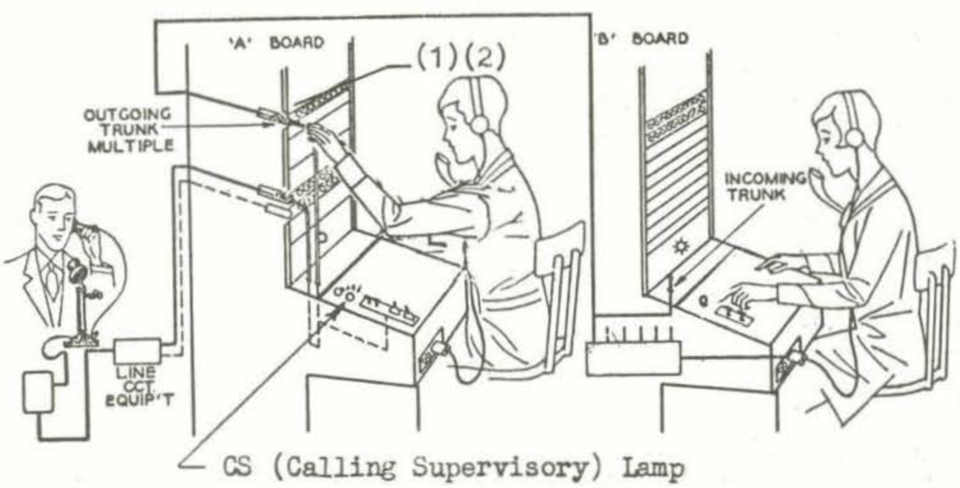


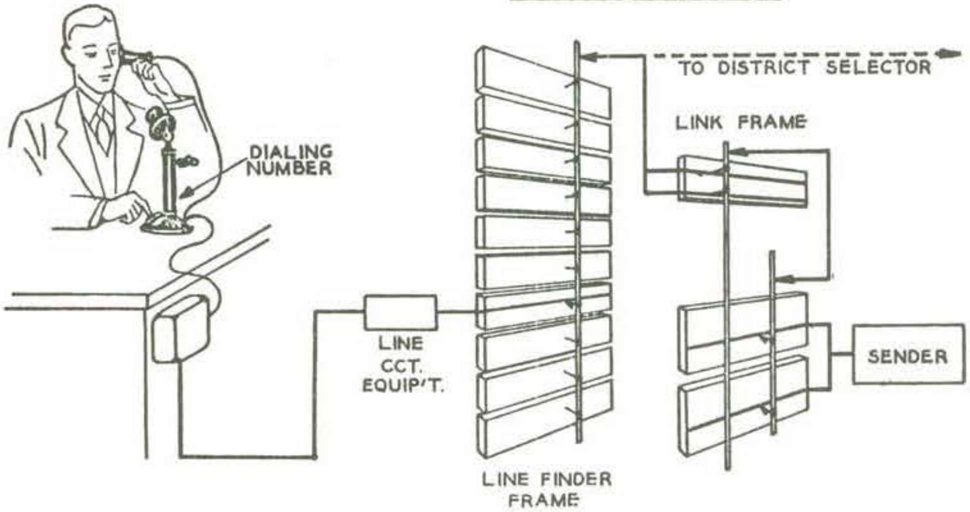
CS (Calling Supervisory) Lamp

When the "A" Operator hears the Central Office Name or Code and the Called Subscriber Number:

1) She tests for an Idle Outgoing Trunk to the Called Office by touching the Tip of the Calling Cord Plug to the Sleeve of the Outgoing Trunk Jack.

   a) A "click" in her Headset indicates a Busy Trunk;
   b) No "click" indicates an Idle Outgoing Trunk.

2) The "A" Operator inserts the Calling Cord Plug into an Idle Outgoing Trunk Jack, lighting the CS (Calling Supervisory) Lamp.



The Panel Dial Subscriber dials the Office Code and 4-digits of the Called Telephone Number, which are stored in Relay Digit Registers in the Sender (Mechanical Operator).

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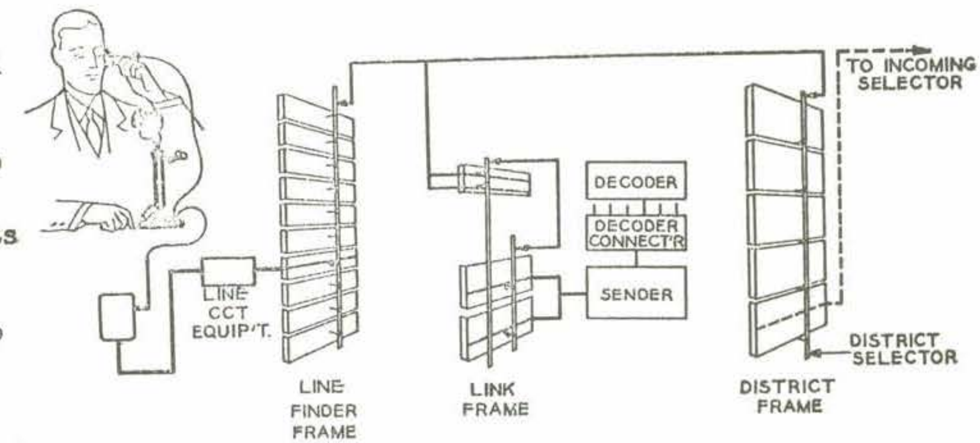

As soon as the Panel Dial Calling Subscriber has dialed the Office Code, the Sender seizes an Idle Decoder.

1) The Sender transmits the Office Code to the Decoder.
2) The Decoder sets up relay combinations in the Sender to inform the Sender the location on the District Selector Frame Multiple Banks of the Outgoing Trunk Group.
3) The Decoder is then released by the Sender to service other calls.
4) The District Selector Frame Multiple Banks correspond to the Outgoing Trunk Multiple on the Manual "A" Switchboard.
5) The District Selector Frame Brush Rod corresponds to the Calling Cord, and the Multiple Brush to the Plug of the Manual "A" Switchboard.

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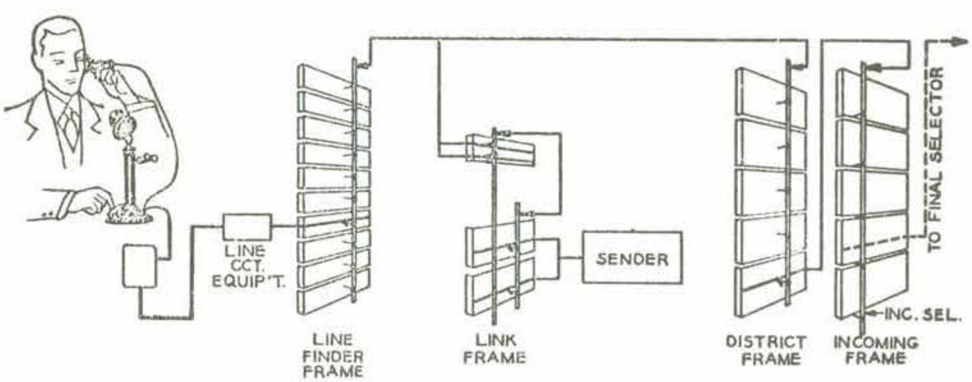
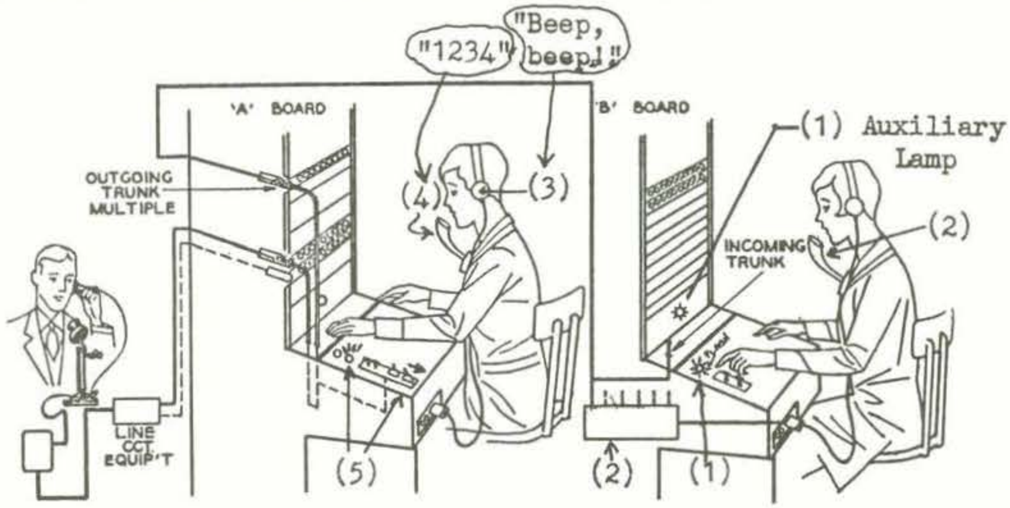


With information obtained from the Decoder, the Sender causes the District Selector Frame Brush Rod to be driven up, so that the Shoes of one of the 5 Multiple Brushes connect with the Terminals of an Idle Outgoing Trunk to the Called Office. Three steps are taken in driving the District Selector Rod vertically:

1) District Brush Selection - The first upward movement - 1" to 2" - positions one of the 5 Multiple Brushes for tripping.
2) District Group Selection - The second upward movement trips the selected Multiple Brush, and the Up-Drive Clutch remains energized until the Multiple Brush Shoes contact the First Trunk in the Group terminating in the Called Office. This completes District Selections by the Sender.
3) Hunting - If the First Trunk in the Group is Busy, the District Selector Circuit (no longer under control of the Sender) hunts up over the remaining Trunks in the Group, stopping when the Multiple Brush Shoes contact the first Idle Set of Multiple Bank Terminals.

1) As soon as the "B" Operator is idle (having completed all other calls assigned ahead of this one), the Trunk Supervisory (Guard and Disconnect) Lamp for the selected Trunk (Outgoing at the "A" Switchboard; Incoming at the "B" Switchboard) flashes 60 times per minute to attract the "B" Operator's attention. The Auxiliary Lamp (1 per each group of 10 Cords) also glows steadily.
2) The "B" Operator's Telephone Set is connected automatically to the Incoming Trunk with the flashing Guard (Trunk Supervisory) Lamp.
3) Two spurts of Tone (Order Tones - "Beep, beep!") are placed on the Trunk.
4) Upon hearing the Order Tones, the "A" Operator repeats the Called Number, "1234," to the "B" Operator.
5) Then the "A" Operator releases her Listening Key. The CS (Calling Supervisory) Lamp at the "A" Switchboard is still lighted.



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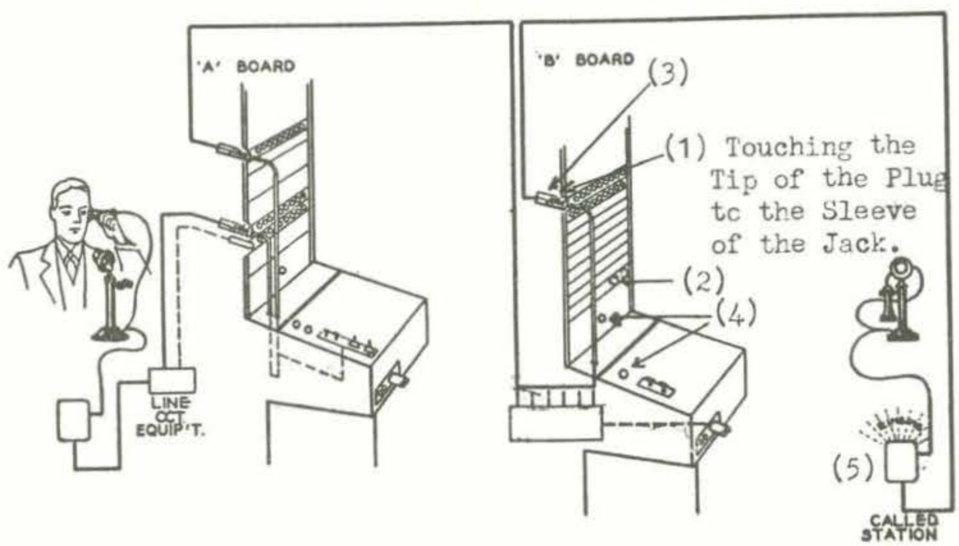
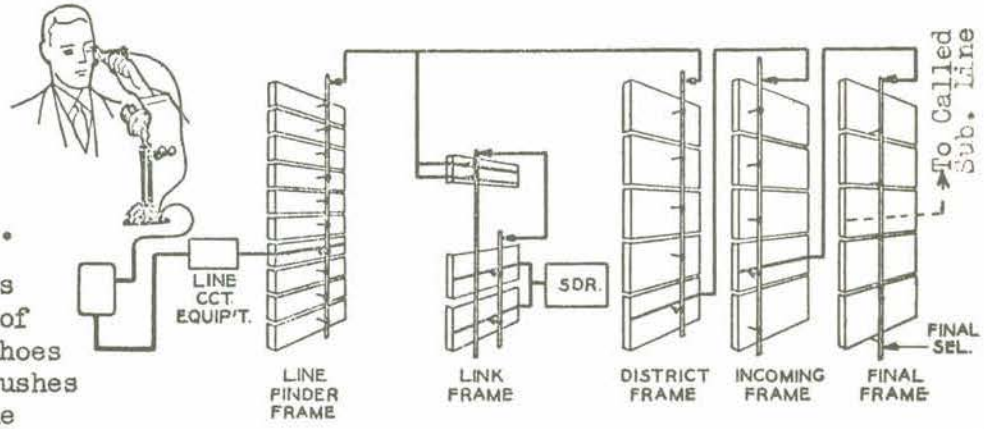


1) The "B" Operator makes a Busy Test of Subscriber Multiple Jack "1234."
2) If the Called Subscriber Line checks Busy, the "B" Operator inserts the Incoming Trunk Cord into a special Busy Back Jack.
3) If the Called Subscriber Line checks Idle, the "B" Operator inserts the Incoming Trunk Cord Plug into Subscriber Multiple Jack "1234."
4) Plugging Up the Call extinguishes the flashing Trunk Supervisory (Guard) Lamp, also the Auxiliary Lamp, and disconnects the "B" Operator's Telephone Set from the Incoming Trunk Circuit, ready for assignment to the next Call Waiting.
5) Ringing Current is applied automatically to the Called Subscriber Line.

The selected Outgoing Trunk on the District Selector Frame Multiple Bank terminates as an Incoming Trunk on one of the Incoming Frame Brush Rods in the Called Office.



This Incoming Brush Rod is driven up, under control of the Sender, so that the Shoes of one of the Multiple Brushes contact the Incoming Frame Multiple Bank Terminals of an Idle Trunk to the Final Selector Frame on which the Called Subscriber' Line appears.

Incoming Selections (IB - Incoming Brush, and IG - Incoming Group) are governed by the "thousands" digit "1" and the "hundreds" digit "2" of the Called Subscriber Number registered in the Sender.

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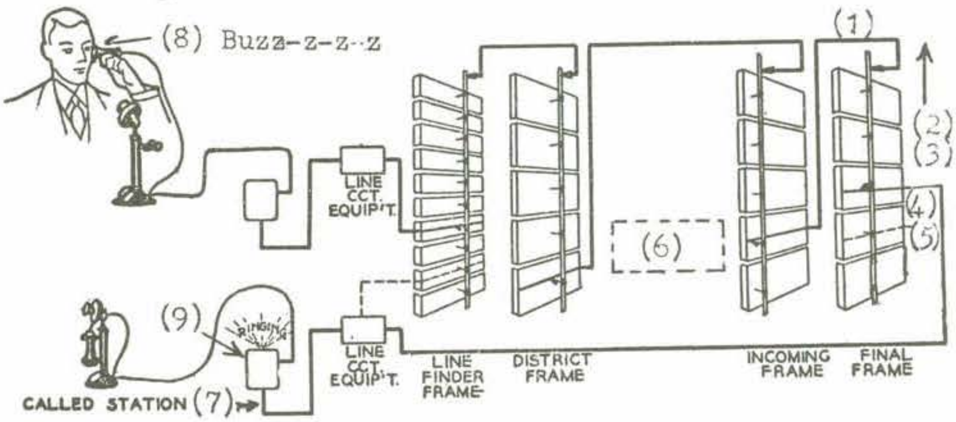
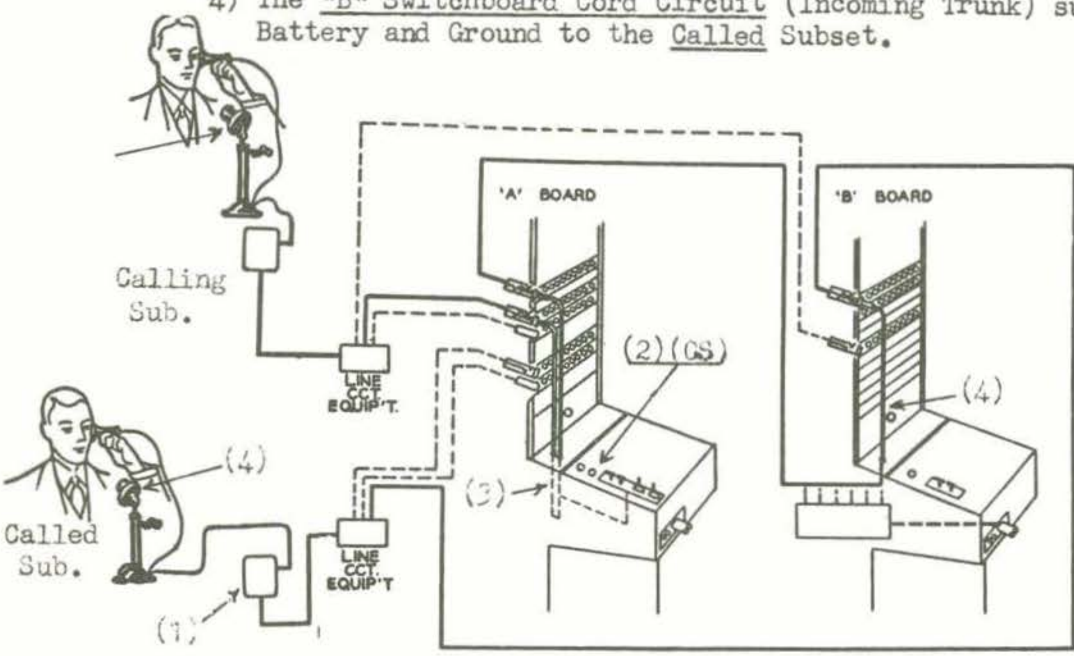


1) The selected Trunk on the Incoming Selector Frame Multiple Bank terminates on one of the Brush Rods of the Final Selector Frame serving Directory Numbers 1000 to 1499, including the Called Subscriber, 1234.
2) This Brush Rod is driven up, under control of the Sender, so that the Shoes of one of the Multiple Brushes connect to the Final Selector Frame Multiple Bank Terminals of the Called Subscriber Line. Upon "cut-through" to the Called Subscriber Line, the Link releases and the Sender restores to normal. Then the Link connects to an Idle Line Finder-District Selector Circuit, ready to handle the next call.
3) The "hundreds" digit "2" sets the Final Selector Frame Multiple Brush Rod for tripping (The Brush Rod is driven up, under control of the Sender, 1" off normal for tripping Brush No. 0, $1\frac{1}{4}$" for No. 1, $1\frac{1}{2}$" for No. 2, 1 3/4" for No. 3 and 2" for No. 4.) Multiple Brush No. 2 to "work" in Multiple Bank No. 2 (third up from the bottom) serving Directory Numbers 1200 to 1299.
4) The "tens" digit "3" causes the Final Selector Frame Brush Rod to be driven up, tripping Multiple Brush No. 2, and stopping the Brush Rod with the Multiple Brush Shoes contacting Multiple Bank Terminals (T, R, S) No. 30.
5) The "units" digit "4" causes the Slow-Speed Up-Drive Clutch to engage, driving the Brush Rod up so that the Multiple Brush Shoes contact Multiple Bank Terminals No. 34 of the Called Subscriber Line.
6) The Sender then restores to normal (releases), ready to set up another call.
7) The Final Selector Circuit checks the Called Subscriber Line to determine if it is Busy or Idle.
8) If the Called Subscriber Line is Busy, the Final Selector Circuit restores to normal, "setting" the Incoming Selector Circuit to return Busy Tone to the Calling Subscriber.
9) If the Called Subscriber Line checks Idle, the Final Selector Circuit signals the Incoming Selector Circuit to apply Ringing Current to the Called Subscriber Line.

When the Called Subscriber answers (Called Handset OFF Switchhook):

1) Ringing Current is tripped (cut off) automatically.
2) The CS (Calling Supervisory) Lamp at the "A" Switchboard is extinguished, signaling the "A" Operator that the Call has been completed.
3) The "A" Switchboard Cord Circuit supplies Talking Battery and Ground to the Calling Subset.
4) The "B" Switchboard Cord Circuit (Incoming Trunk) supplies Talking Battery and Ground to the Called Subset.



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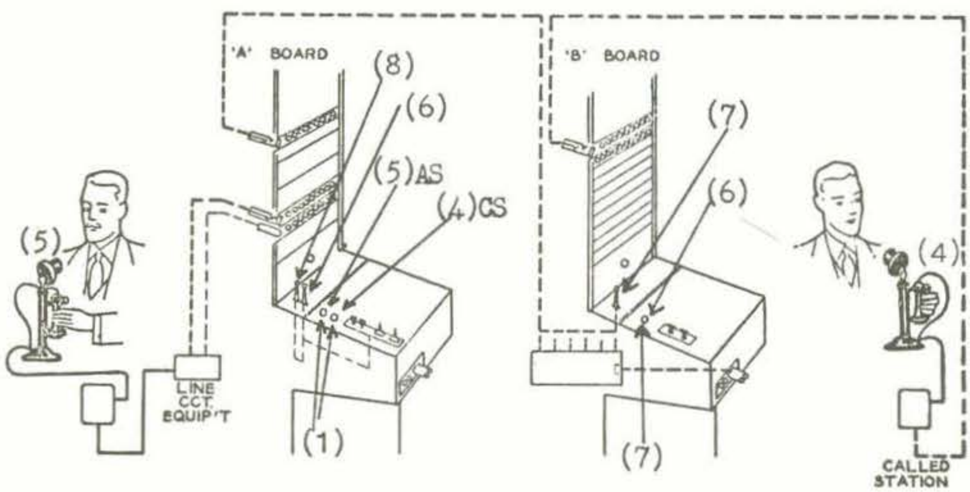


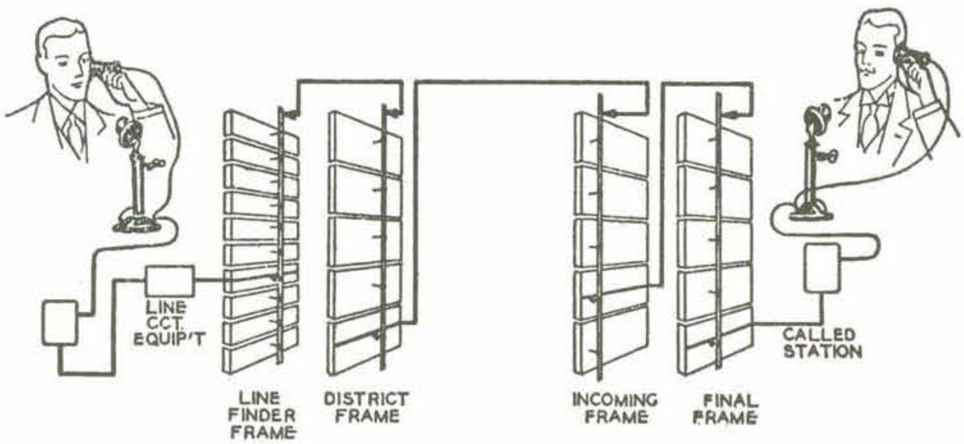
1) When the Manual Subscribers finish talking and replace their Handsets, a "Double-Disconnect" Signal appears at the "A" Switchboard.
2) The "A" Operator takes down both Cords, which brings up the Disconnect Signal at the "B" Switchboard.
3) The "B" Operator takes down the Trunk Cord, restoring the Switchboard Equipment to normal.
4) The Called Handset ON Switchhook lights the Calling Supervisory (CS) Lamp at the "A" Switchboard.
5) The Calling Handset ON Switchhook lights the Answering Supervisory (AS) Lamp at the "A" Switchboard.
6) The "A" Operator takes down the Calling Cord at the "A" Switchboard, extinguishing the Calling Supervisory (CS) Lamp, and lighting the Trunk Supervisory (Disconnect) Lamp at the "B" Switchboard.
7) The "B" Operator takes down the Trunk Cord at the "B" Switchboard, extinguishing the Trunk Supervisory (Disconnect) Lamp, and restoring the "B" Switchboard to normal.
8) The "A" Operator withdraws the Answering Cord Plug from the Answering Jack at the "A" Switchboard, extinguishing the AS (Answering Supervisory) Lamp, and restoring the "A" Switchboard to normal.

When the Called Subscriber answers (Called Handset OFF Switchhook):

1) Ringing Current is tripped (cut off) automatically.

2) The District Selector Circuit supplies Talking Battery and Ground to the Calling Subset.

3) The Incoming Selector Circuit supplies Talking Battery and Ground to the Called Subset.



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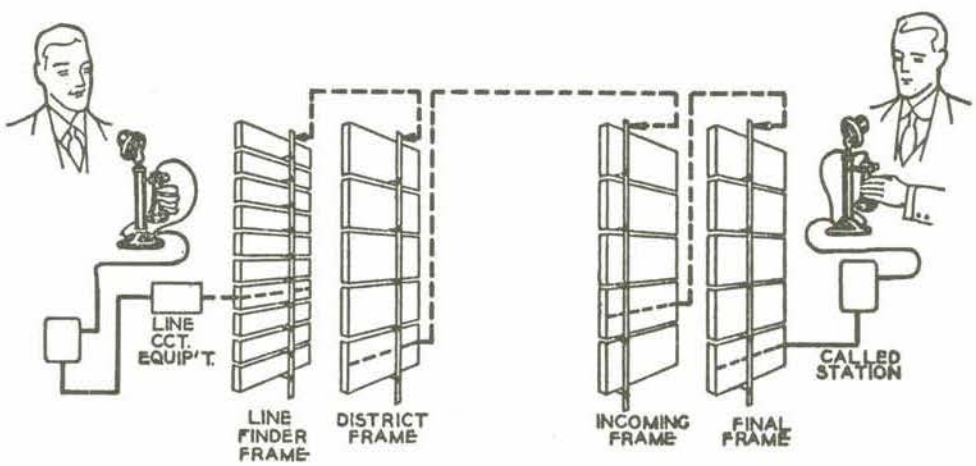
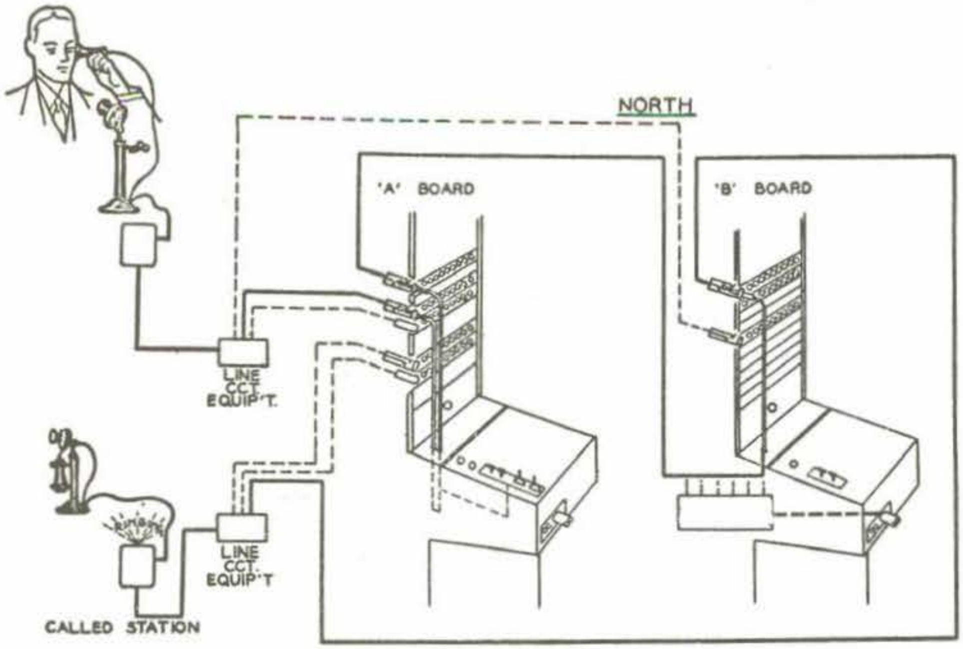


When the Panel Dial Subscribers replace their Handsets, the 1) Line Finder,
2) District,
3) Incoming, and
4) Final Selector
Brush Rods restore to normal, ready for use in handling other calls.



A Call between two NORTH Manual Subscribers would originate at the NORTH "A" Switchboard and terminate through the NORTH "B" Switchboard.

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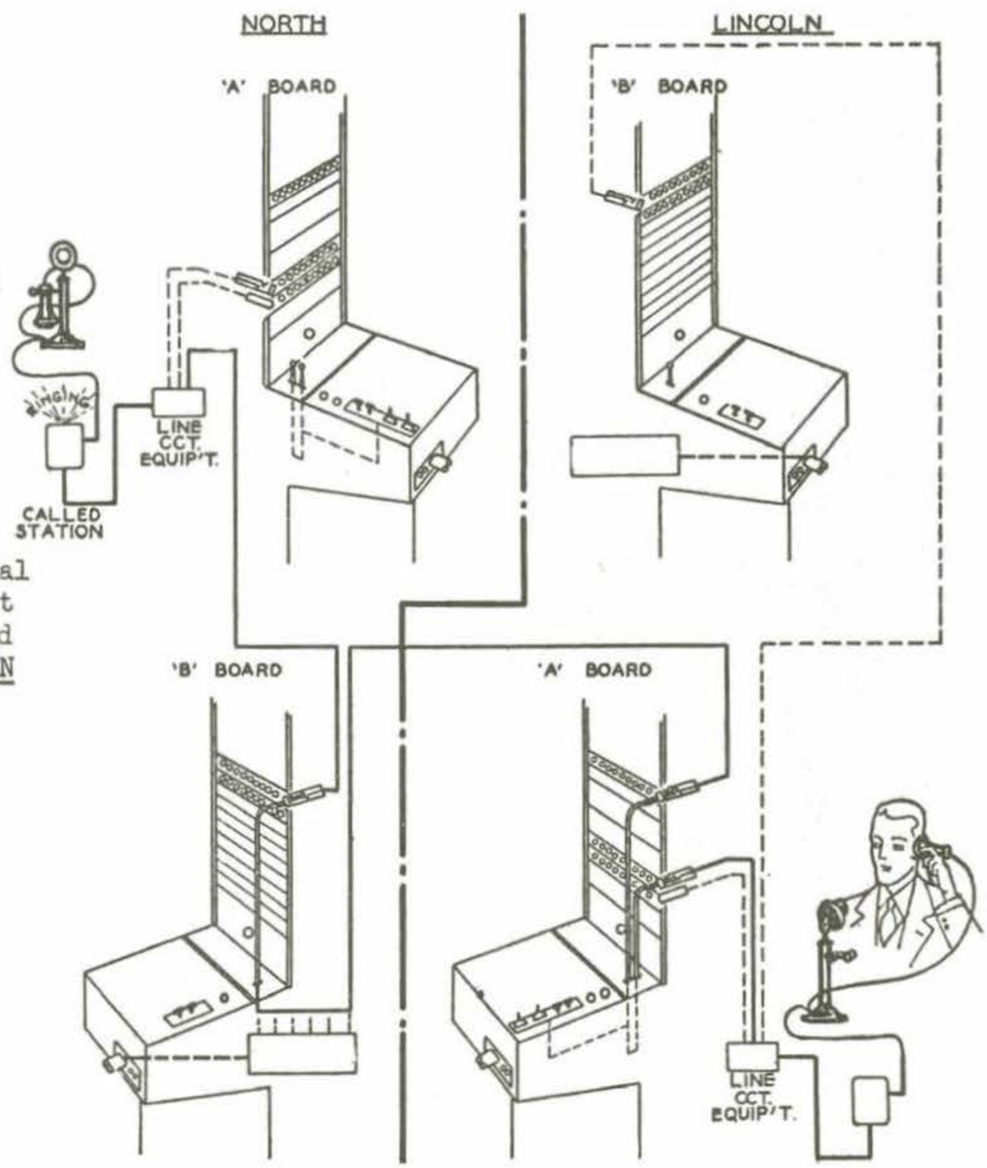
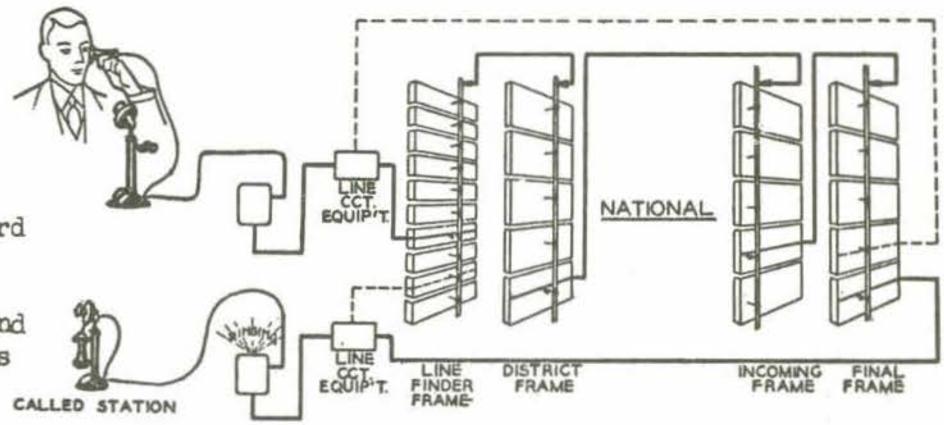
A Call from a LINCOLN Manual Subscriber to a NORTH Manual Subscriber would originate at the LINCOLN "A" Switchboard and terminate through the NORTH "B" Switchboard.

A Call from a NORTH Manual Subscriber to a LINCOLN Manual Subscriber would originate at the NORTH "A" Switchboard and terminate through the LINCOLN "B" Switchboard.



In handling a Call between two NATIONAL Panel Dial Subscribers:

1) The Line Finder and District Selector Frames replace the Manual "A" Switchboard as the originating switching equipment.
2) While the Incoming and Final Selector Frames replace the Manual "B" Switchboard as the terminating switching equipment.



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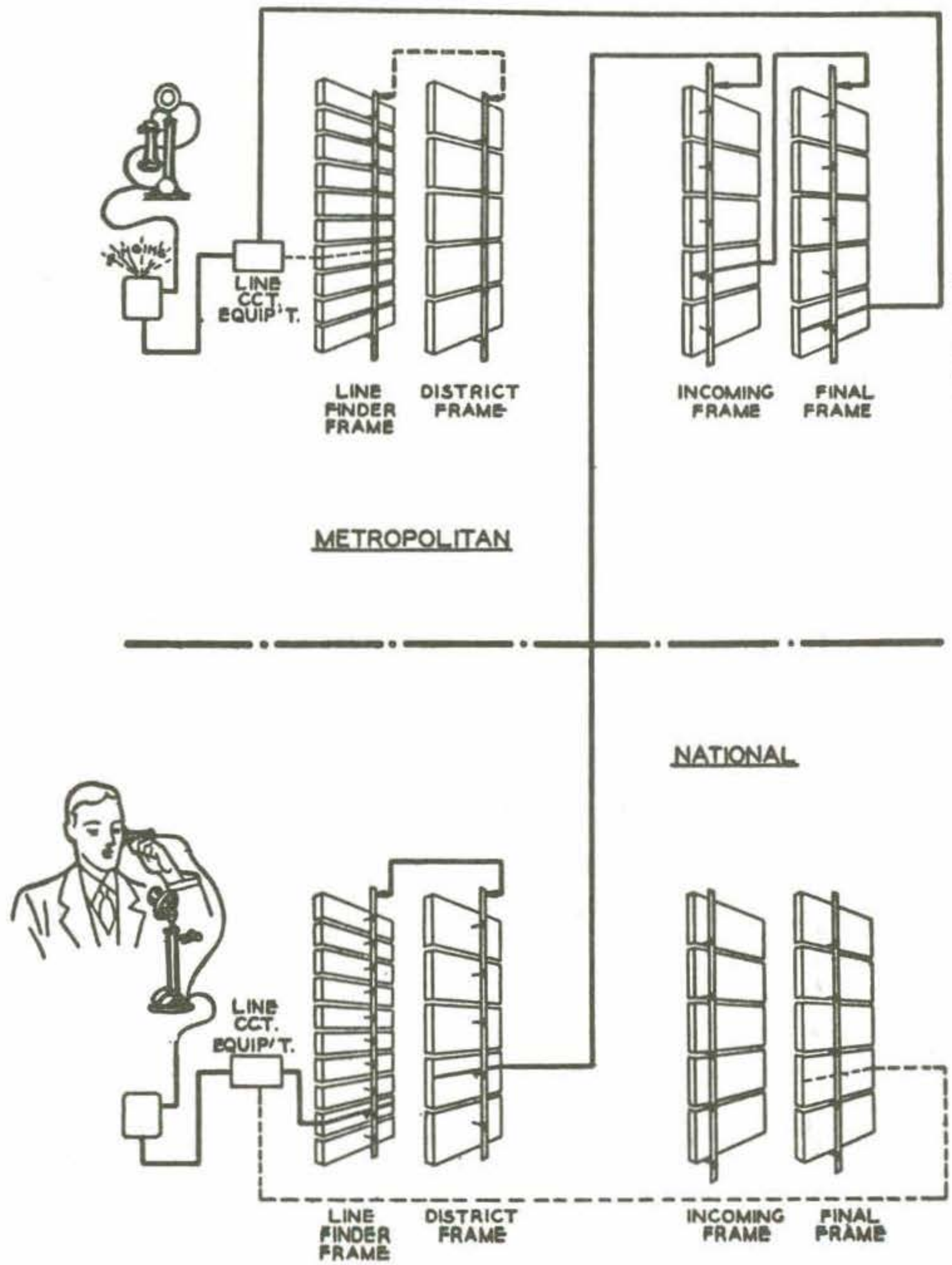
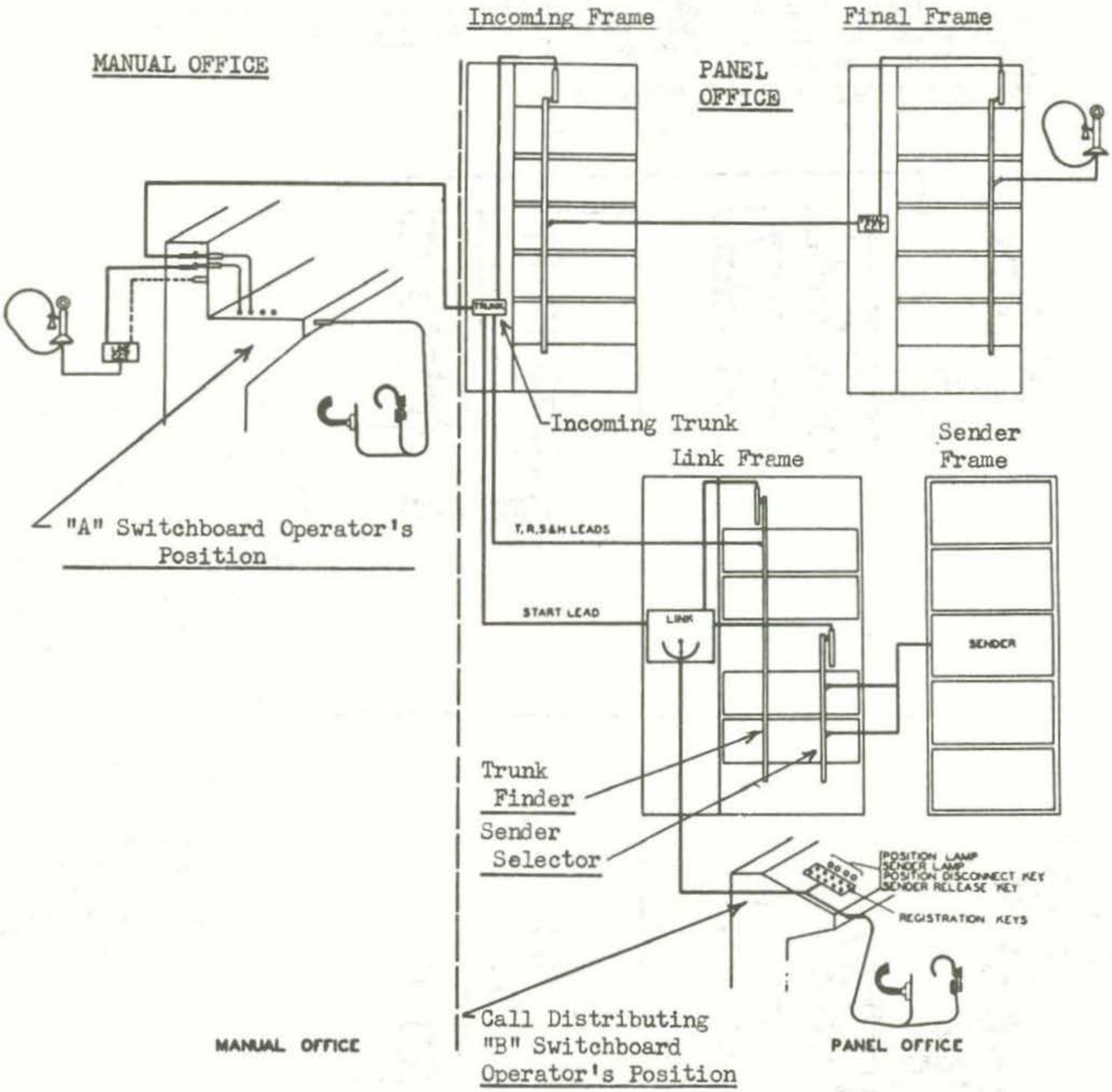


A Call made by a NATIONAL Panel Dial Subscriber to a METROPOLITAN Panel Dial Subscriber is switched through:

1) The Line Finder and District Selector Frames in the NATIONAL Central Office Building.
2) The Incoming and Final Selector Frames in the METROPOLITAN Central Office Building, and
3) The Sender in the NATIONAL Office has control of all selections in both Central Offices.

PATH OF A CALL FROM A MANUAL SUBSCRIBER TO A PANEL DIAL SUBSCRIBER

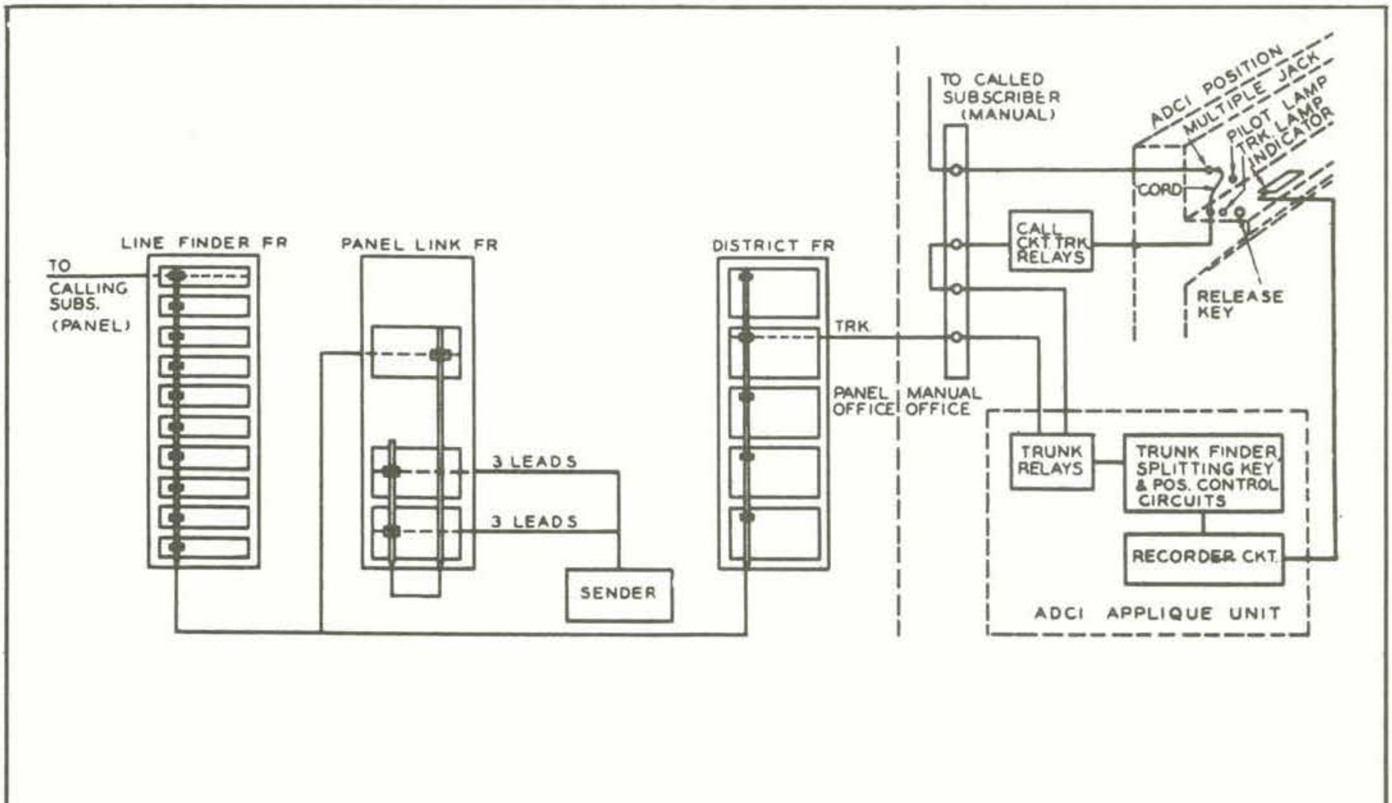
1) The Manual "A" Operator passes the Called Subscriber Number to the Panel Dial "B" Operator.
2) The Panel Dial "B" Operator keys the Number into the Sender.
3) The Sender sets up the Call from the Incoming Trunk to the Called Subscriber Line through the Incoming and Final Selector Frames.



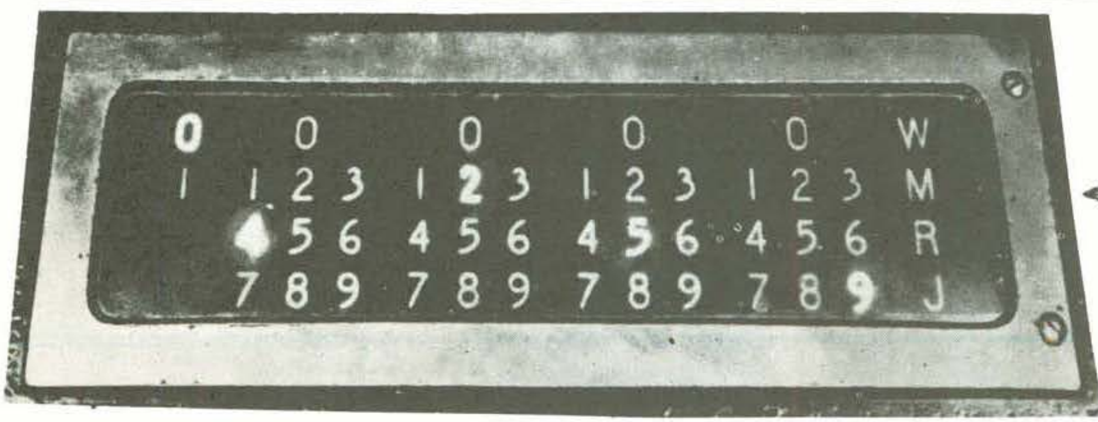
PATH OF A CALL FROM A PANEL DIAL SUBSCRIBER TO A MANUAL SUBSCRIBER

ADCI (Automatic Display Call Indicator) Method

1) The Panel Dial Calling Subscriber dials the Called Subscriber Number into the Panel Sender.
2) The Sender controls selection of an Idle Outgoing Trunk to the Manual Office.
3) The Sender "outpulses" the Called Subscriber Number, over the Trunk, into the ADCI Equipment in the Manual Office.
4) The ADCI Equipment registers and translates the pulses into signals which light up the proper digits on the Indicator glass plate.
5) The Panel Dial "B" Operator reads the Called Subscriber Number on the Indicator and inserts the Incoming Trunk Cord Plug into the Subscriber Multiple Jack, "wiping out" the display. The ADCI Equipment is now ready to handle the next Waiting Call.
6) Since this method of handling calls was developed for the Panel Dial System, the pulses are called PCI (Panel Call Indicator) Pulses.

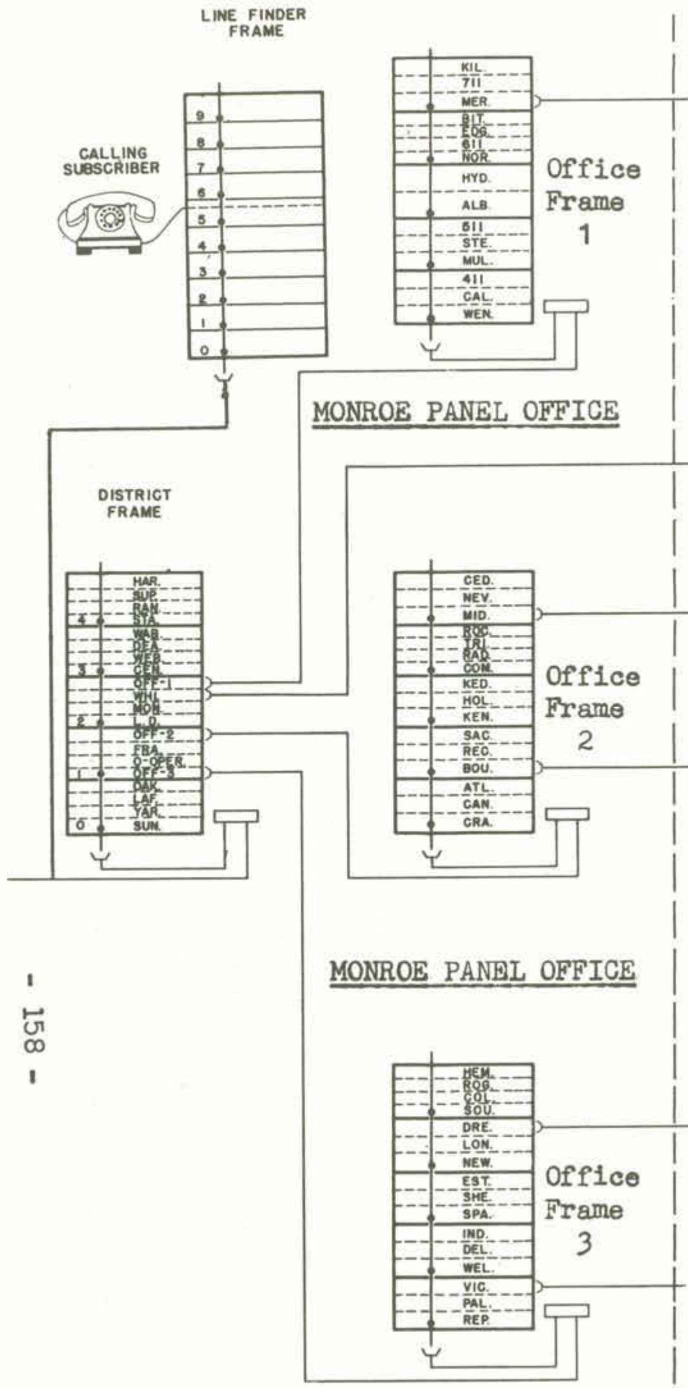


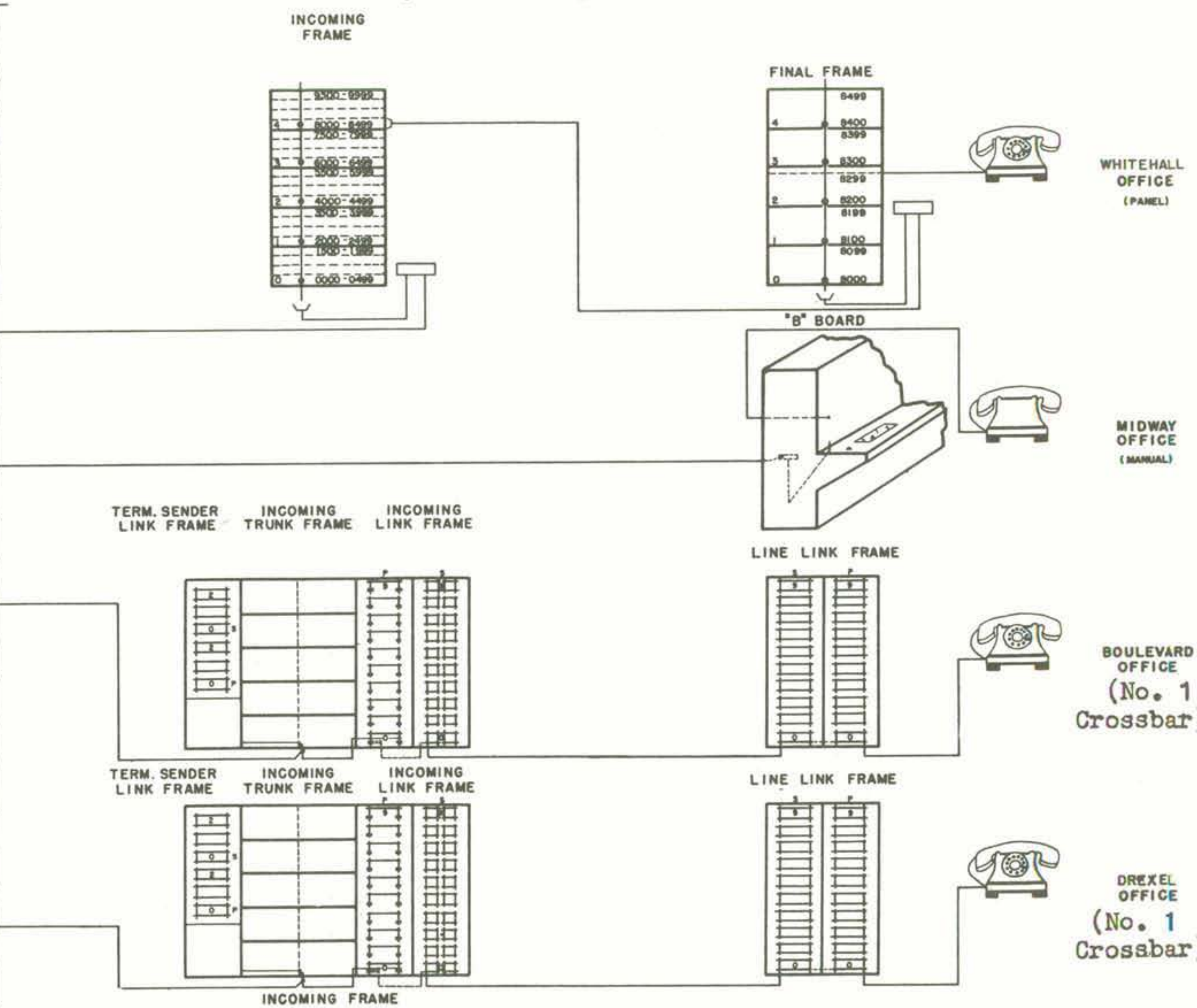
PATH OF A CALL BETWEEN PANEL DIAL SYSTEM AND MANUAL SYSTEM SUBSCRIBER

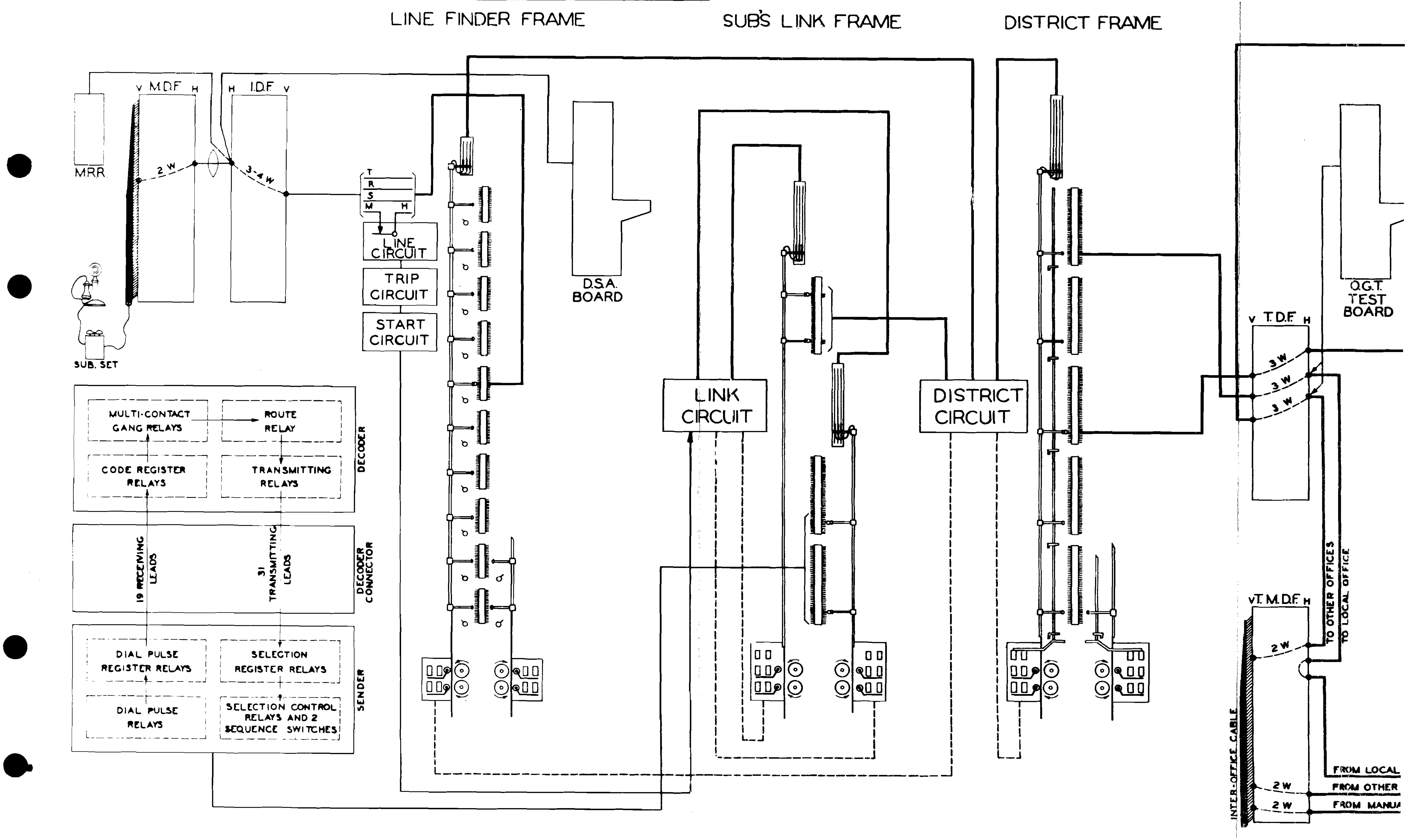


← Call Indicator Display

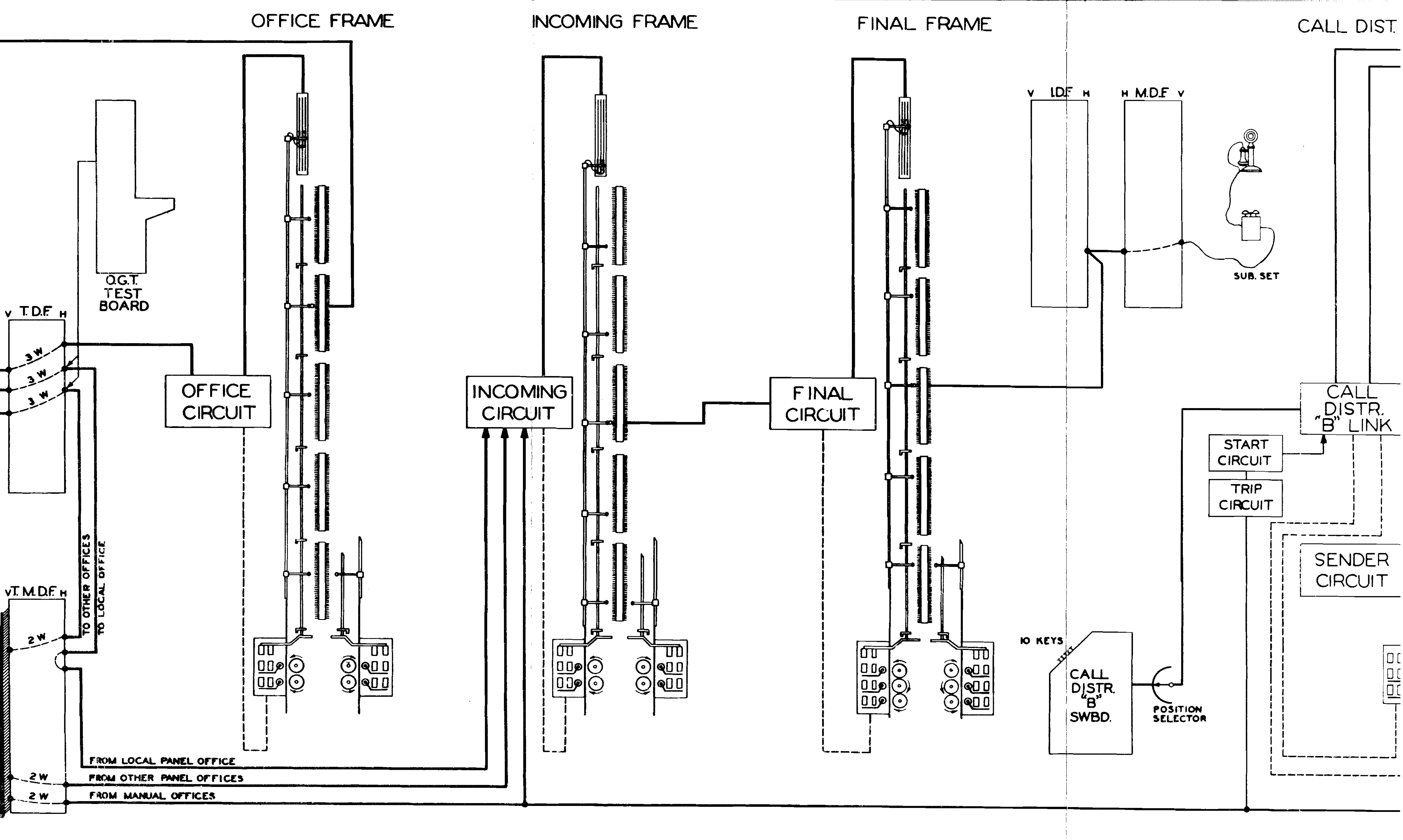
In large Central Office Buildings, the number of Outgoing Trunks to the different Central Offices exceeds the capacity of the District Selector Frame. Additional Trunks appear on Office Selector Frames. Thus some Calls are switched directly to the Outgoing Trunk through the District Selector Frame, while others are routed through the Office Selector Frame. The Decoder sets up the Sender for Office Selections (OB and OG - Office Brush and Office Group), in addition to District Selections, when Calls are routed through the Office Selector Frame.







EQUIPMENT REQUIRED FOR



REQUIRED FOR HANDLING PANEL DIAL TRAFFIC

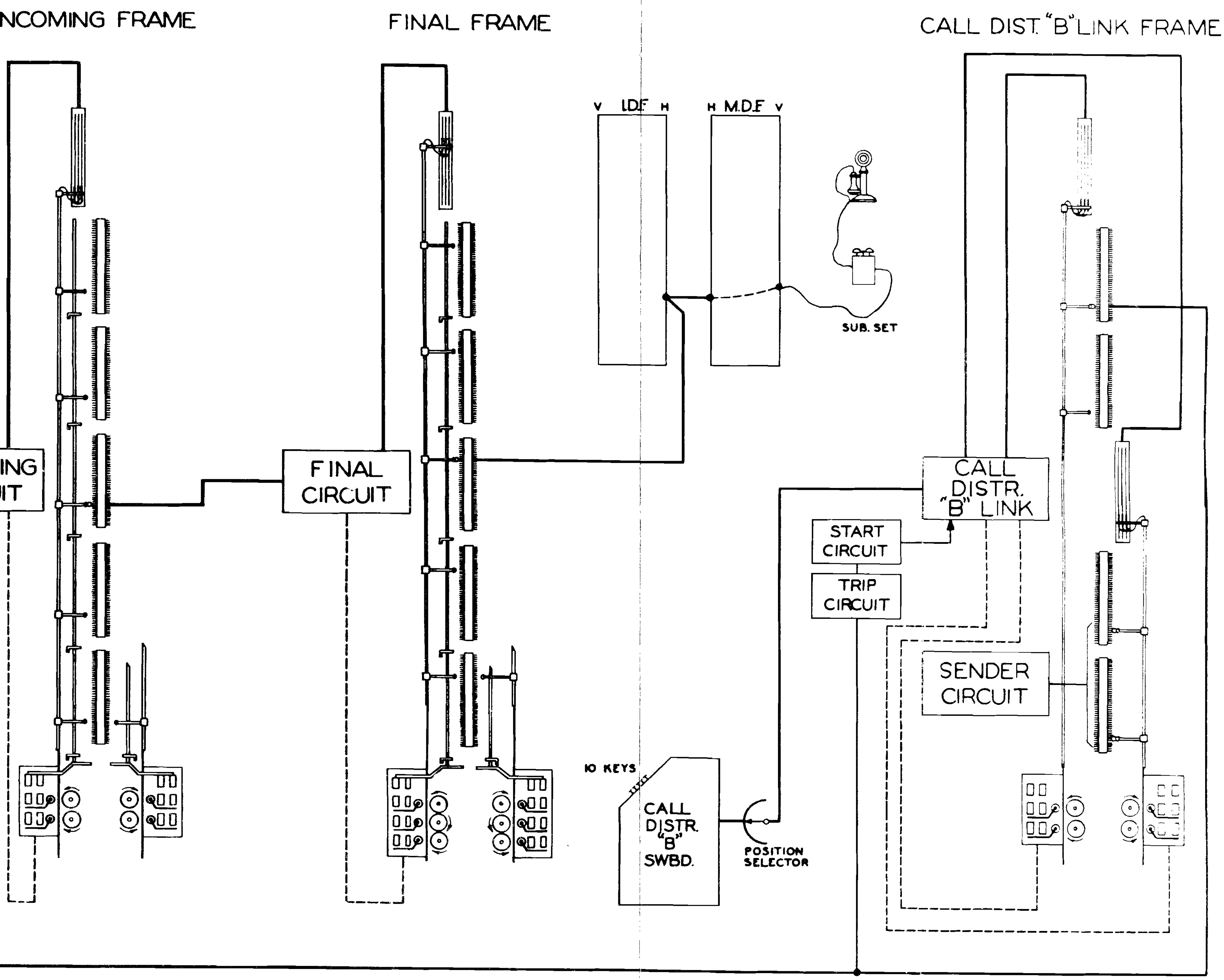


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FIG - 1

Lesson No. 1

FUNDAMENTALS OF TELEPHONY

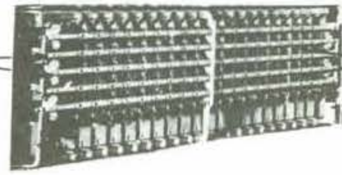
Section 11

The Crossbar Dial Switching System

CONTENTS

Crossbar - So called because of Horizontal Selecting Bars mounted across, and in front of, Vertical Holding Bars on the Crossbar Switch, the main Switching Device in building up a Talking Path between two Subscribers.

Horizontal Selecting Bars

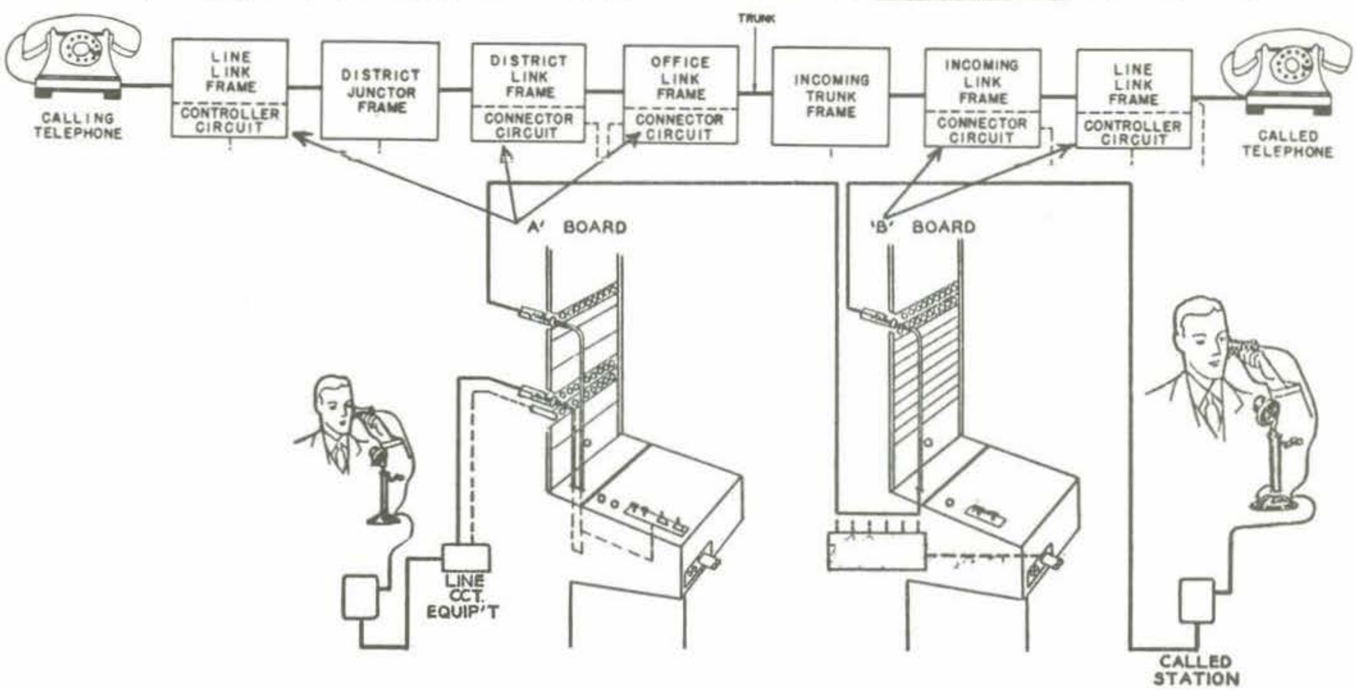


Vertical Holding Bars

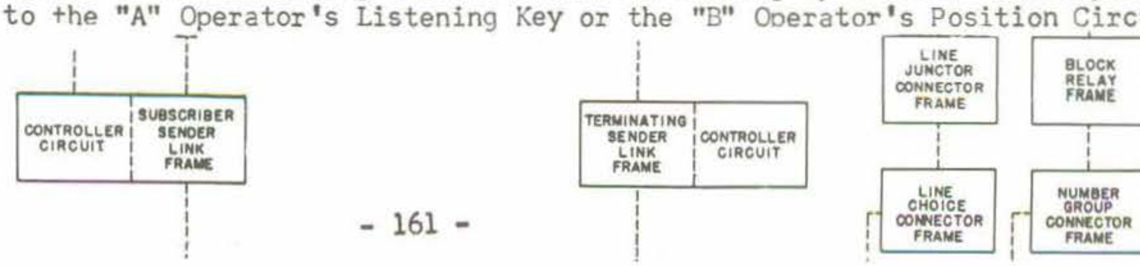
Main Divisions of Crossbar Switching Equipment (No. 1 Crossbar Dial System):

1) The Common Control Equipment, which replaces Switchboard Operators, builds up a Talking Path by operating Crossbar Switches on the Frames making up the Switching Network.

2) The Switching Network, which replaces the Switchboards, consisting principally of Crossbar Switches on which the Talking Path is built up.

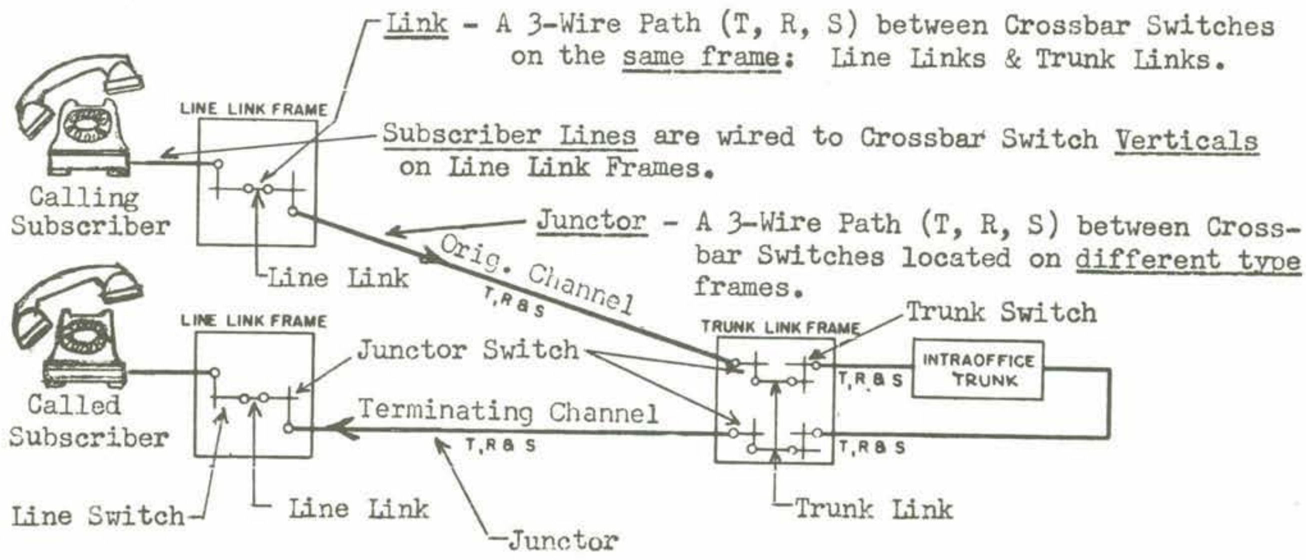


3) Connector and Sender Link Frames - Afford the Common Control Equipment access to the Switching Network Frames in setting up a Call. Corresponds to the "A" Operator's Listening Key or the "B" Operator's Position Circuit.



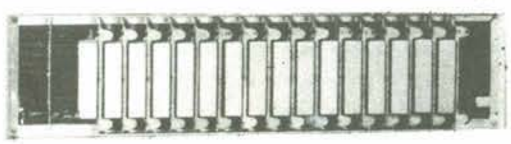
Crossbar Dial Subscriber Lines and Trunks are cabled to Crossbar Switches mounted on the Switching Network Frames.

NO. 5 Crossbar Dial System

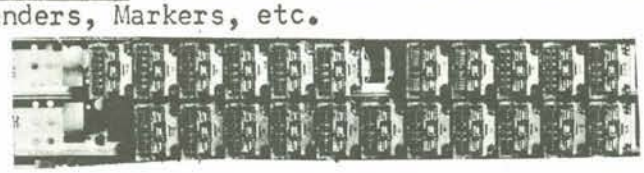


Crossbar Frames are made up of 3 Major Apparatus Items:

1) Crossbar Switch - Used principally in building up the Talking Path.
2) Multicontact Relays - For connecting a large number of leads between Frames in setting up a Call.

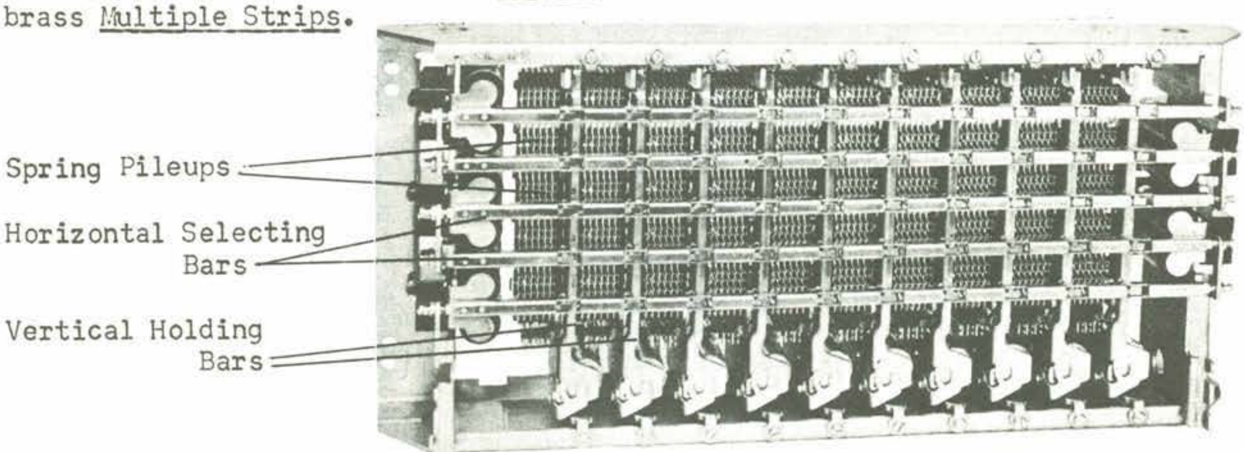


3) General Purpose Relays - Used in Trunk Circuits and Control Circuits, Registers, Senders, Markers, etc.

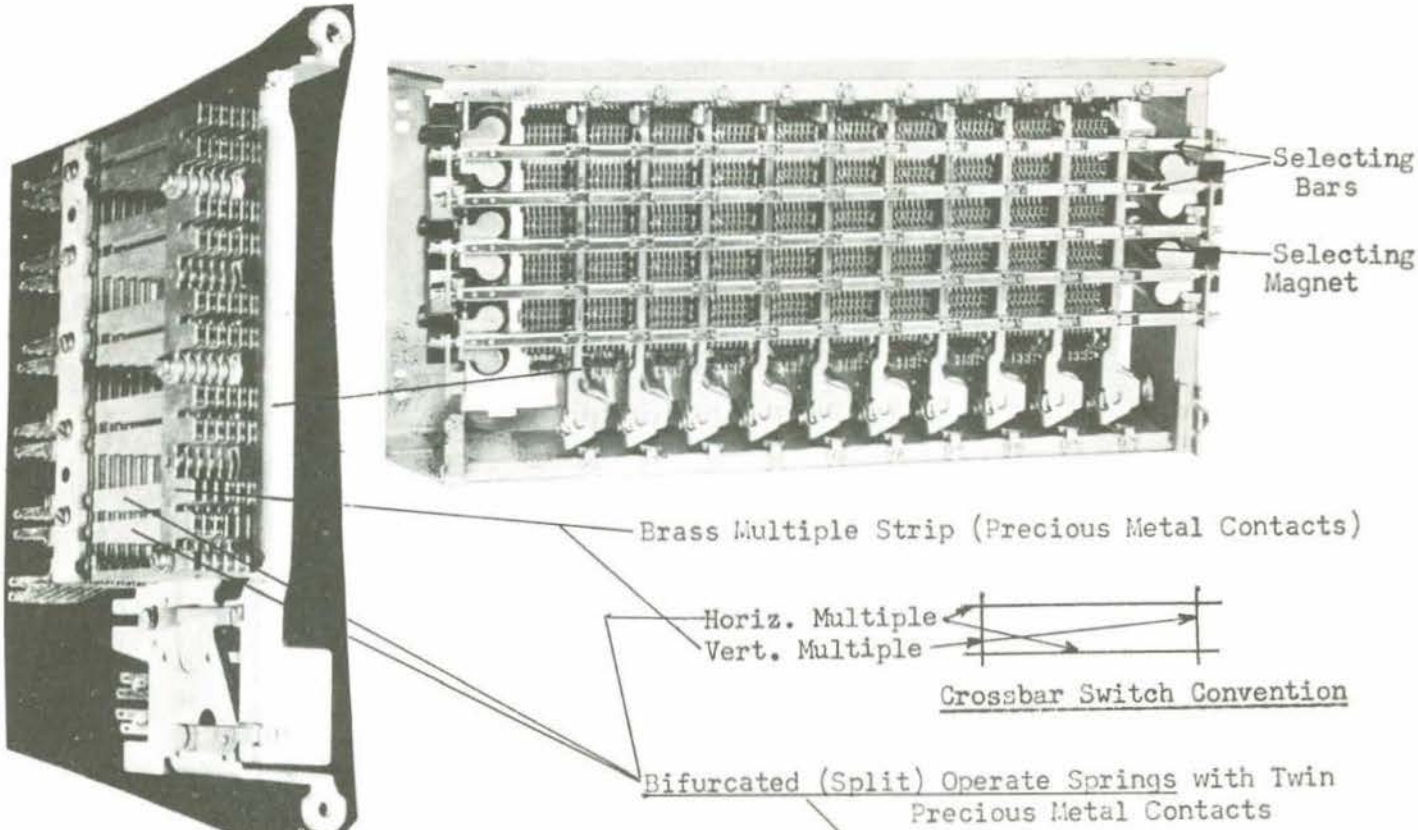


THE CROSSBAR SWITCH

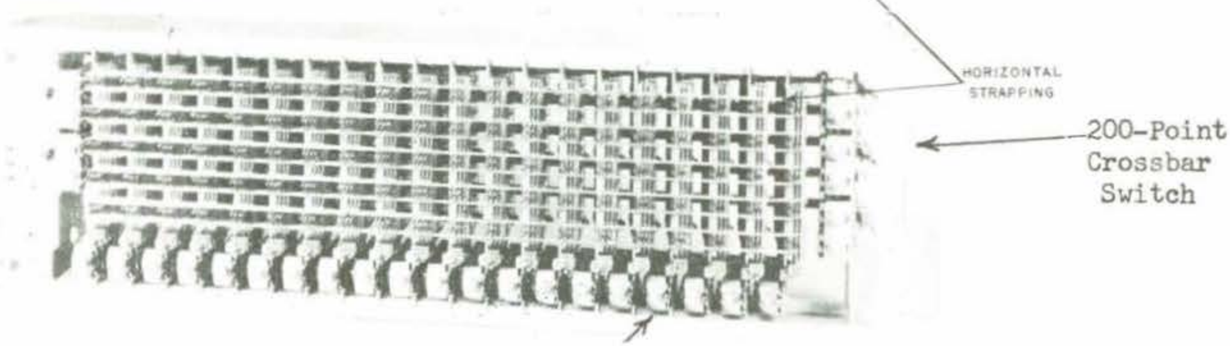
A "2-Step" Relay made up of a large number of "make" contacts on Operate Springs, arranged in Horizontal Rows or Levels, and stationary mate contacts on Vertical brass Multiple Strips.



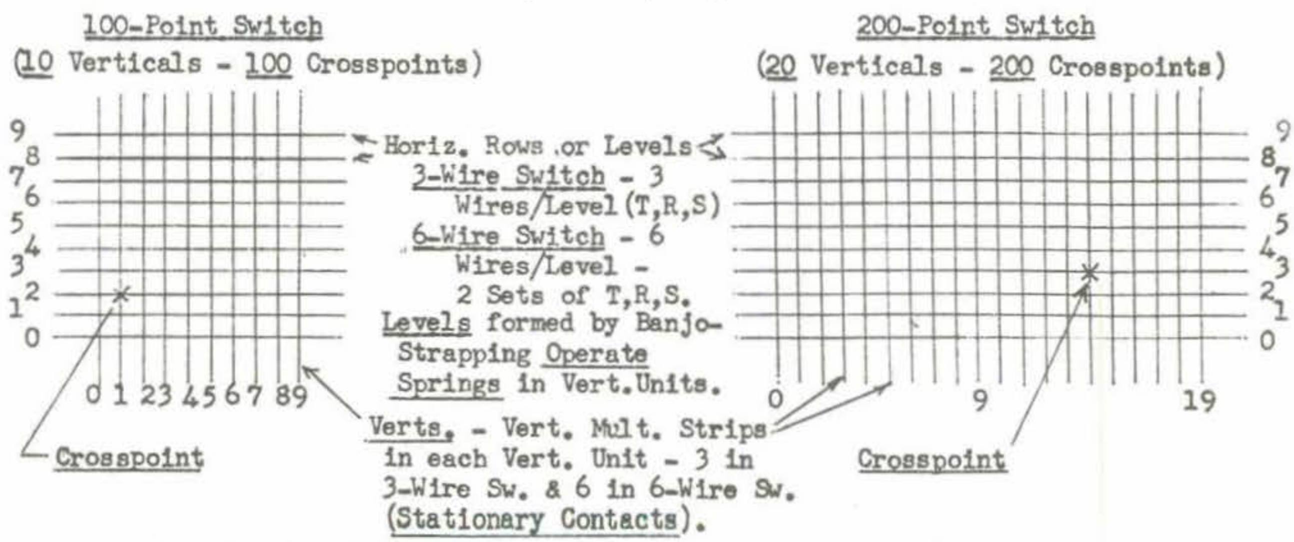
100-Point Crossbar Switch



Crossbar Switch Vertical Unit

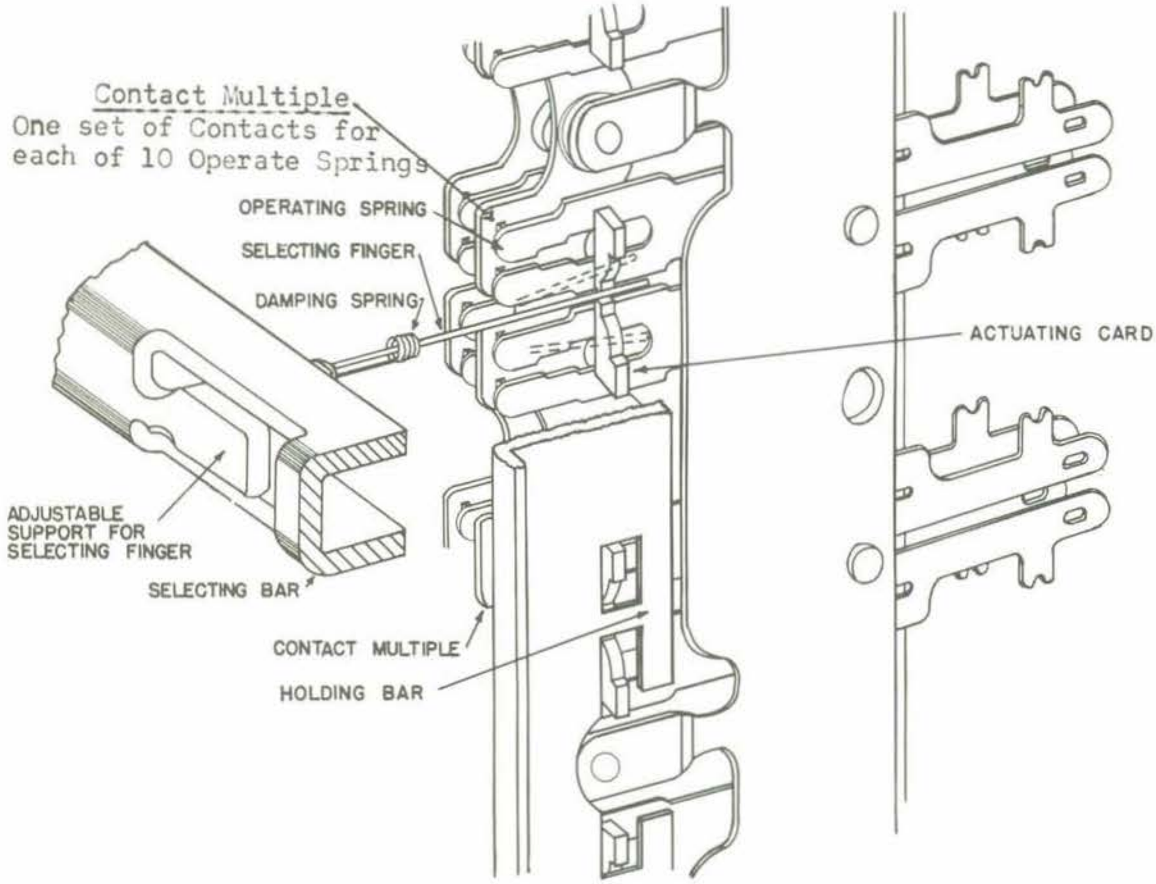


Rear View of Crossbar Switch Showing Horizontal (Banjo) Strapping of Operate Springs.

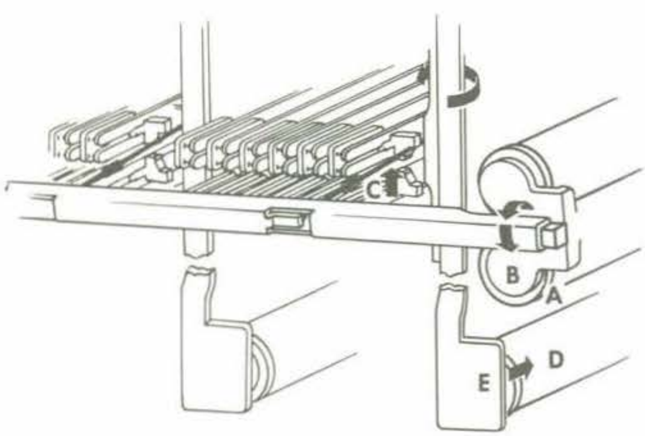


A Crosspoint is closed by operation of a Selecting Magnet (located at the end of the Switch), followed by operation of a Holding Magnet on one of the Vertical Units. After operation of the Holding Magnet, the Selecting Magnet releases.

CROSSBAR SWITCH SELECTING MECHANISM



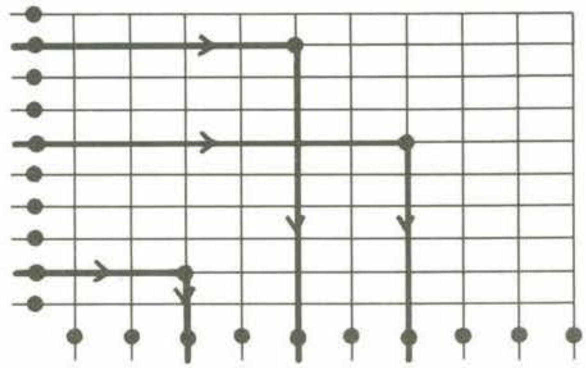
HOW THE CROSSBAR SWITCH WORKS



(1) The electromagnet marked (A) pulls the ear-like projection (B). This tilts the horizontal bar so that a wire (C) projecting from the bar into the switch mechanism is raised into position.

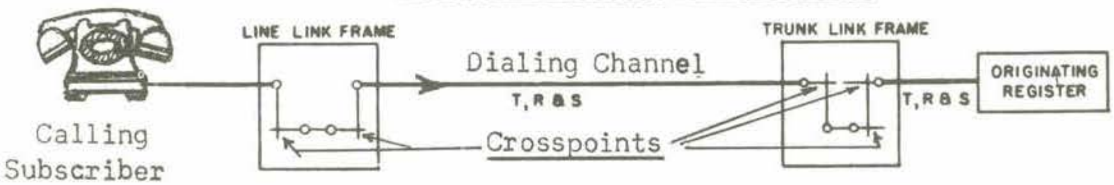
(2) The electromagnet (D) now operates and pivots the vertical bar (E) inward. The vertical bar pressing against the projecting wire (C) closes the contacts and completes the connection.

3 of 10 Possible Paths Through a Crossbar Switch



Common Control Equipment operates Crossbar Switches, closing a set of Crosspoints (on Switching Network Frames - For example: Line Link and Trunk Link Frames in No. 5 Crossbar) to pick up the "free ends" of one set of short pieces of circuits (Links and Junctors, wired to Crossbar Switch Verticals or Horizontals.), and "ties" them together to build up a Talking Path.

No. 5 Crossbar DIALING Channel



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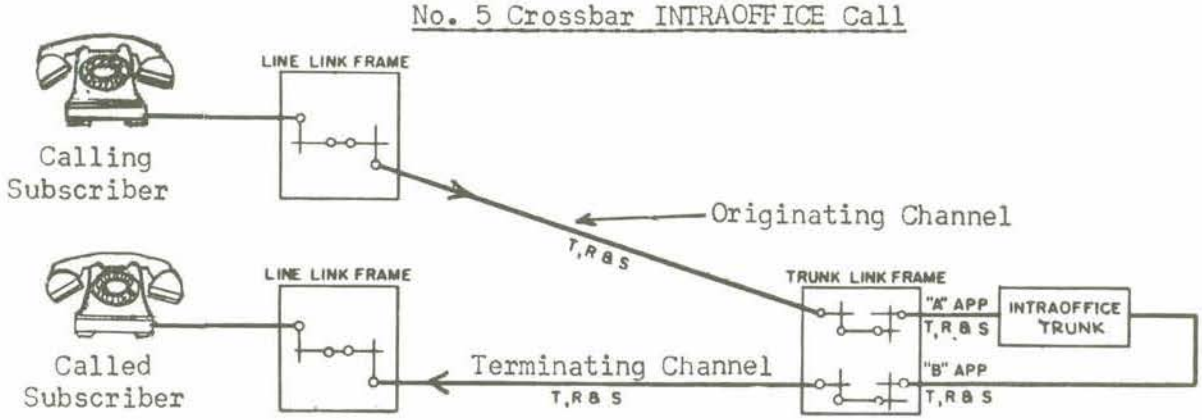
No. 5 Crossbar INTRAOFFICE Call



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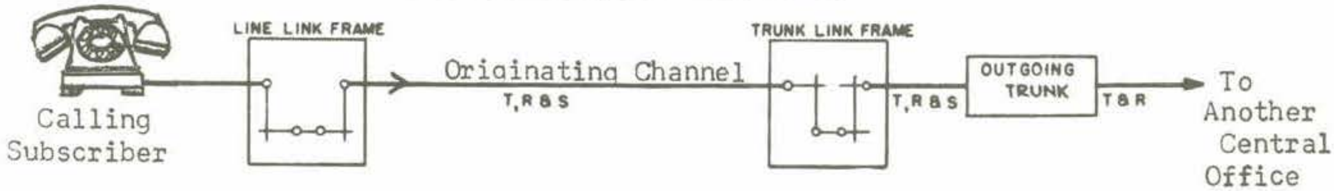
No. 5 Crossbar OUTGOING Call



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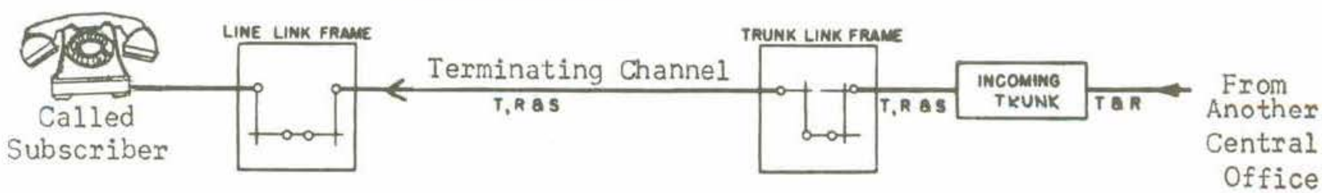
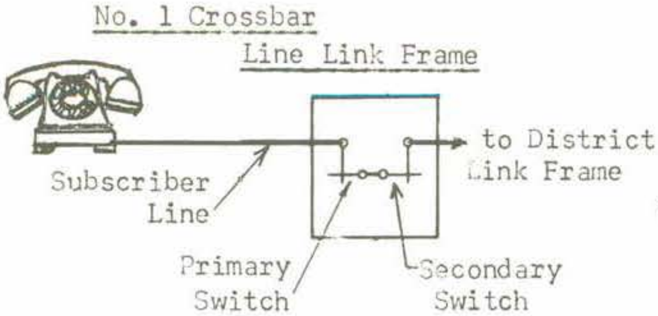
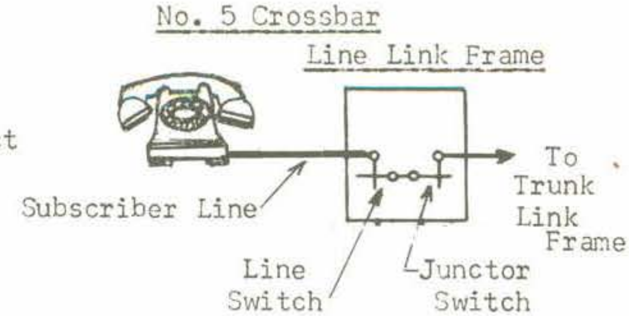
No. 5 Crossbar INCOMING Call



Subscriber Lines cable to Vertical Units of Crossbar Switches on Line Link Frames.





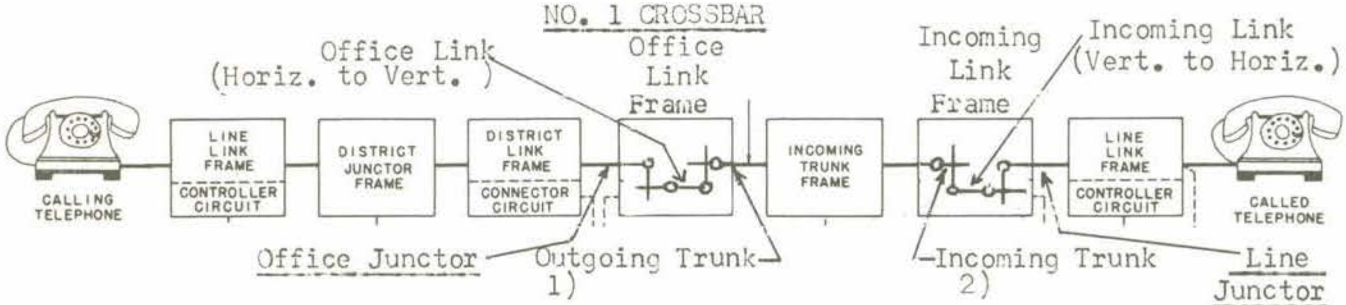
Trunks cable to Horizontals or Levels of:

1) Office Link Frames in No. 1 Crossbar.
2) Incoming Link Frames in No. 1 Crossbar.
3) Trunk Link Frames in No. 5 Crossbar.
4) Trunk Link Frames in Crossbar Tandem.
5) Office Link Frames in Crossbar Tandem.
6) Incoming Frames in No. 4A Crossbar Toll.
7) Outgoing Frames in No. 4A Crossbar Toll.

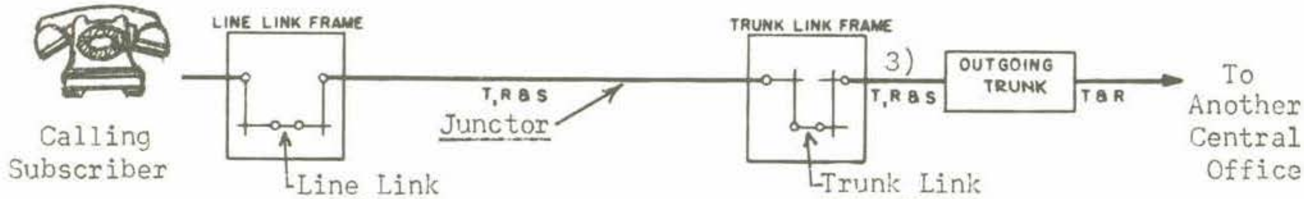
Links are paths between Crossbar Switches on the same Frame.

Junctors are paths between Crossbar Switches on different Frames.

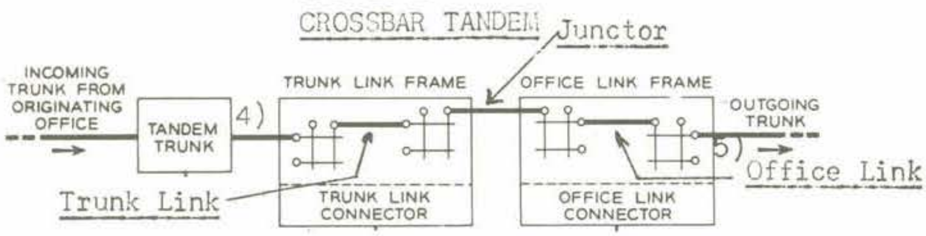
NO. 1 CROSSBAR



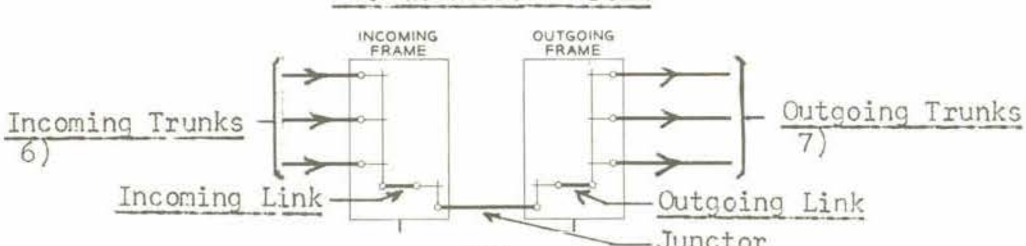
NO. 5 CROSSBAR



CROSSBAR TANDEM



NO. 4A CROSSBAR TOLL

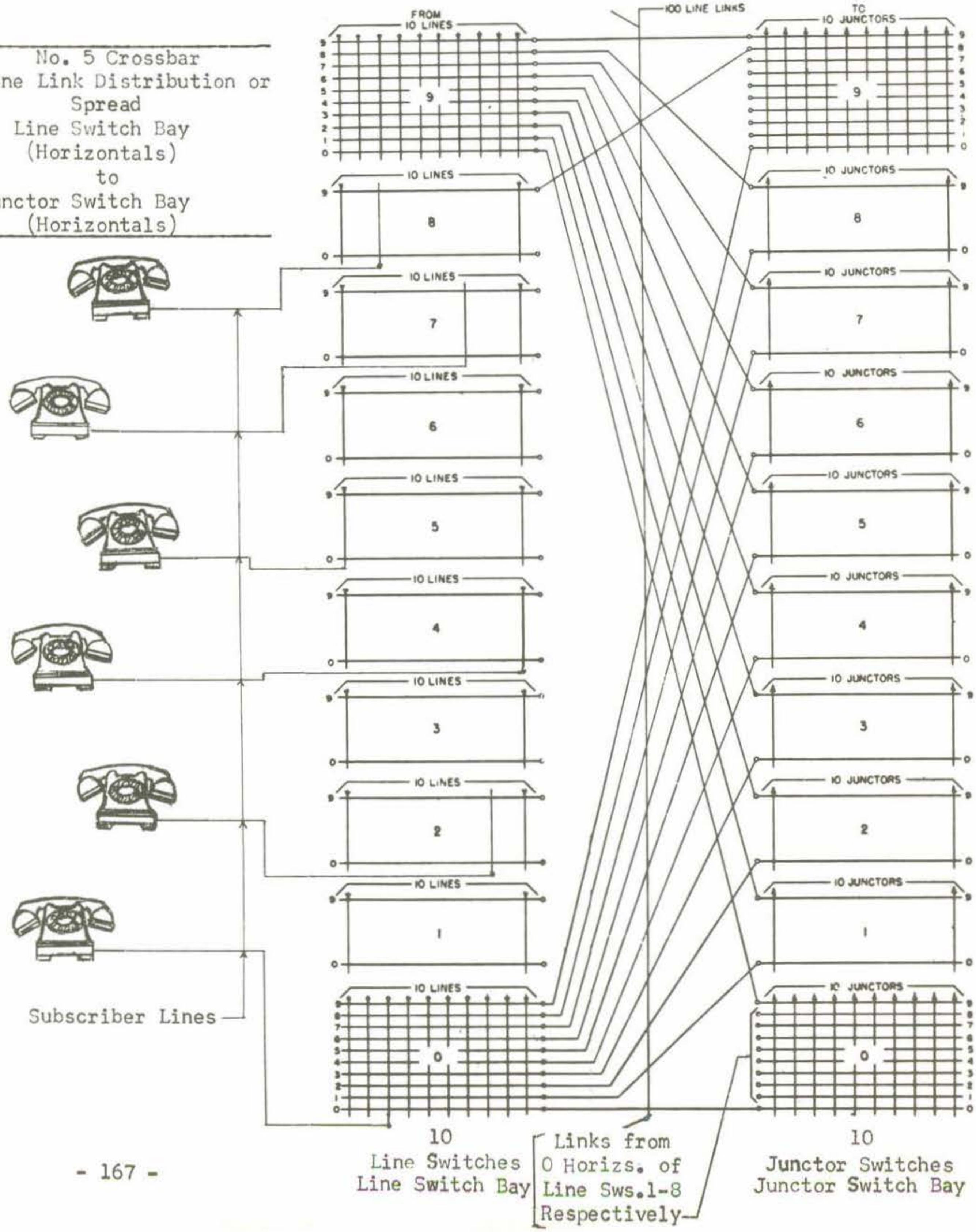


Crossbar Switches are used in "Tandem" (one following the other) in building up a Talking Path through the Switching Frames. For example, in Crossbar System Line Link Frames:

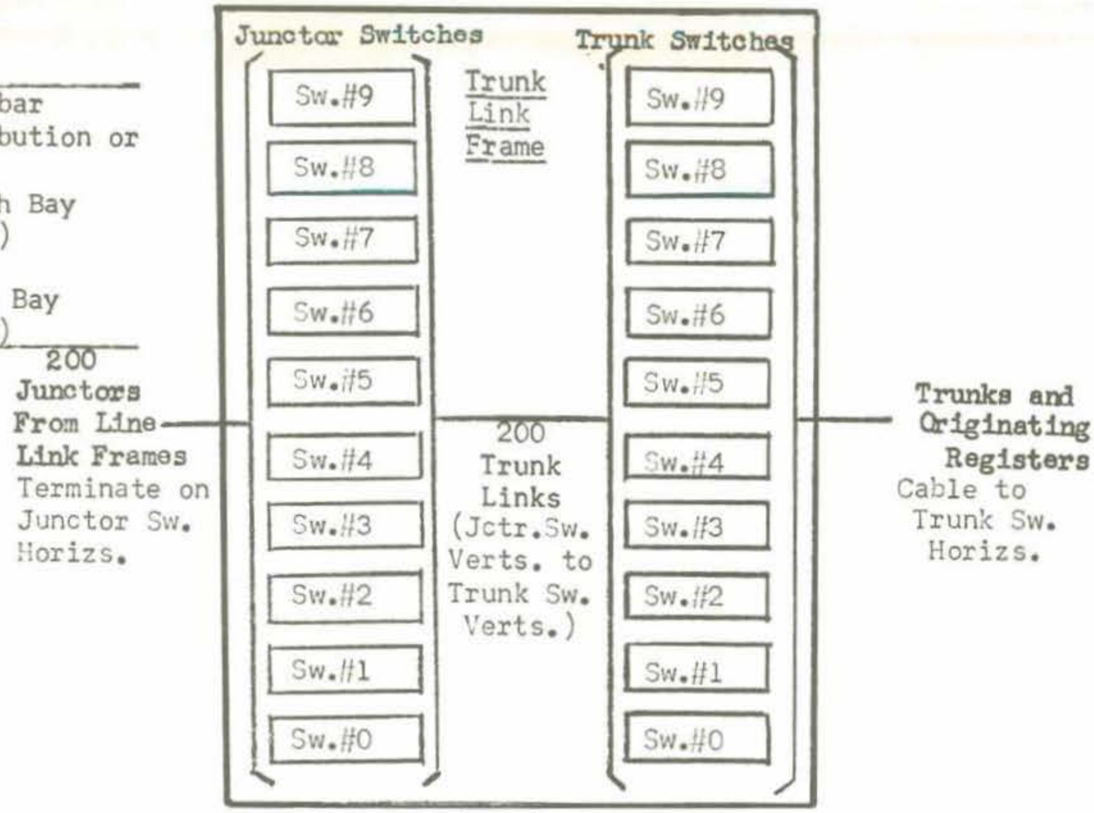
10 Switches mount, one above the other, in a Bay (the space between two Vertical Uprights) - No. 1 Crossbar Primary Bay,
No. 5 Crossbar Line Switch Bay.

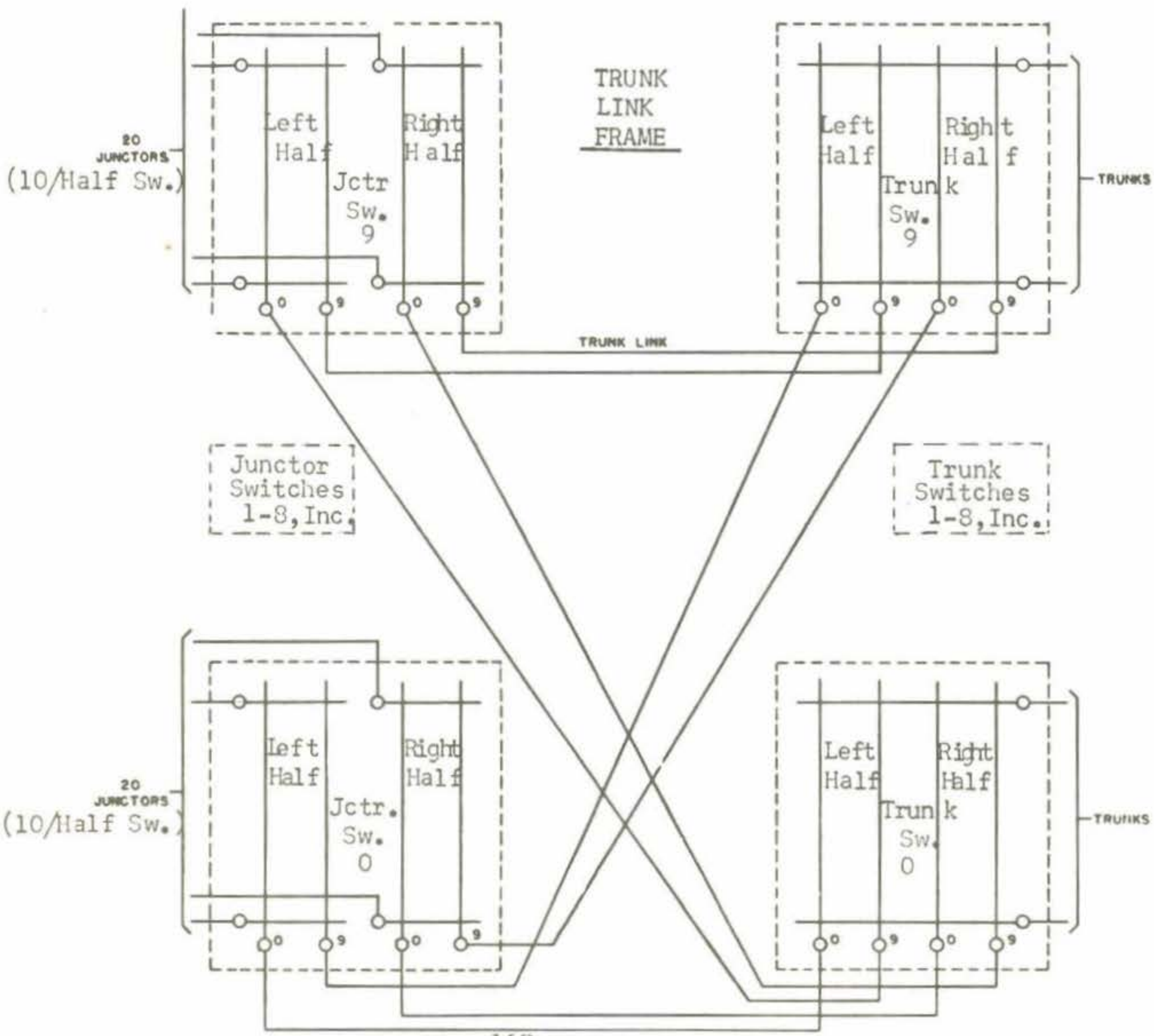
10 Other Switches mount, one above the other, in a second Bay, alongside the first Bay - No. 1 Crossbar Secondary Bay,
No. 5 Crossbar Junctor Switch Bay.

No. 5 Crossbar
Line Link Distribution or Spread
Line Switch Bay (Horizontals)
to
Junctor Switch Bay (Horizontals)



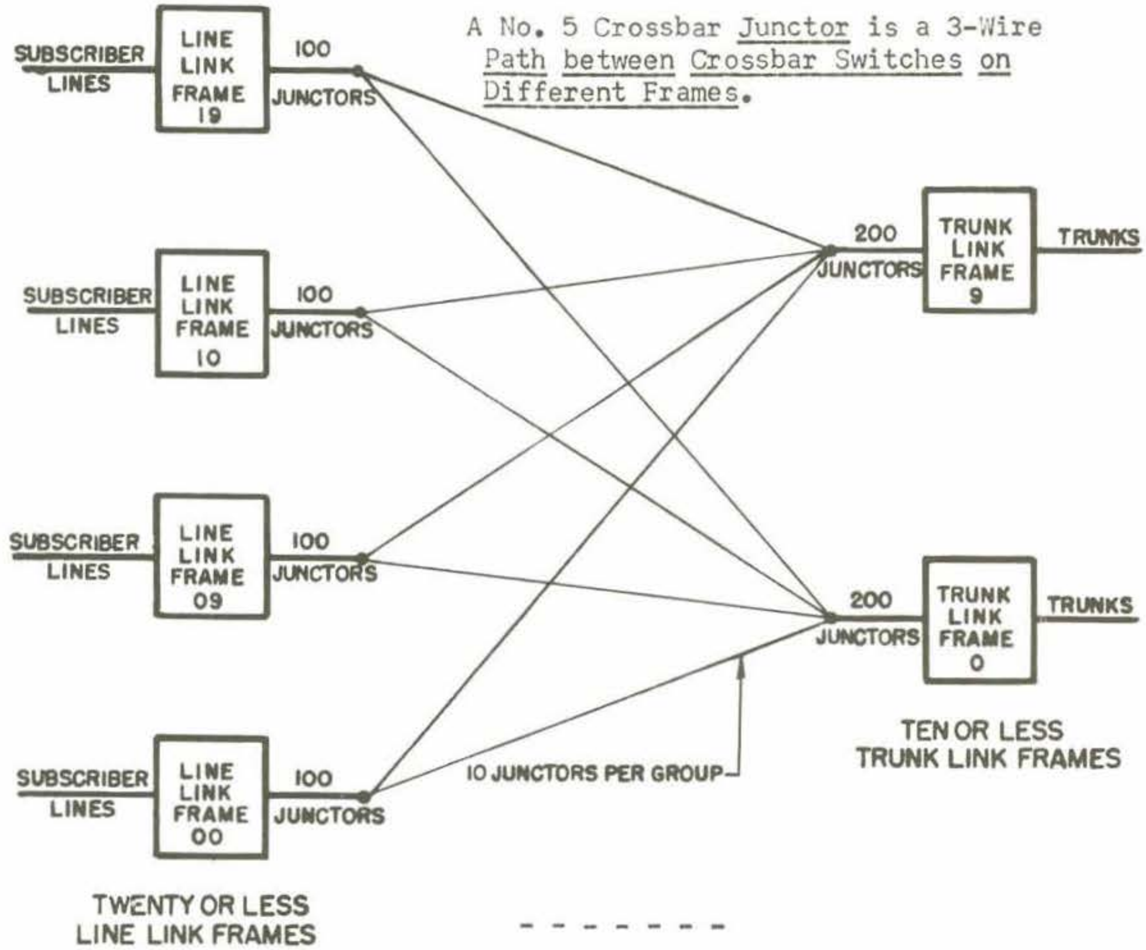
No. 5 Crossbar
Trunk Link Distribution or Spread
Junctor Switch Bay
(Verticals)
to
Trunk Switch Bay
(Verticals)





No. 5 Crossbar - Typical Junctor Distribution Pattern

A No. 5 Crossbar Junctor is a 3-Wire Path between Crossbar Switches on Different Frames.



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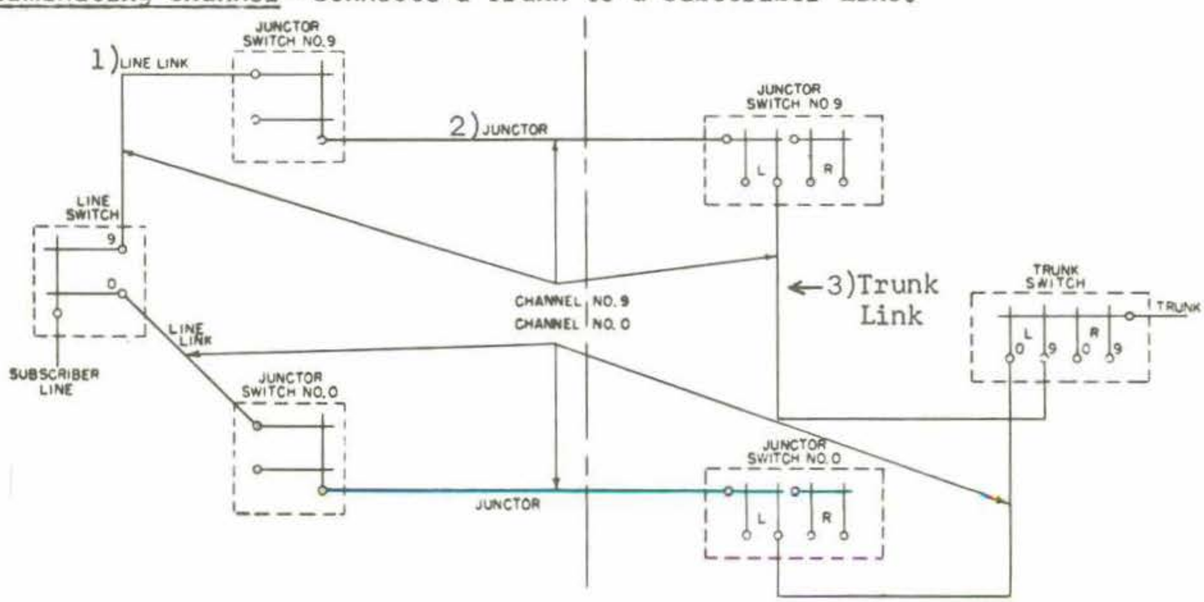
NO. 5 Crossbar CHANNELS

A Channel is a combination of 1) a Line Link, 2) a Junctor, and 3) a Trunk Link, selected by the Common Control Equipment, and "tied" together, end-to-end, by Crossbar Switch Crosspoint Closures, to interconnect a Subscriber Line and a Trunk or Register.

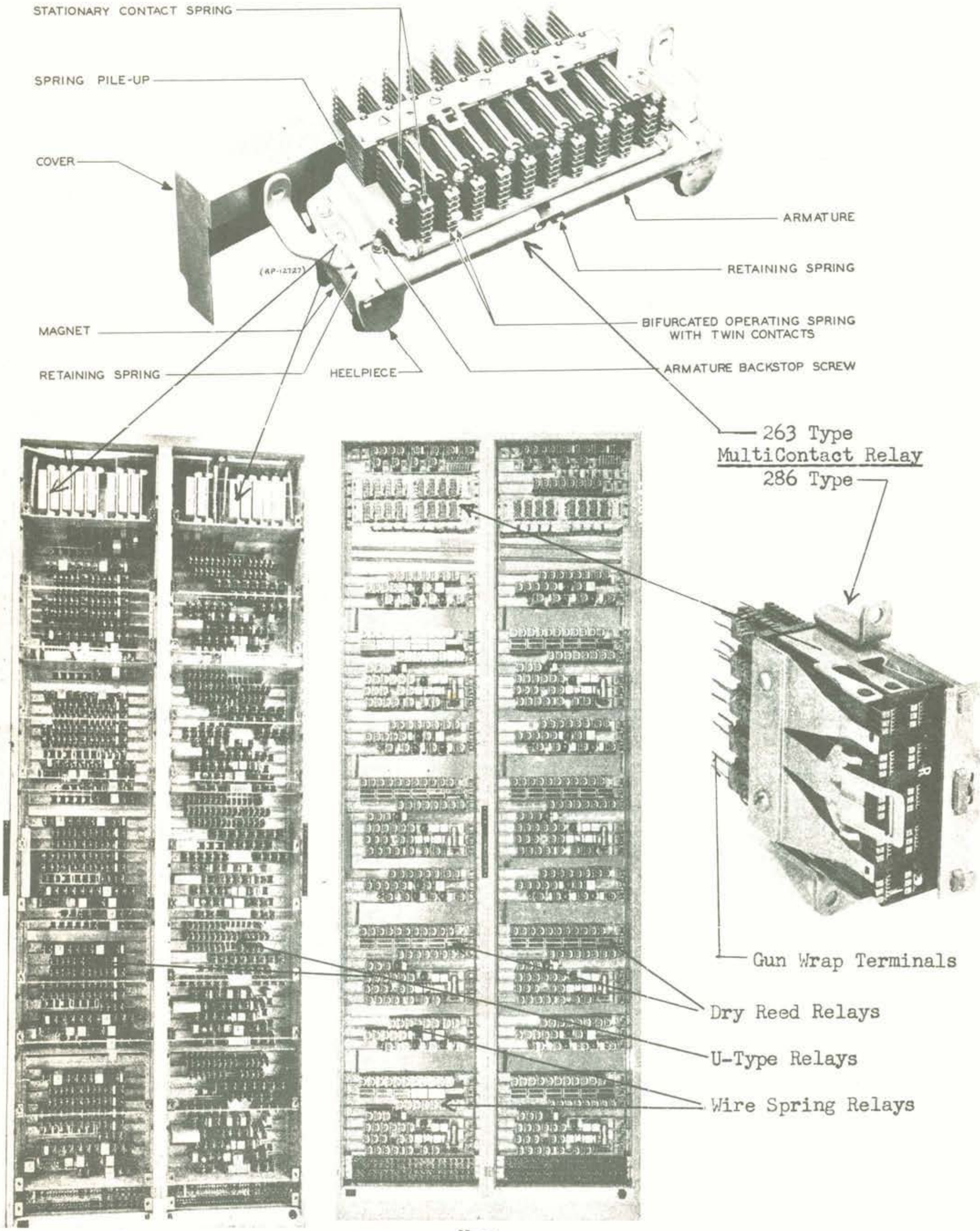
Dialing Channel - Connects a Calling Subscriber Line to an Originating Register.

Originating Channel- Connects a Subscriber Line to a Trunk.

Terminating Channel- Connects a Trunk to a Subscriber Line.



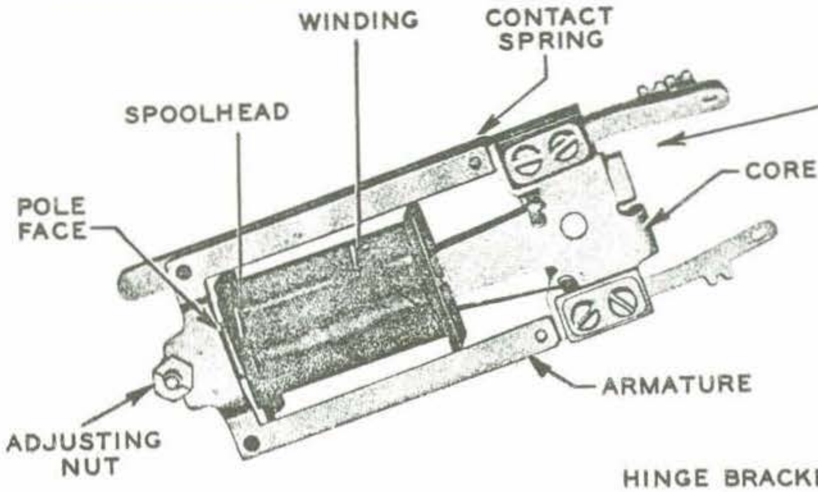
Multicontact Relays are used to cut through a large number of leads between Frames in Setting up a Call.



Old New

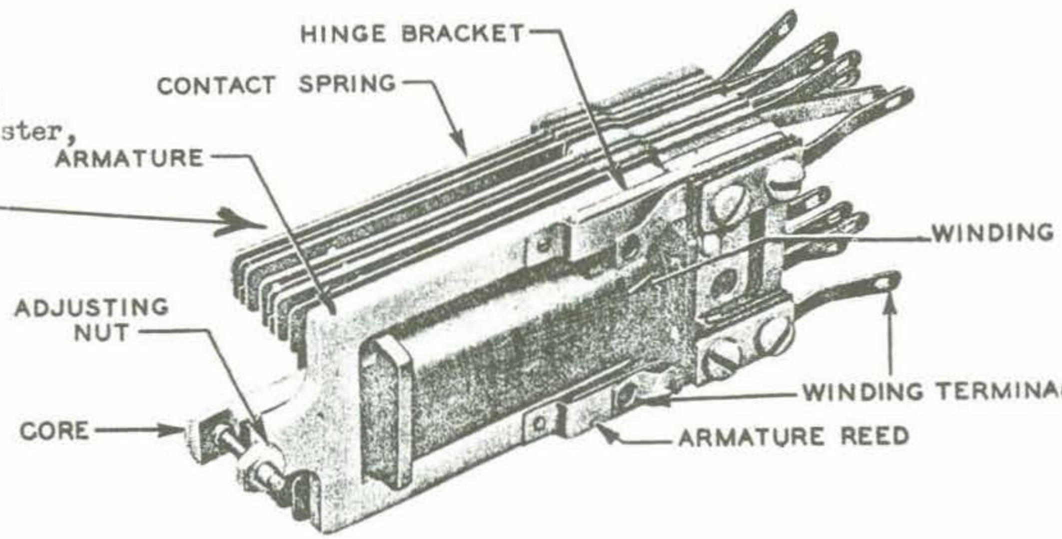
Originating Register Frames

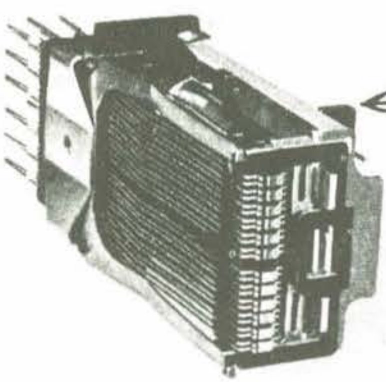
General Purpose Relays are used in Senders, Registers, Marker, Trunks and Control Circuits



FLAT TYPE RELAY - Used as Line Relay on Line Link Frame.

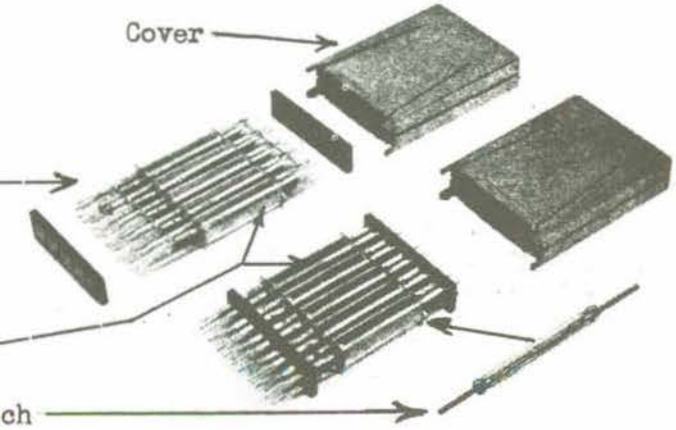
U TYPE RELAY - Used in Counting, Register, Steering, etc., Circuits.





WIRE SPRING RELAY - Replaces U Type in many applications.

DRY REED RELAY - Used in Digit Storage (Register) Circuits.

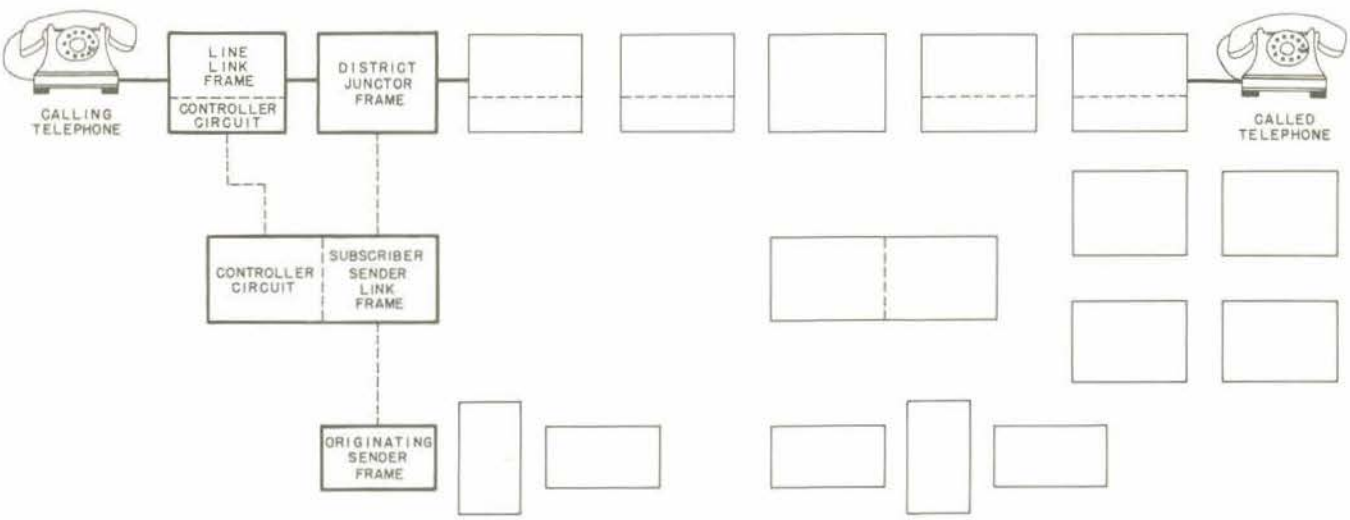


THE CROSSBAR SWITCHING SYSTEMS

1) No. 1 Crossbar - A Common Control Switching System replacing Panel Dial in Large Cities.
2) No. 4 Crossbar - A Common Control Toll or Long Distance Switching System. CAMA Equipment may be provided for No. 4A to record data for billing Calls.
3) No. 5 Crossbar - A versatile Common Control Switching System for Areas on the Outskirts of Large Metropolitan Centers, and for use in Medium to Large Offices, with Tandem and Toll Features, as well as facilities for Local Traffic.
4) Crossbar Tandem - A Common Control Switching System for Traffic Between Local Dial Offices, and a Toll Switching System for Intertoll Traffic, where the large capacity and full versatility of No. 4A Toll would not be economical. CAMA on Crossbar Tandem makes possible Subscriber Dialing of Calls where AMA is not available in Local Offices.

METHODS OF COMPLETING CALLS THROUGH THE CROSSBAR SYSTEMS

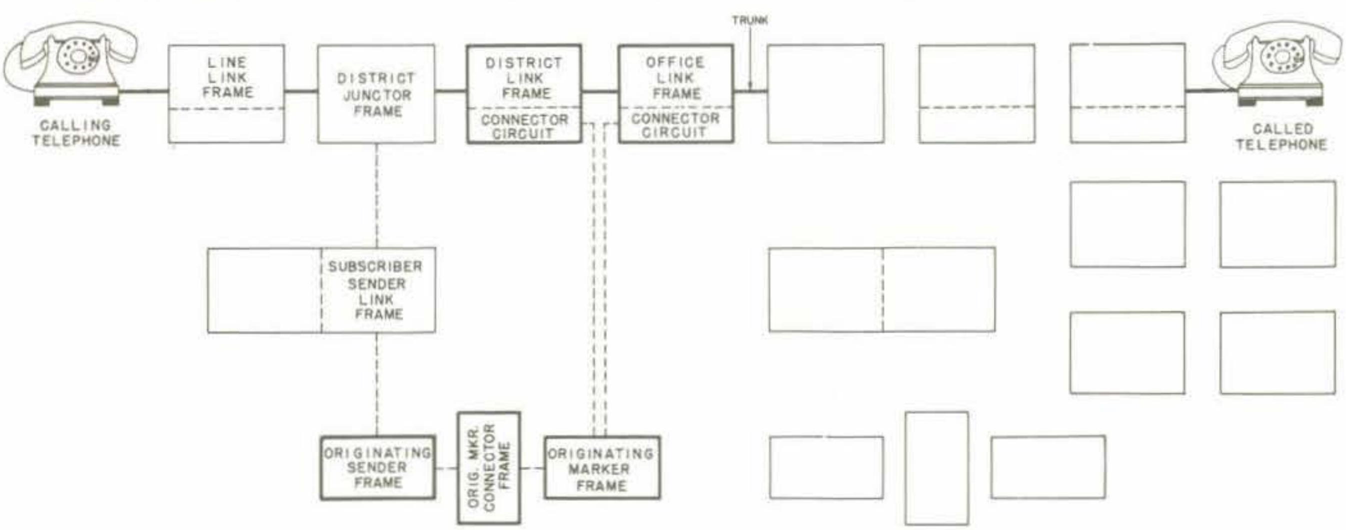
No. 1 Crossbar System



SK. 1

CALLING SUBSCRIBER REMOVES HANDSET

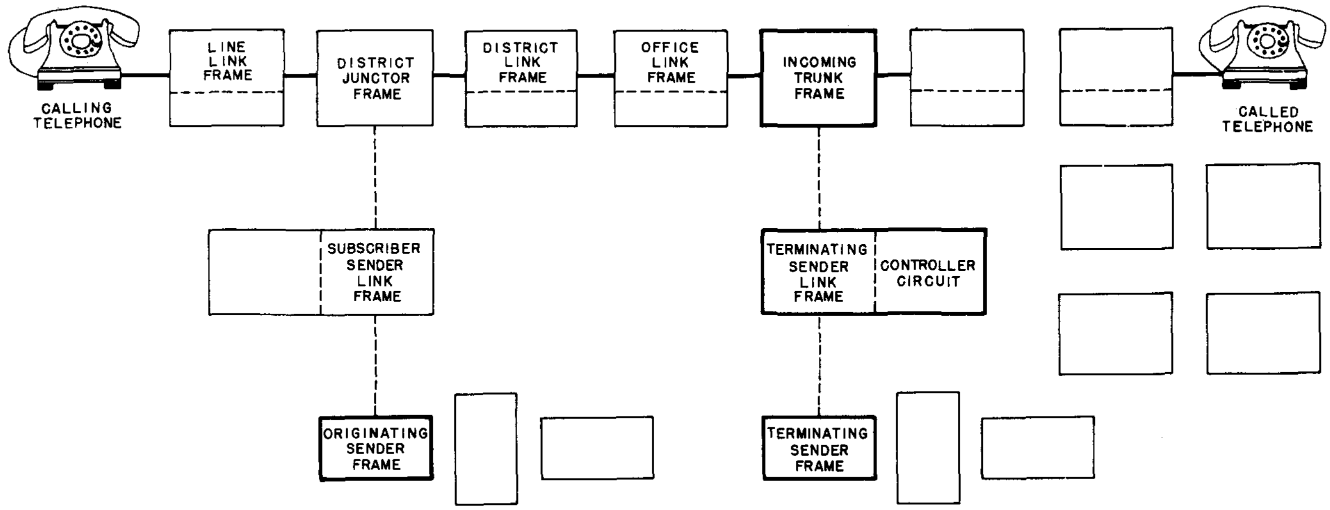
ON THE REMOVAL OF THE HANDSET BY THE CALLING SUBSCRIBER, THE LINE LINK FRAME CONTROLLER CIRCUIT FUNCTIONS TO LOCATE THE CALLING LINE AND IN CONJUNCTION WITH THE SUBSCRIBER SENDER LINK CONTROLLER CIRCUIT SELECTS AN IDLE DISTRICT JUNCTOR. THE SUBSCRIBER SENDER LINK CONTROLLER CIRCUIT ALSO SELECTS AN IDLE ORIGINATING SENDER. THE TWO CONTROLLER CIRCUITS EXTEND THE CALLING LINE TO THE SENDER BY SETTING UP IDLE PATHS THROUGH THE LINE LINK AND SUBSCRIBER SENDER LINK FRAME AND THEN RESTORE TO NORMAL. THE SENDER RETURNS DIAL TONE TO THE CALLING LINE AS AN INDICATION THAT DIALING CAN BE STARTED.



SK. 2

CALLING SUBSCRIBER DIALS THE OFFICE CODE-"OA4" FOR OAKLAND 4

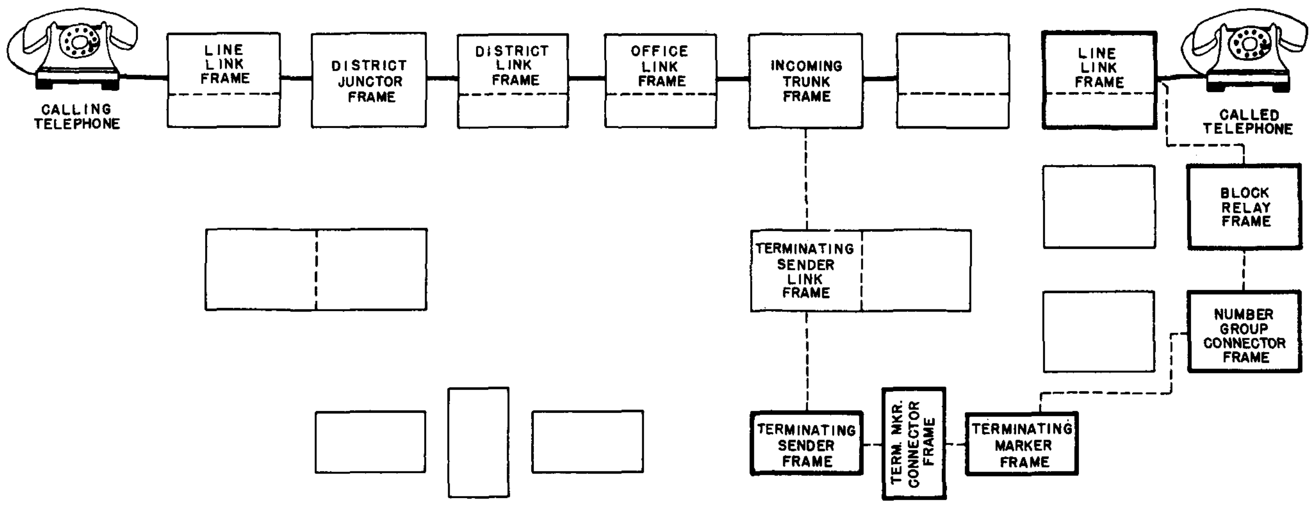
WHEN THE DIAL PULSES FOR THE OFFICE CODE ARE REGISTERED IN THE SENDER, THE SENDER WILL CALL ON AN ORIGINATING MARKER CONNECTOR TO PROVIDE AN IDLE ORIGINATING MARKER. THE SENDER THEN PASSES INFORMATION TO THE ORIGINATING MARKER AS TO THE OFFICE CODE DIALED, CLASS OF SERVICE OF THE CALLING LINE, ETC. THE ORIGINATING MARKER PROCEEDS TO SELECT AN IDLE TRUNK AND THEN SETS UP IDLE PATHS THROUGH AND BETWEEN THE DISTRICT LINK AND OFFICE LINK FRAMES TO CONNECT THE TRUNK TO THE DISTRICT JUNCTOR. THE CONNECTIONS BETWEEN THE ORIGINATING MARKER AND THESE FRAMES ARE THROUGH DISTRICT LINK AND OFFICE LINK CONNECTOR CIRCUITS. THE CONNECTOR CIRCUITS, ORIGINATING MARKER, AND ORIGINATING MARKER CONNECTOR THEN RELEASE.



SK. 3

CALLING SUBSCRIBER DIALS THE NUMERICAL CODE-1234

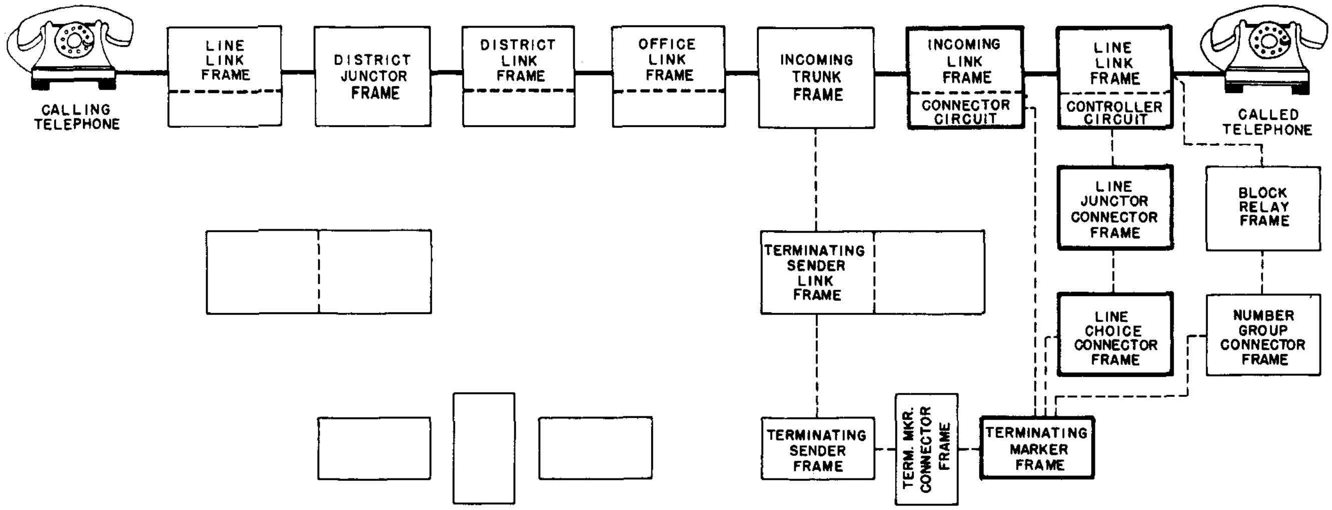
WHEN THE THOUSANDS AND HUNDREDS DIGITS OF THE NUMERICAL CODE HAVE BEEN REGISTERED IN THE ORIGINATING SENDER THE SELECTED TRUNK IS CLOSED THROUGH THE INCOMING TRUNK TO THE TERMINATING SENDER LINK FRAME. THE ASSOCIATED CONTROLLER CIRCUIT SELECTS AN IDLE TERMINATING SENDER AND AN IDLE PATH THROUGH THE TERMINATING SENDER LINK FRAME, CONNECTING THE TERMINATING SENDER TO THE SELECTED TRUNK AND THEN THE CONTROLLER CIRCUIT RELEASES. THE THOUSANDS AND HUNDREDS DIGITS AS REGISTERED IN THE ORIGINATING SENDER ARE NOW TRANSFERRED AND REGISTERED IN THE TERMINATING SENDER. THE TENS AND UNITS DIGITS WHEN DIALED ARE ALSO TRANSFERRED TO THE TERMINATING SENDER. THE ORIGINATING SENDER AND SUBSCRIBER SENDER LINK NOW RELEASE FROM THE CALL.



SK. 4

TESTING THE CALLED SUBSCRIBER LINE

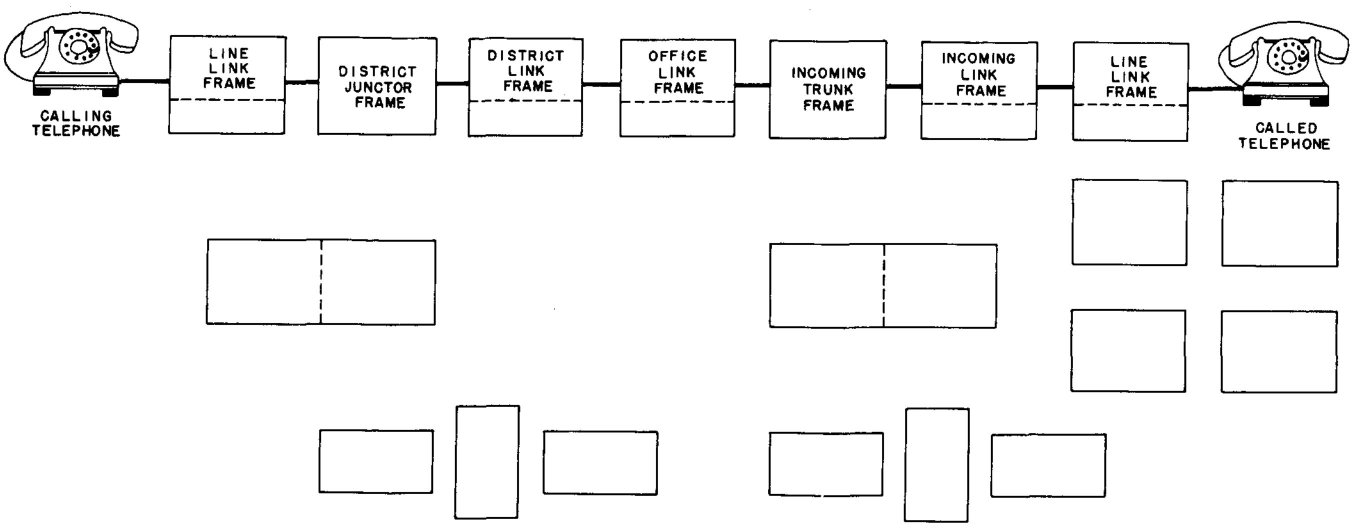
AS SOON AS THE NUMERICAL CODE HAS BEEN TRANSFERRED AND REGISTERED IN THE TERMINATING SENDER, THE SENDER CALLS ON A TERMINATING MARKER CONNECTOR TO PROVIDE AN IDLE TERMINATING MARKER. THE TERMINATING SENDER THEN PASSES THE NUMERICAL CODE INFORMATION TO THE TERMINATING MARKER. THE TERMINATING MARKER SELECTS AND CONNECTS TO THE SLEEVE LEAD OF THE CALLED LINE, LOCATED ON A LINE LINK FRAME, THROUGH A NUMBER GROUP CONNECTOR AND BLOCK RELAY FRAME. A TEST IS NOW MADE BY THE TERMINATING MARKER FOR A BUSY OR IDLE CONDITION ON THE LINE. IF THE CALLED LINE IS BUSY THE INCOMING TRUNK IS SET BY THE TERMINATING MARKER TO SEND BUSY TONE TO THE CALLING SUBSCRIBER AND THE TERMINATING SENDER, TERMINATING MARKER CONNECTOR, TERMINATING MARKER, NUMBER GROUP CONNECTOR AND BLOCK RELAY CIRCUITS RESTORE TO NORMAL IMMEDIATELY. LET IT HOWEVER BE ASSUMED THAT THE CALLED LINE IS IDLE.



SK. 5

CONNECTING INCOMING TRUNK TO CALLED LINE

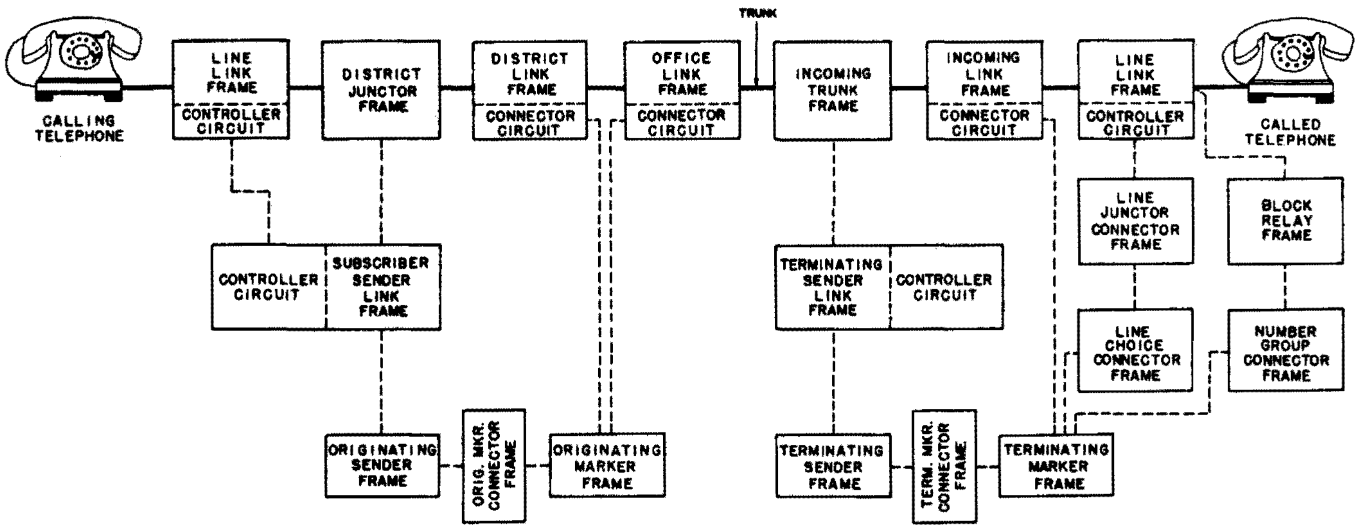
THE TERMINATING MARKER ON FINDING THE LINE IDLE SETS UP IDLE PATHS THROUGH AND BETWEEN THE INCOMING LINK AND LINE LINK FRAMES, CONNECTING THE INCOMING TRUNK TO THE CALLED LINE. THE TERMINATING MARKER ACCOMPLISHES THIS WITH THE AID OF THE INCOMING LINK CONNECTOR CIRCUIT, LINE CHOICE CONNECTOR, LINE JUNCTOR CONNECTOR AND LINE LINK CONTROLLER CIRCUIT. THE INCOMING TRUNK PROCEEDS TO RING THE CALLED SUBSCRIBER BELL. THE TERMINATING SENDER LINK, TERMINATING SENDER, TERMINATING MARKER CONNECTOR, TERMINATING MARKER, NUMBER GROUP CONNECTOR, BLOCK RELAY, LINE CHOICE CONNECTOR, LINE JUNCTOR CONNECTOR, LINE LINK CONTROLLER, AND INCOMING LINK CONNECTOR CIRCUITS RESTORE TO NORMAL



SK. 6

SUBSCRIBER TALKING PATH

WHEN THE CALLED SUBSCRIBER ANSWERS, THE TALKING PATH IS COMPLETED BETWEEN THE CALLING AND CALLED LINES. TALKING BATTERY IS FURNISHED TO THE CALLING LINE BY THE DISTRICT JUNCTOR AND TO THE CALLED LINE BY THE INCOMING TRUNK.



SK. 7

SEQUENCE OF FRAMES INVOLVED IN COMPLETING A CALL BETWEEN TWO SUBSCRIBERS

No. 1 Crossbar System

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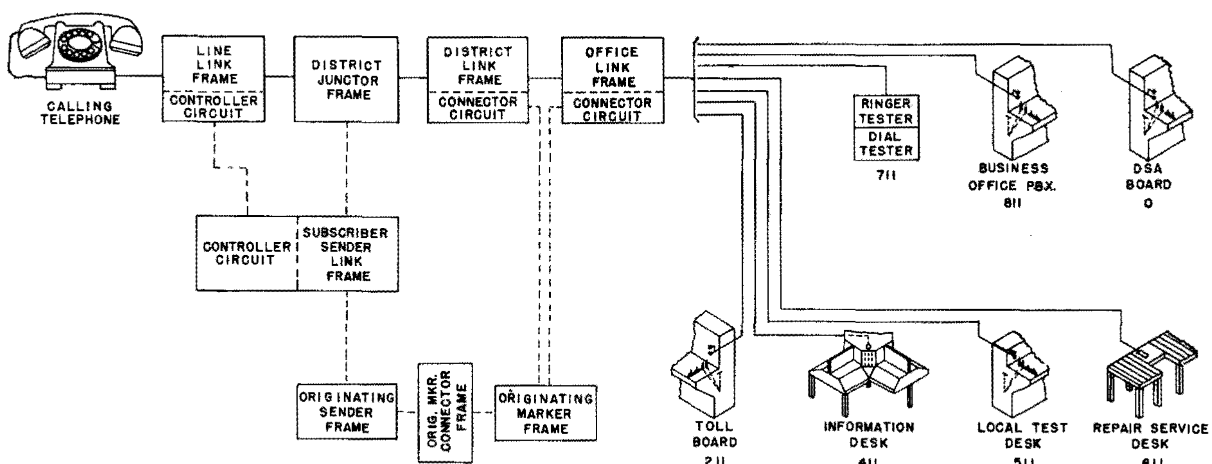
Calls to Switchboards, Desks and Special Equipment Used In No. 1 Crossbar Offices



SK. 8

SEQUENCE OF FRAMES INVOLVED IN COMPLETING CALLS TO SWITCHBOARDS, DESKS & SPECIAL EQUIPMENT

SKETCH NO. 8 SHOWS THE CROSSBAR FRAMES REQUIRED TO ENABLE THE CALLING SUBSCRIBER TO GAIN ACCESS TO THE DIAL SYSTEM "A" BOARD, TOLL BOARD, INFORMATION DESK, REPAIR SERVICE DESK, AND BUSINESS OFFICE PBX, AND TO GIVE A TELEPHONE REPAIR MAN ACCESS TO THE TEST DESK AND RINGER AND DIAL TESTING EQUIPMENT. CALLS TO THESE POINTS ARE MADE BY DIALING THE NUMBERS AS SHOWN BELOW:

211 PROVIDES A CONNECTION TO THE TOLL OPERATORS AT THE TOLL BOARD, WHO WILL COMPLETE ANY CALL THAT MUST BE HANDLED ON A TOLL CHARGE BASIS.

411 PROVIDES CONNECTION TO THE OPERATORS AT THE INFORMATION DESK WHO WILL FURNISH INFORMATION ON CHANGED SUBSCRIBER NUMBERS OR NEW NUMBERS NOT LISTED IN THE DIRECTORY.

511 PROVIDES A CONNECTION WHEREBY A REPAIR MAN CAN CONNECT TO A TEST MAN AT A LOCAL TEST DESK WHEN REPAIRING TROUBLE ON THE LINE.

611 PROVIDES CONNECTION TO THE REPAIR CLERK AT THE REPAIR SERVICE DESK TO WHOM THE SUBSCRIBER MAY REPORT A TELEPHONE OUT OF ORDER OR MAKE ANY SERVICE COMPLAINTS.

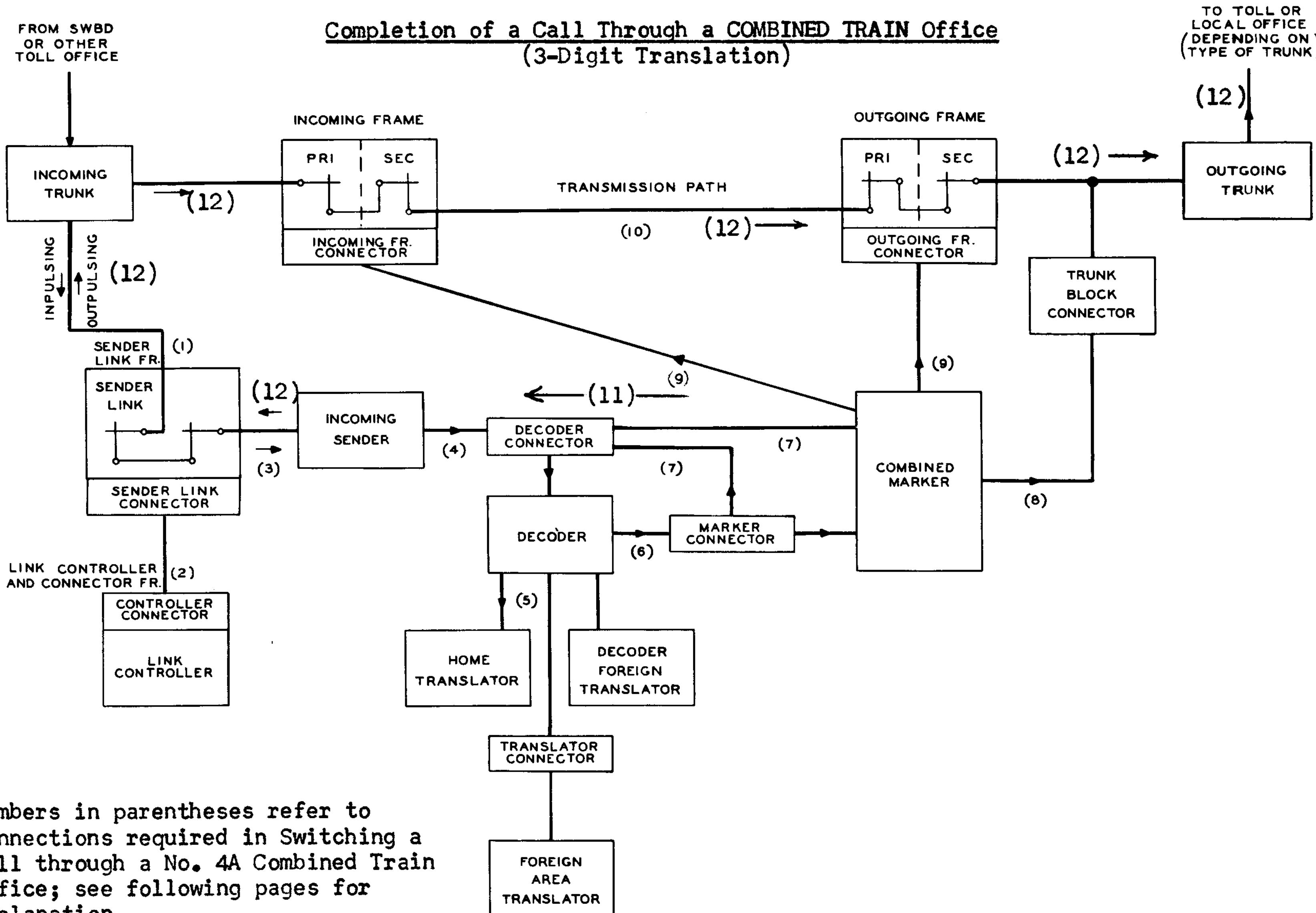
711 PROVIDES A CONNECTION WHEREBY A REPAIR MAN AT A SUBSCRIBER STATION CAN OBTAIN ACCESS TO DIAL AND RINGER TESTING EQUIPMENT.

811 PROVIDES A CONNECTION TO THE BUSINESS OFFICE PBX FOR SERVICE INFORMATION OR COMPLAINTS.

0 PROVIDES A CONNECTION TO THE DSA OPERATOR AT THE DIAL SYSTEM "A" SWITCHBOARD WHO WILL HANDLE SHORT HAUL (AB) TOLL CALLS, EMERGENCY CALLS TO DOCTORS, HOSPITALS, POLICE OR FIRE STATIONS, AND CALLS ON WHICH ASSISTANCE IS NECESSARY DUE TO A SUBSCRIBERS INABILITY TO DIAL.

NO. 4A TOLL SWITCHING SYSTEM

Completion of a Call Through a COMBINED TRAIN Office
(3-Digit Translation)



Note: Numbers in parentheses refer to connections required in Switching a Call through a No. 4A Combined Train Office; see following pages for explanation.

Equipment Arrangements for the No. 4A Toll Switching System

1) COMBINED TRAIN Office - A single Switching Train is provided for Small Offices, handling both Intertoll and Toll Completing Traffic:

   Maximum: 40 Incoming Link or Outgoing Link Frames
   10 Markers
   10 Decoders.

2) SEPARATE TRAIN-COMBINED OPERATION Office - Two Switching Trains are provided for Large Offices; each Train handling both Intertoll and Toll Completing Traffic:

   Maximum: 40 Incoming Link or Outgoing Link Frames per Train
   10 Markers per Train
   18 Common Decoders.

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Completion of a Call Through a COMBINED TRAIN Office
No. 4A Toll Switching System
(3-Digit Translation)

1) When the Incoming Trunk is seized by an Outward Operator, or a Distant Automatic Toll Office, it signals a Sender Link to connect an Idle Incoming Sender for Registering the Incoming Pulses ("Inpulsing").

2) The Sender Link Controller signals a Controller Connector to seize an Idle Link Controller.

3) The Link Controller tests for, and seizes, an Idle Incoming Sender, closing Crosspoints on the Sender Link Frame to connect the Incoming Sender to the Incoming Trunk.

   Then the Sender Link Controller and the Controller Connector release.

4) The Incoming Sender signals the Outward Operator, or the Outgoing Sender, in the Distant Office to begin Outpulsing.

   When the Incoming Sender has registered three (3) digits, it signals a Decoder Connector to seize an Idle Decoder.

5) The Decoder immediately connects to its Home Translator. The Foreign Area Translator is used on Calls requiring 6-Digit Translation - Area Code + Local Office Code.

   The Incoming Sender transmits the three digits through the Decoder to the Home Translator, causing a Punched Metal Card corresponding to the 3-Digit Area Code to be dropped.

   A light-sensitive photo-transistor system associated with the Metal Card coded by means of perforations, furnishes to the Decoder information on Trunk Selection, Alternate Routing, Code Conversion, Variable Spilling of Digits, etc.

6) The Decoder "reads" the Dropped Card and signals a Marker Connector to seize an Idle Marker.

7) Upon Marker seizure, the Marker Connector signals the Decoder Connector to connect the Incoming Sender to the Selected Marker.
The Incoming Trunk registers its Incoming Frame Appearance in the Marker via the Sender Link, Incoming Sender and Decoder Connector.

8) The Marker obtains the locations of the required Outgoing Trunks from the Decoder and the Dropped Card; see Connection "5)".
The Marker selects an Idle Outgoing Trunk through a Trunk Block Connector.
The Selected Trunk registers its Outgoing Frame Appearance in the Marker.
The Decoder and the Dropped Card inform the Marker:
a) The Type of Outpulsing required,
b) If digits should be outpulsed ("spilled forward") to the next office as received,
c) If digits should be deleted,
d) If digits should be substituted - Code Conversion, or
e) If digits should be prefixed.
Then the Marker signals the Decoder to release.

9) The Marker now sets up the Transmission (Talking) Path from the Incoming Trunk to the Selected Outgoing Trunk.
The Marker gains access to the Incoming Links through the Incoming Frame Connector, and to the Outgoing Links and Junctors through the Outgoing Frame Connector.

10) The Marker tests the: 1) Incoming Links,
2) Outgoing Links, and
3) Junctors, to find an Idle Channel.
Then the Marker closes through that Idle Channel from the Incoming Trunk to the Outgoing Trunk.

11) The Marker passes the Outpulsing information to the Sender, then releases.

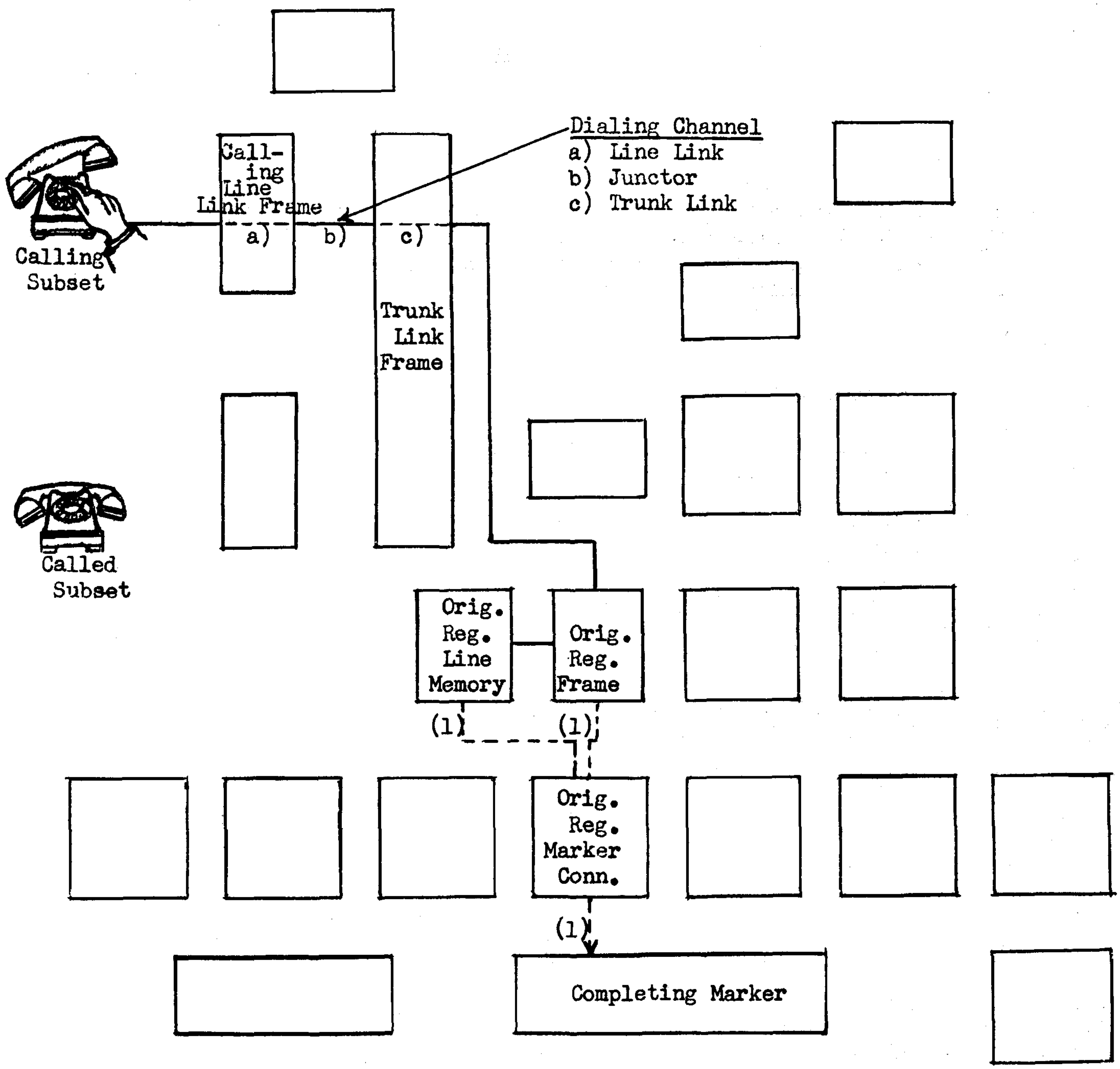
12) The Sender Outpulses (Multifrequency (MF) or Dial Pulse (DP)) the digits through the Sender Link, over the Transmission Path, to the Outgoing Trunk, and through to the next office. Then the Incoming Sender and Sender Link release.
Calls outgoing to offices requiring Panel Call Indicator (PCI) Pulsing or Revertive Pulsing (RP) make use of:
a) An Incoming Sender to register the Called Number as "Inpulsed,"
b) And an Outgoing Sender to "Outpulse" the Called Number.
The Incoming Sender pulses into the Selected Outgoing Sender through the Incoming and Outgoing Frames, the Outgoing Trunk, and the Outgoing Sender Link.

13) Crosspoints in the Transmission Path release when a Disconnect Signal is received.

THE INTRAOFFICE CALL

A Call between two Subscribers in the same Office, served by the same Marker Group, but not on the same Subscriber Line, is an Intraoffice Call. The following sketches show the frames involved and the functional steps required subsequent to the Dial Tone Job and registration of the dialed digits.

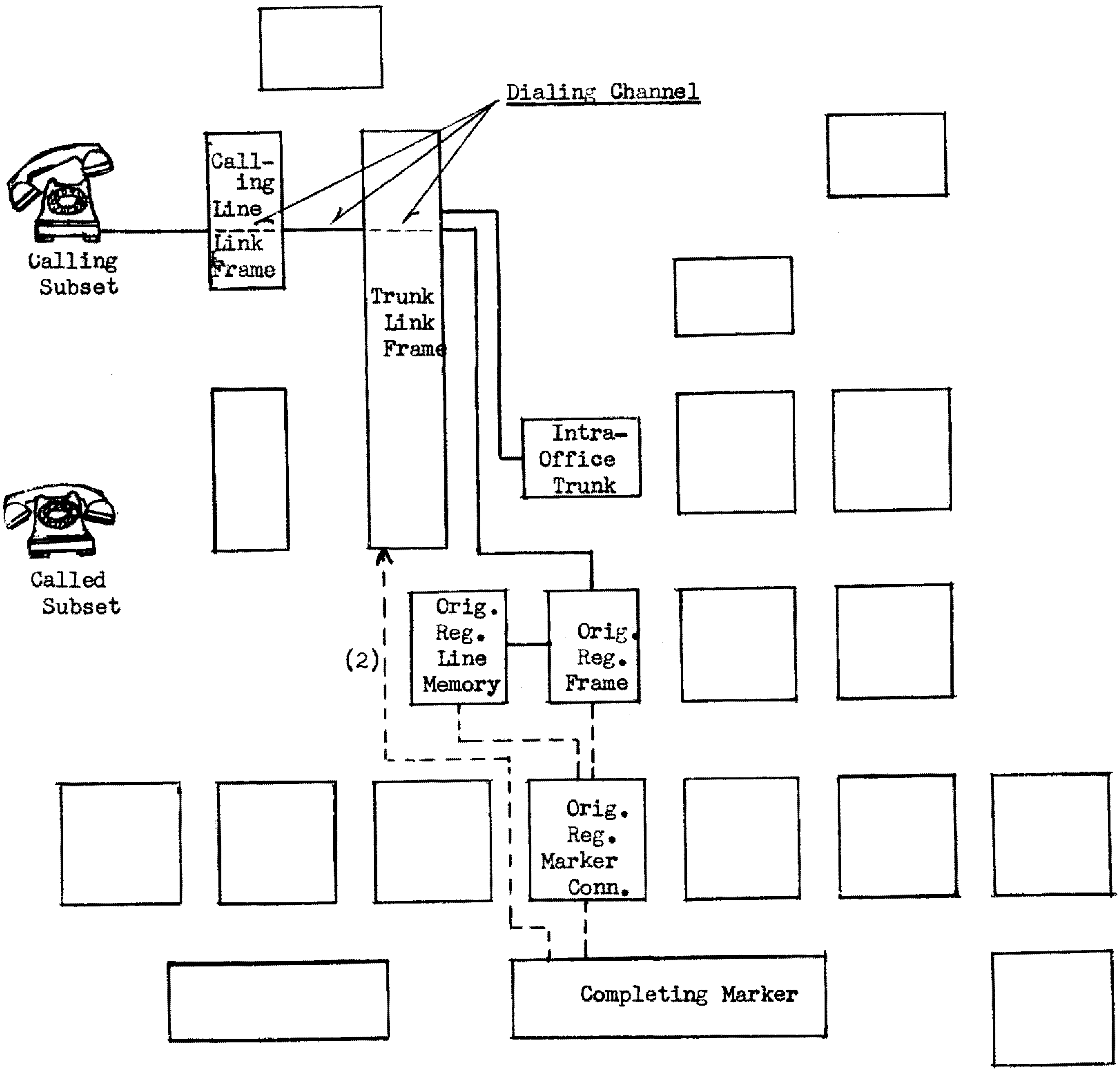
Note: Numbers in parentheses, "(1), (2), (3)," etc., indicate the connection made in that particular sketch.



SKETCH 1

The Originating Register Seizes an Idle Completing Marker

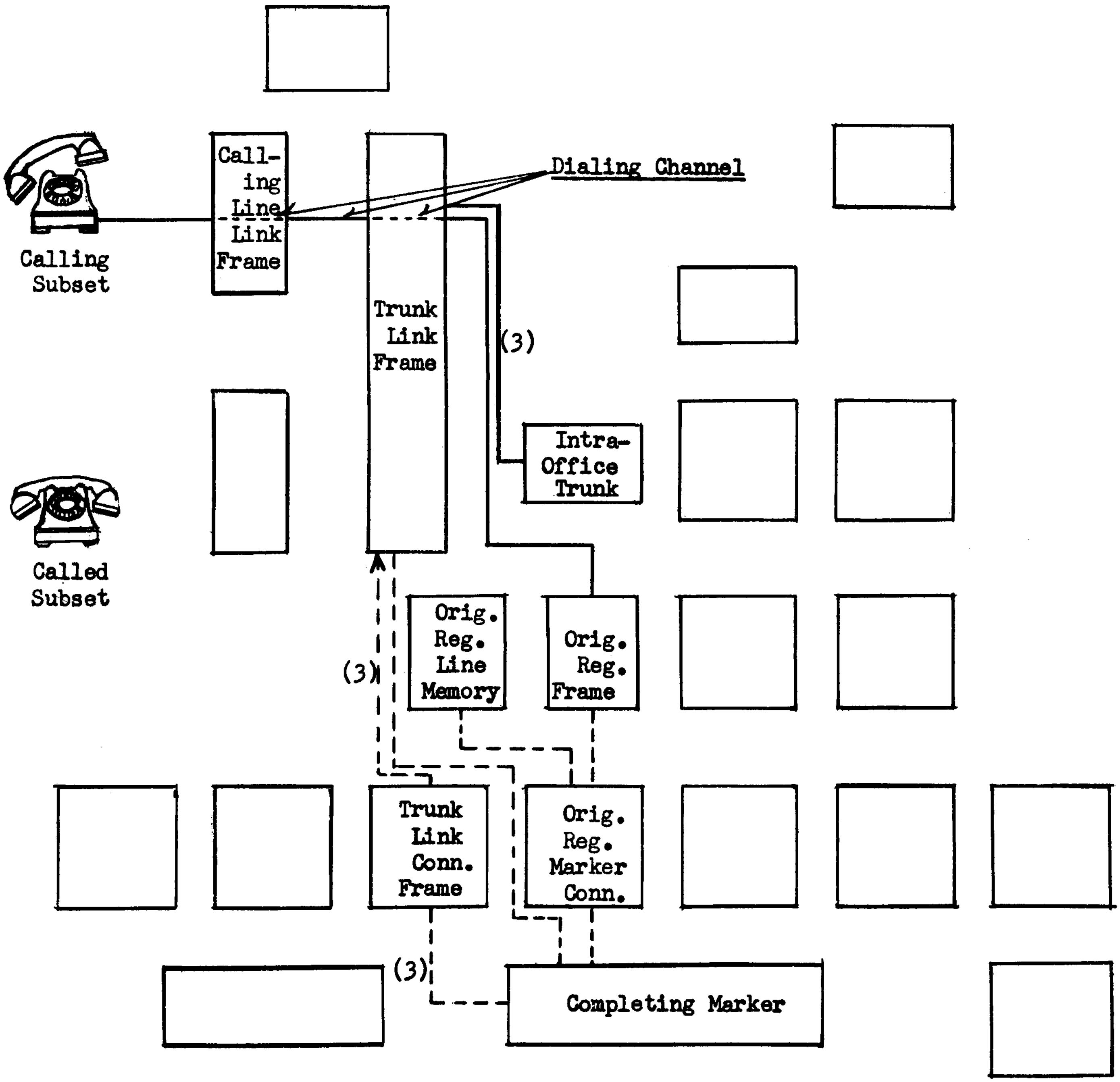
The Calling Subscriber receives Dial Tone from the Originating Register and proceeds to Dial the digits of the Called Telephone Number. The Originating Register stores the digits in the order dialed. Upon completion of Subscriber Dialing, the Originating Register and associated Originating Register Line Memory Frames connect to an idle Completing Marker through the Originating Register Marker Connector Frame. Calling Line location and Class of Service information, as well as the number of the Line Link used in the Dialing Channel, together with the Called Telephone Number are transferred to the Completing Marker.



SKETCH 2

The Completing Marker Checks all Idle Trunk Link Frames for Idle Intraoffice Trunks

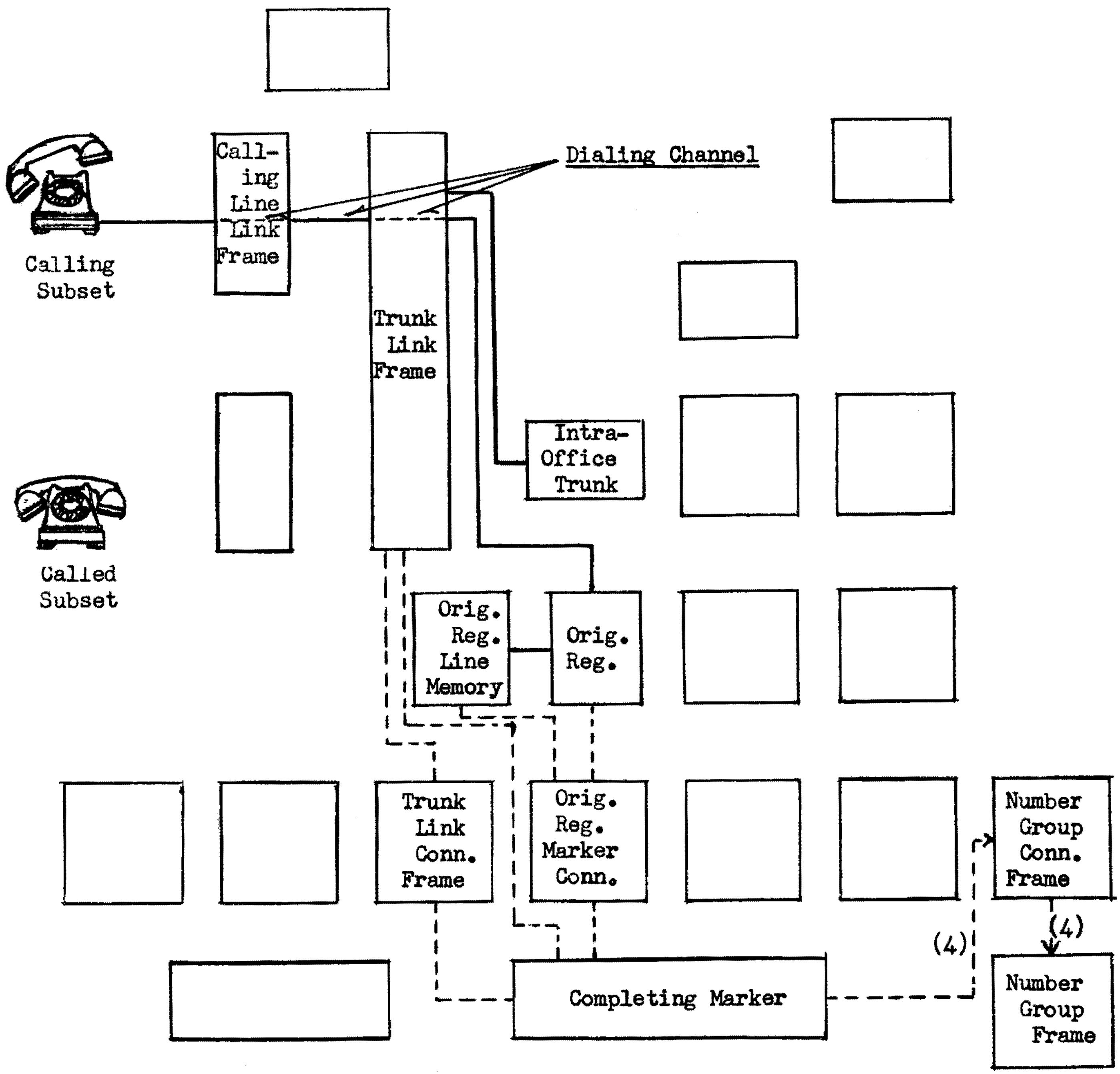
The Completing Marker, recognizing the Dialed Office Code as being associated with its own group of Line Link Frames, checks all Idle Trunk Link Frames for Idle Intraoffice Trunks. An Idle Trunk Link Frame with Idle Intraoffice Trunks is selected.



SKETCH 3

The Completing Marker Seizes the Trunk Link Frame and an Idle Intraoffice Trunk

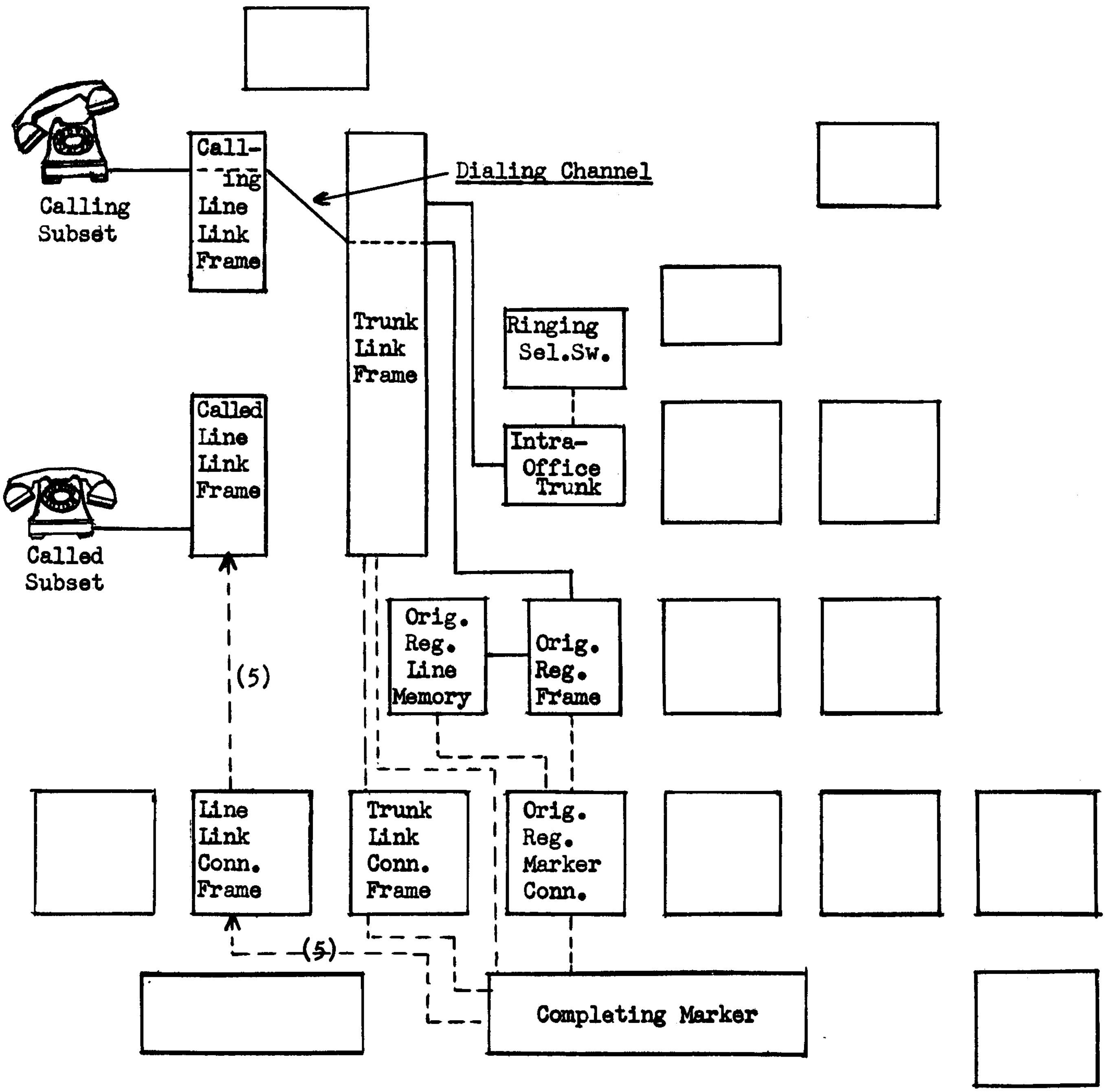
The Completing Marker seizes the selected Trunk Link Frame and connects to it through the Trunk Link Connector Frame. The Completing Marker then selects an Idle Intraoffice Trunk.



SKETCH 4

The Completing Marker Seizes the Called Line Number Group Frame

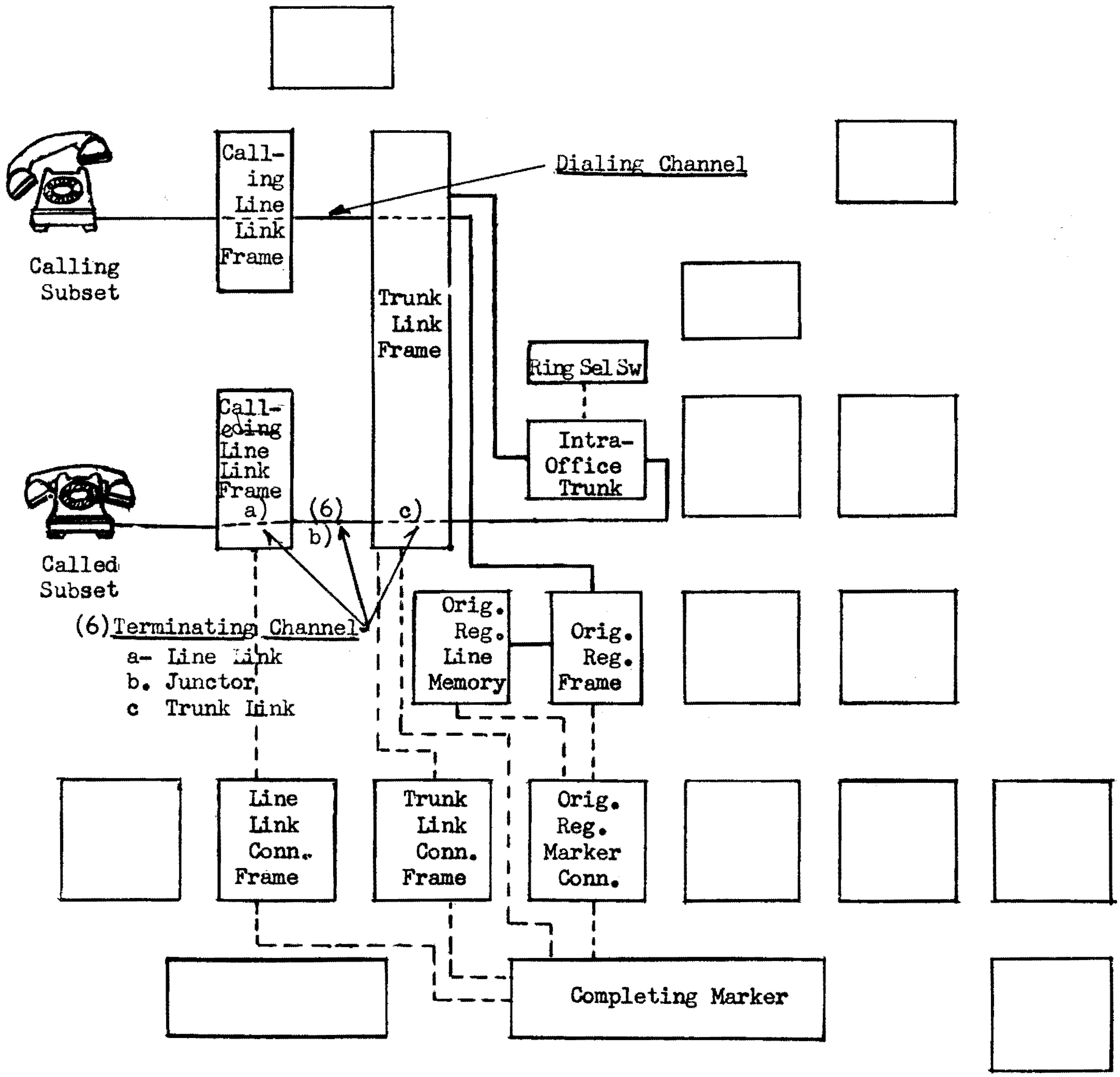
While selecting an Idle Intraoffice Trunk, the Completing Marker, through the Number Group Connector Frame, seizes the Number Group Frame upon which the Called Line Location information appears. The Number Group Frame furnishes the following information to the Completing Marker: 1) The Line Link Frame number, 2) Called Subscriber Line Location on that Frame, and 3) the Ringing Current to be applied. The Completing Marker releases the Number Group and Number Group Connector Frame.



SKETCH 5

The Completing Marker Seizes the Called Line Link Frame

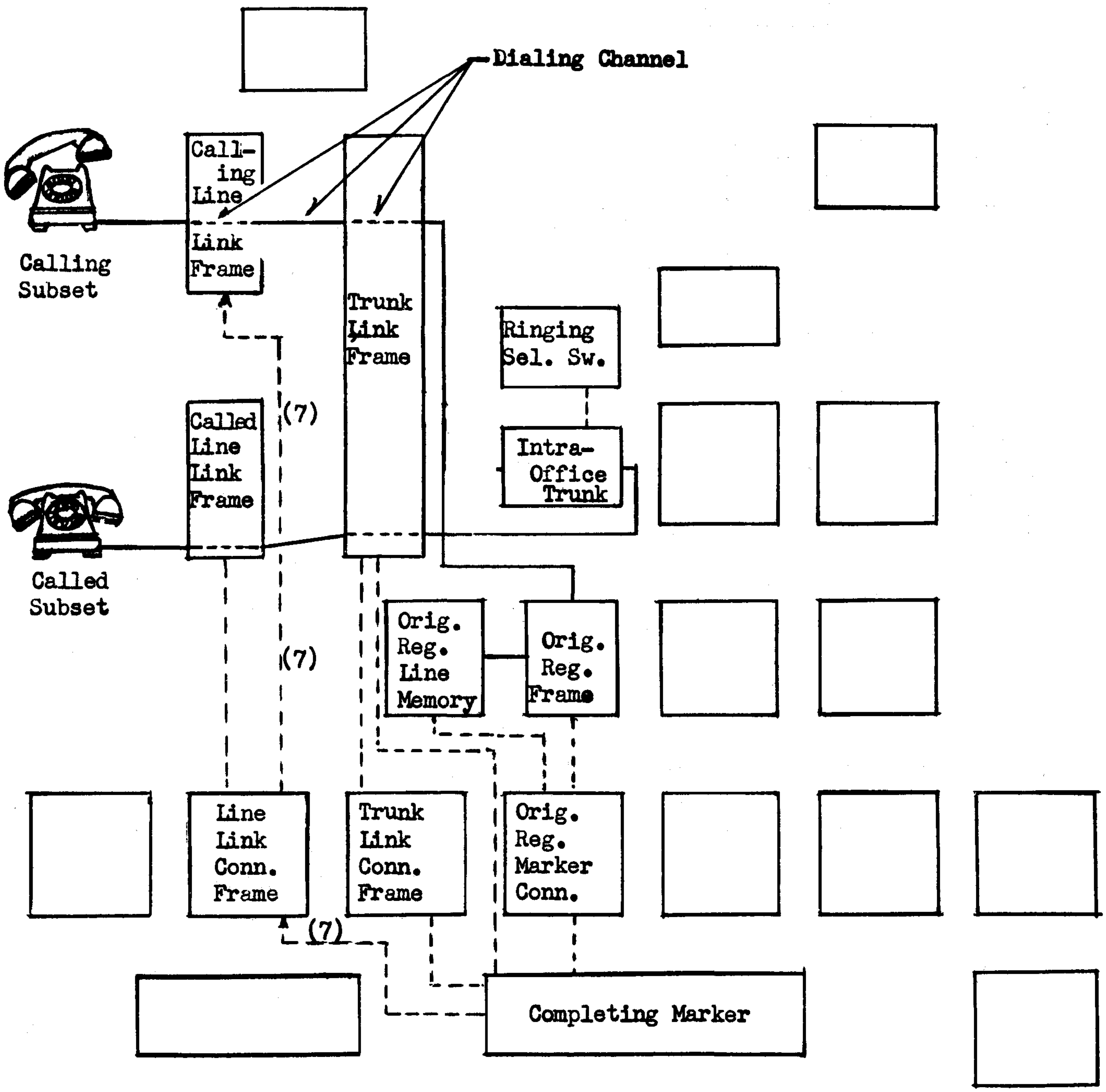
The Completing Marker seizes the Line Link Frame on which the Called Subscriber Line appears, through the Line Link Connector Frame.



SKETCH 6

The Completing Marker Closes Through a Terminating Channel

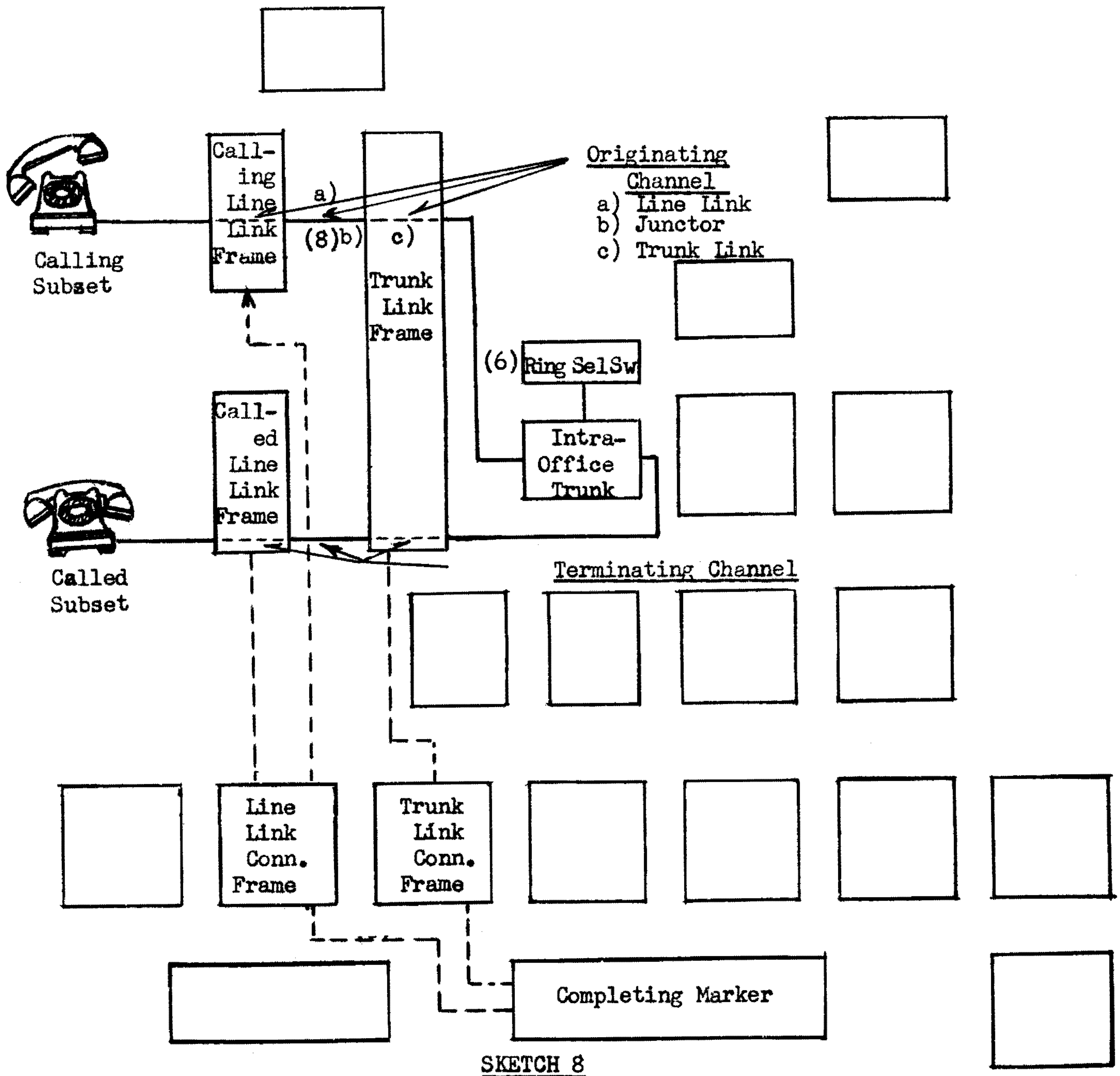
Following seizure of the Called Line Link Frame in Sketch 5, the Completing Marker checks the Called Subscriber Line for a busy condition. If the Called Subscriber Line is Idle, the Completing Marker proceeds to select and close through an Idle Channel from the Intraoffice Trunk to the Called Subscriber Line. At the same time, the Completing Marker connects the Intraoffice Trunk to the Ringing Selection Switch through the Trunk Link Connector Frame. If the Called Subscriber Line checks busy, the Completing Marker releases the Intraoffice Trunk and selects an Idle Tone Trunk, which it links to the Calling Subscriber Line to furnish Busy Tone.



SKETCH 7

The Completing Marker Seizes the Calling Line Link Frame

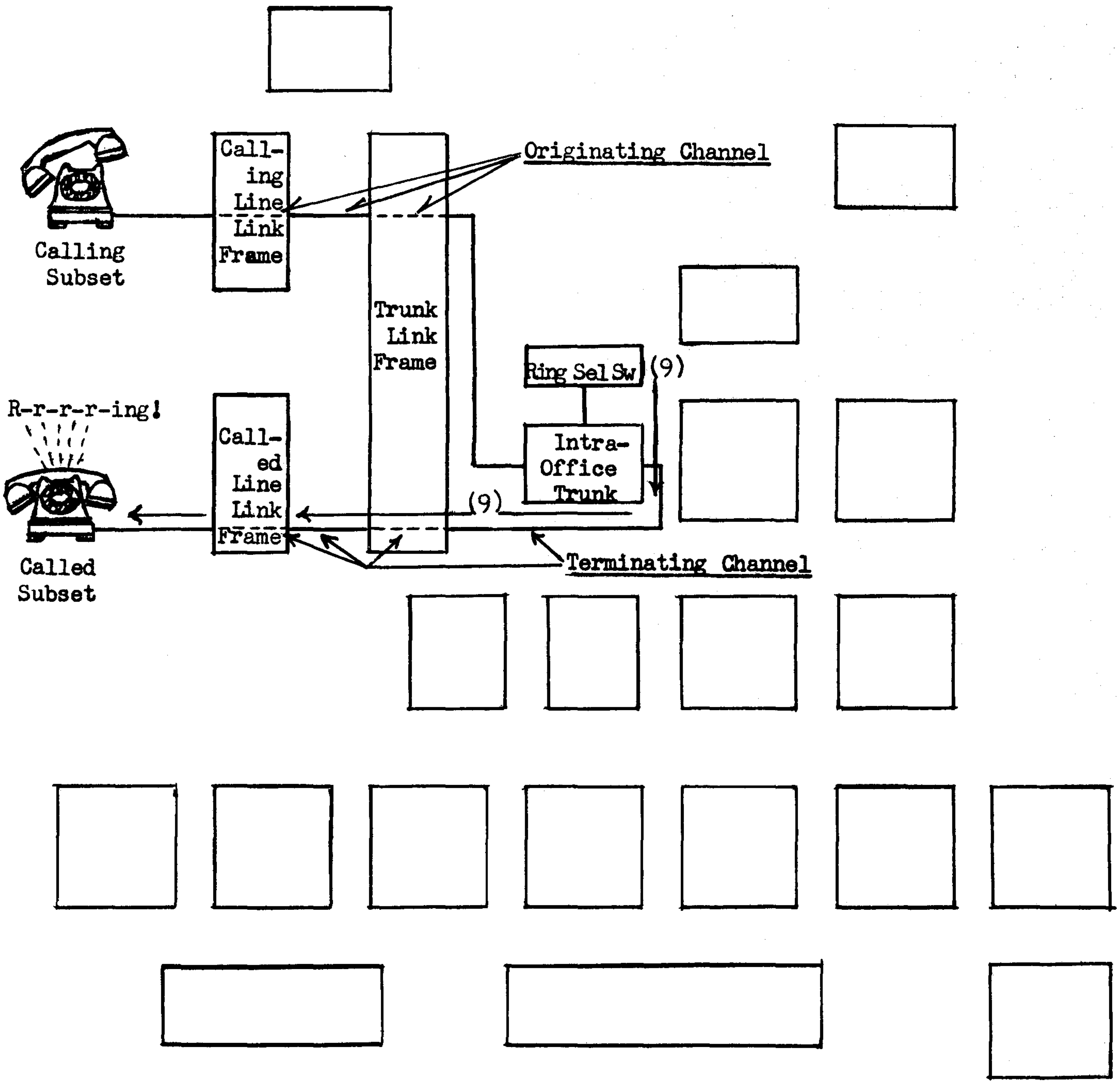
The Completing Marker, having established a Channel from the Intraoffice Trunk to the Called Subscriber Line, now seizes the Calling Line Link Frame through the Line Link Connector Frame and prepares to close through a Channel from the Calling Subscriber Line to the Intraoffice Trunk.



SKETCH 8

The Completing Marker Closes Through an Originating Channel

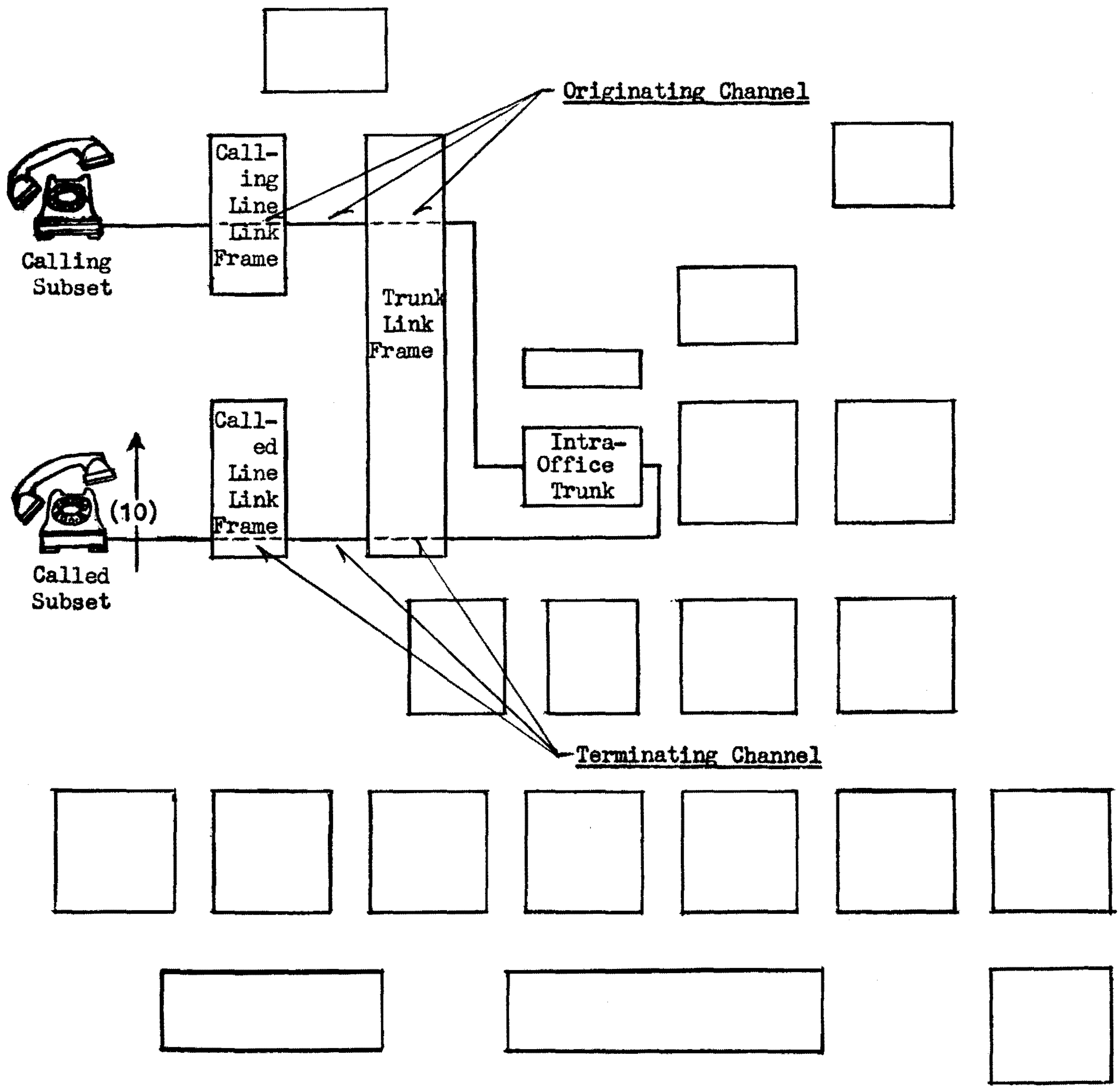
Following seizure of the Calling Line Link Frame through the Line Link Connector Frame, the Completing Marker tests and selects an Originating Channel (Line Link, Junctor and Trunk Link) from the Calling Subscriber Line to the Intraoffice Trunk. The Dialing Channel, Originating Register and Originating Register Line Memory Frames release, and the Completing Marker closes through the Originating Channel. Then the Completing Marker and associated Connectors release.



SKETCH 9

Ringing Current is Applied to the Called Subscriber Line

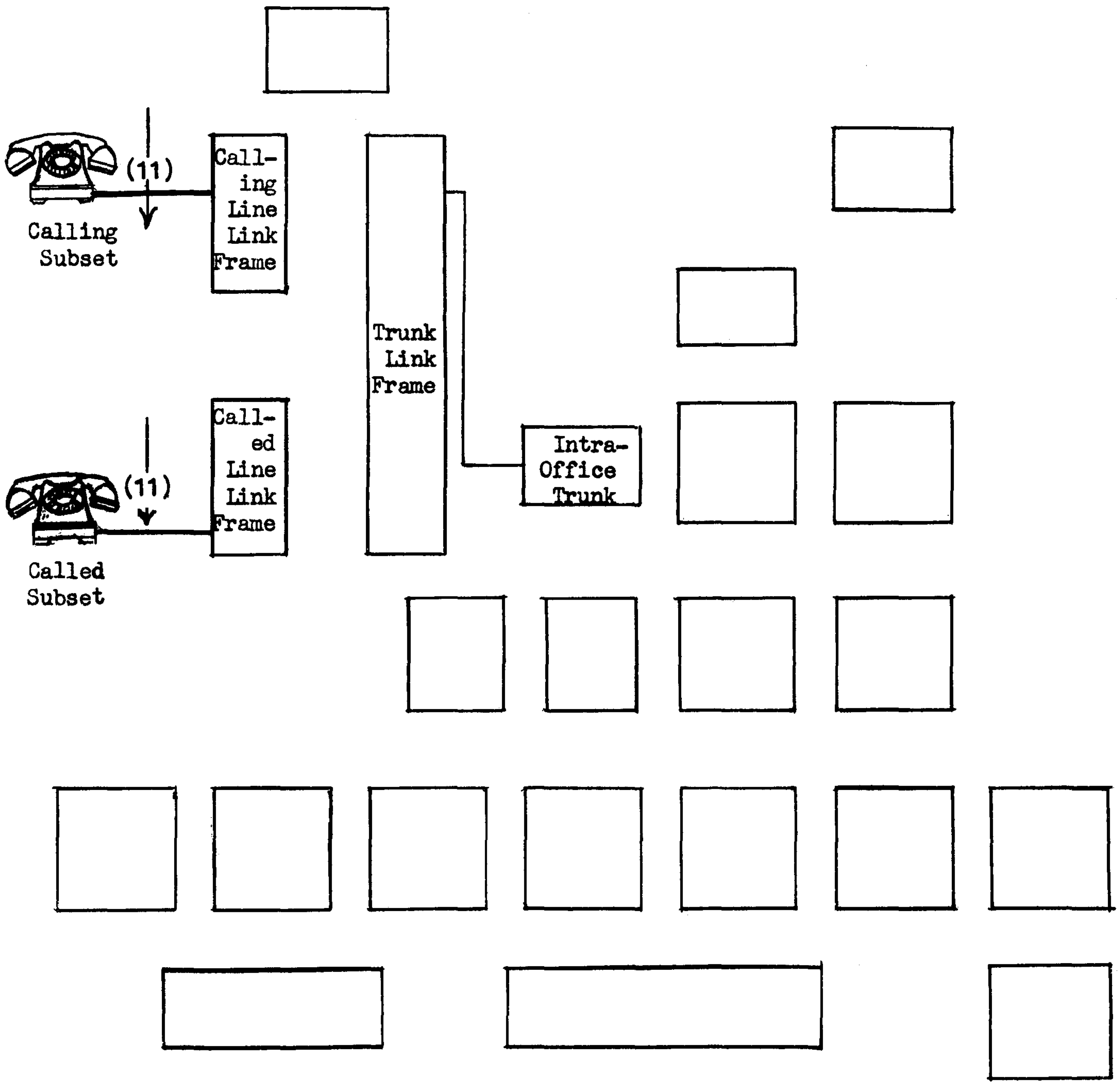
Ringing Current is applied to the Called Subscriber Line through the Intraoffice Trunk, over the Terminating Channel, from the Ringing Selection Switch.



SKETCH 10

The Called Subscriber Answers

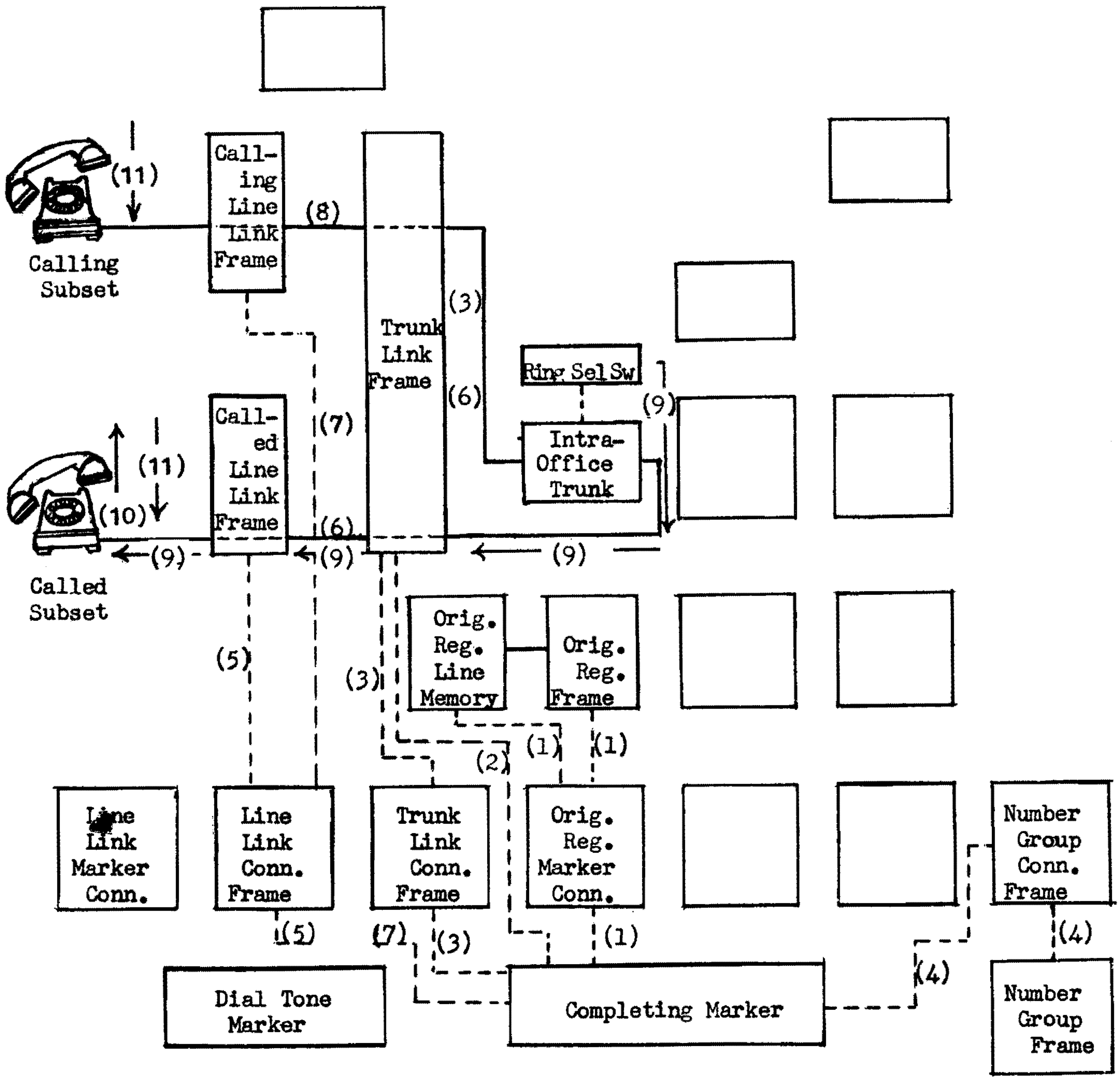
Ringing Current is tripped (cut off) by removal of the Called Subscriber Handset, and the connection from the Intraoffice Trunk to the Ringing Selection Switch released. Talking Battery and Ground are furnished to the Calling and Called Subsets by the Intraoffice Trunk.



SKETCH 11

The Calling and Called Subscribers Replace Their Handsets

The release of all Channel Crosspoints results when the Talking Battery Path to the Calling and Called Subsets is broken by replacement of the Handsets.



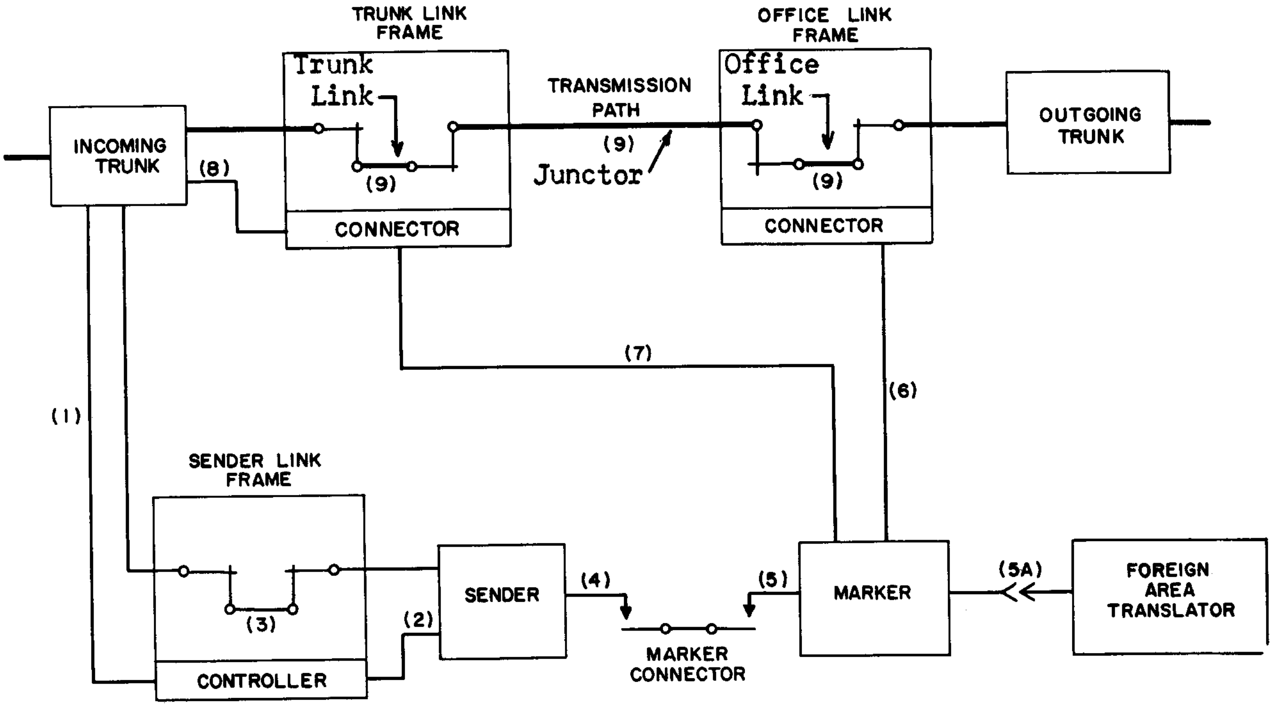
SKETCH 12

Frames Involved in Completing a Call Between Two Subscribers
In the Same No. 5 Crossbar Dial Central Office

The Talking Path is shown in heavy black lines.
Broken Lines indicate temporary connections required between various frames in setting up the Call.

Completion of a Call Requiring 3-Digit Translation

The Crossbar Tandem Switching System handles traffic between Local Dial Offices in the same Metropolitan Area, as well as Intertoll Traffic.



1) When the Incoming Trunk is seized at the Originating End, it signals a Sender Link Controller to select an Idle Sender for registering the Incoming Pulses ("Inpulsing").

2) The Sender Link Controller tests for and selects an Idle Sender.

3) The Sender Link Controller operates Crossbar Switches on the Sender Link Frame to connect the Sender to the Incoming Trunk.
   Then the Sender Link Controller releases.
   The Number of the Trunk Link Frame on which the Incoming Trunk appears is stored in the Sender.

4) The Sender signals the Originating Operator or Sender in the preceding office to start Outpulsing.
   When three digits have been registered, the Sender signals the Marker Connector to select an Idle Marker.

5) The Marker Connector seizes an Idle Marker.
   The Sender "spills" the first three digits into the Marker, along with the Number of the Trunk Link Frame on which the Incoming Trunk appears - "3)."
   The Marker:
   a) Decodes the information received from the Sender.
   b) Operates a Route Relay from which it determines routing information for the Call.
   c) Passes Outpulsing instructions to the Sender.

5A) 6-Digit Translation permits two or more Routes from the Switching Center to or towards the Foreign Area.

When the first three digits are XOX/X1X, the Sender waits for six digits before seizing a Marker.

The Marker decodes the first three digits (Area Code) and operates an Area Relay.

Operation of the Area Relay causes seizure of a Foreign Area Translator.

Digits 4, 5 and 6 are transmitted to the Foreign Area Translator.

The Foreign Area Translator passes one of 60 Route Indications to the Marker, then releases.

The Marker handles the Call as in the case of 3-Digit Translation.

6) The Marker seizes the Office Link Connector serving the Office Link Frame on which the Outgoing Trunks appear, and tests for an Idle Outgoing Trunk.

The Marker signals the Sender to release the Marker Connector.

The Marker Connector releases the Marker.

7) The Marker seizes the Trunk Link Connector serving the Trunk Link Frame on which the Incoming Trunk appears.

8) The Marker directs the Incoming Trunk, through the Sender, to connect to the Trunk Link Connector.

The Trunk Link Connector cuts through to the Marker test leads for the Trunk Links serving the Switch on which the Incoming Trunk appears.

The Marker maintains a path to the Sender through the Trunk Link Connector, the Incoming Trunk and the Sender Link.

The Marker informs the Trunk Link Frame to cut through the test leads for the Junctors to the Office Link Frame on which the Outgoing Trunk appears.

9) The Marker tests for and closes through an Idle Channel (Trunk Link, Junctor and Office Link) from the Incoming Trunk to the Outgoing Trunk.

The Marker informs the Sender the Channel has been closed through, then the Marker releases.

10) Upon receipt of a "Go" Signal from the next office, the Sender Outpulses.

After completion of Outpulsing, the Talking Path is cut through.

The Sender passes supervision of the Call to the Incoming Trunk.

Then the Sender and Sender Link Frames release.

11) When a Disconnect Signal is received from the Calling End, all Crosspoints on the Trunk Link and Office Link Frames release, restoring the Equipment to normal.

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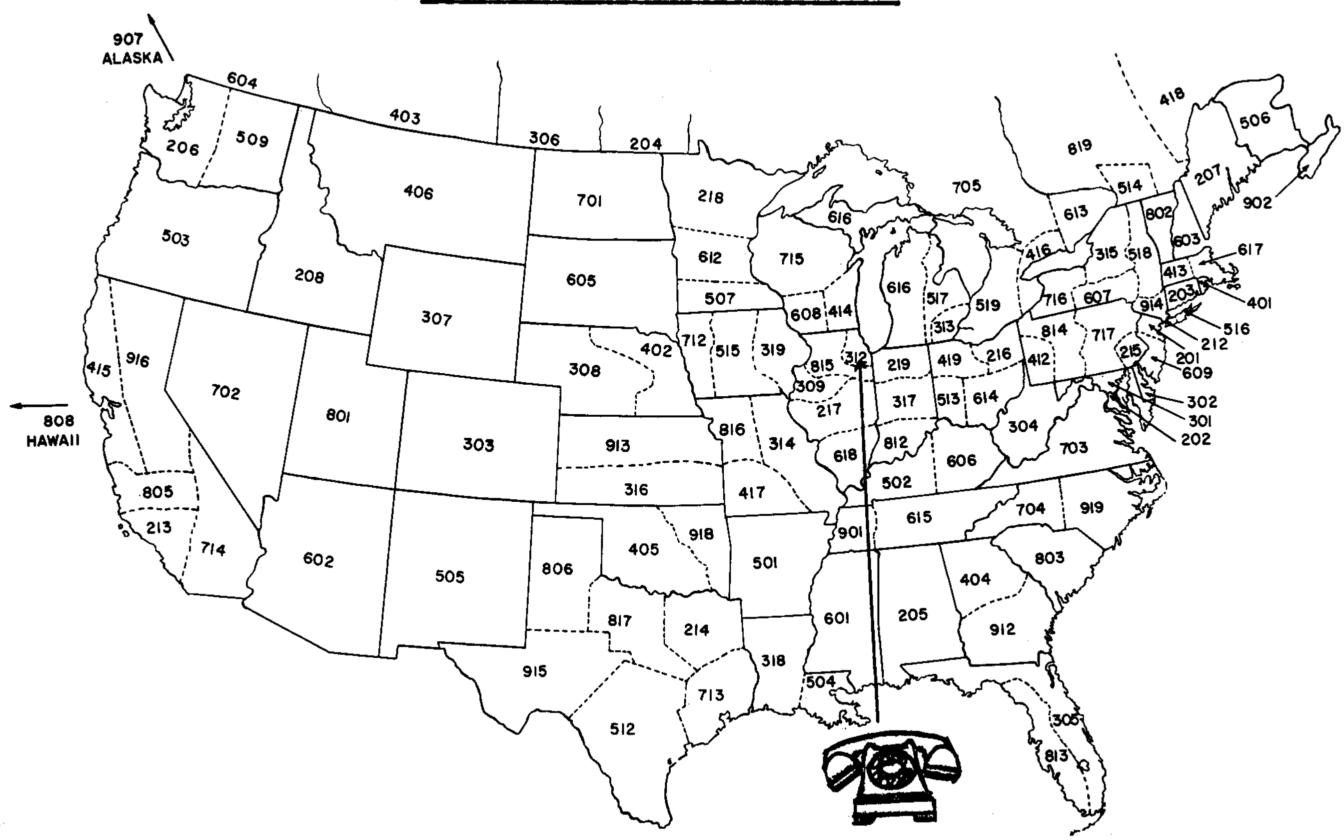
Some Features of DDD (Direct Distance Dialing).

1) Numbering Plan Areas and Codes
2) Switching Plan for DDD
3) Switching Features:
   a) Alternate Routing
   b) Storing and Spilling Forward Digits as Required
   c) Code Conversion
   d) Prefixing
   e) 6-Digit Translation

1) NUMBERING PLAN AREAS AND CODES



312-WH3-2700

To make possible DDD, each Telephone has a Distinctive Directory Number - 10 or 11 Digits:

312-WH3-2700

1) AREA CODE - 3 Digits - XOX and X1X
2) CENTRAL OFFICE CODE - 3 Digits - ABX
3) NUMERICALS - 4 Digits - 5th Digit - W,J,R, or M, Party Letter

To reach the above Telephone from any point within Area 312, Dial WH3-2700.
To reach the above Telephone from any point outside Area 312, Dial 312-WH3-2700.

2) SWITCHING PLAN FOR DDD

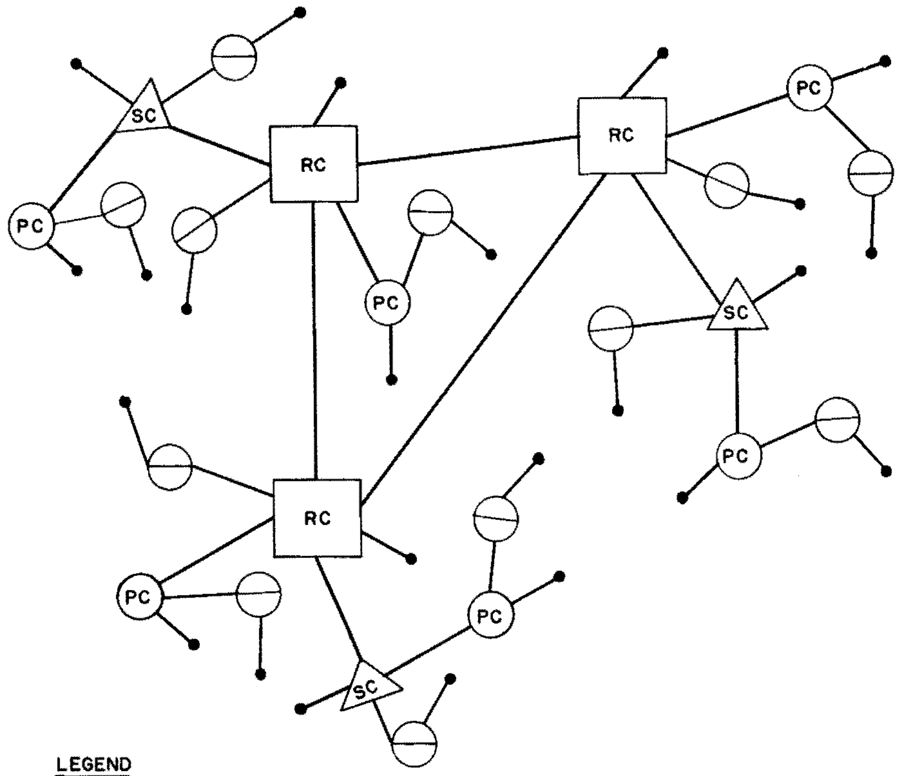
The Switching Plan employs Alternate Routing of Toll Calls, using Intertoll Trunks at very high efficiency, and minimizing delay of a Call due to ATB (All Trunks Busy).

CSP's - Control Switching Points - More Important Toll Offices:

A) Distribute Traffic over High Usage and Final Trunk Groups.

B) Types of CSP's:

1) RC - Regional Center - Class 1 Office
2) SC - Sectional Center - Class 2 Office
3) PC - Primary Center - Class 3 Office



LEGEND

SYMBOL	CLASS	NAME	ABBREVIATION
□	1	REGIONAL CENTER	RC
△	2	SECTIONAL CENTER	SC
○	3	PRIMARY CENTER	PC
⊖	4	TOLL CENTER	TC
●	5	END OFFICE	EO

C) CSP Switching Systems:

1) No. 4A or *4M Toll Crossbar
2) Crossbar Tandem
3) No. 5 Crossbar
4) Step by Step Dial.

*4M - No. 4 Toll Crossbar converted to have full CSP features of 4A.

D) Each TC (Toll Center) has a Final Group to a particular HOME CSP - a PC, SC or RC.

E) Each PC "HOMES" on an SC or RC

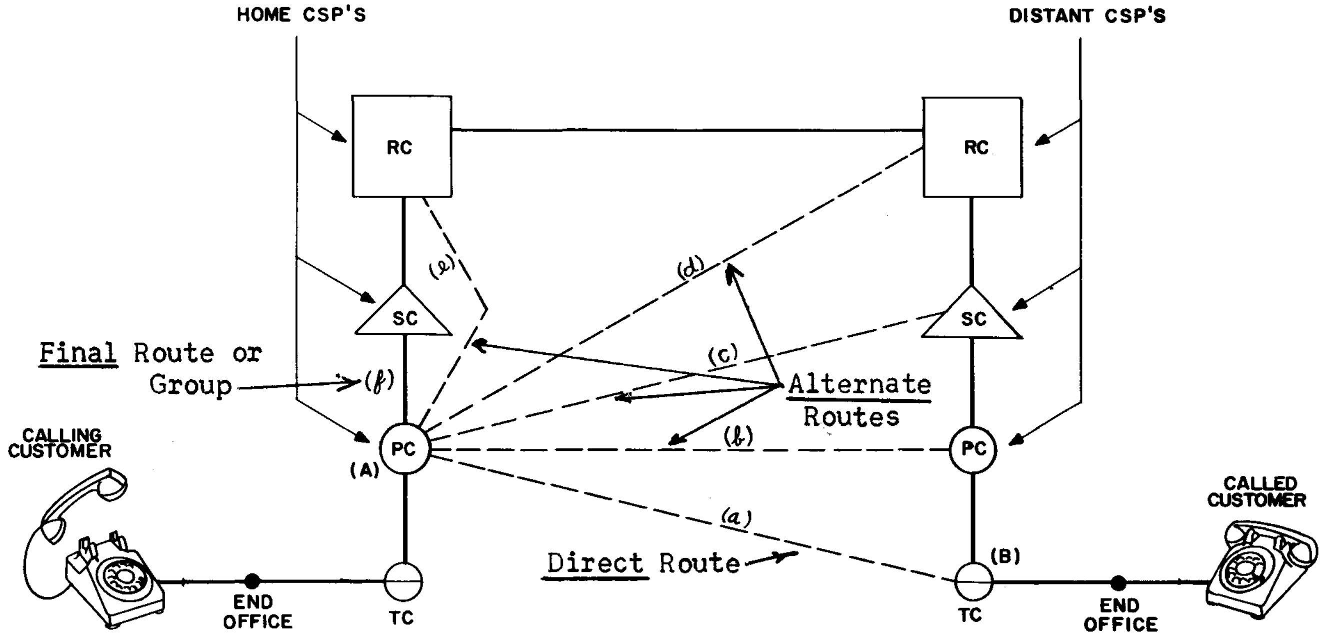
F) Each SC "HOMES" on an RC

G) All RC's interconnected with Final Trunk Groups - Backbone Network between any two (2) TC's.

H) High Usage Trunk Groups provided between any two Offices where Traffic warrants, regardless of Class - TC, PC, SC or RC.

Intertoll Trunk Groups - High Usage Groups handle only part of the Busy Hour Traffic, with the excess Calls overflowing to successive Trunk Groups.

A) Direct Route - First Choice.
B) Alternate Routes - Second, Third, etc., Choice.
   1) No. 4A - Max. 6 Alternate Routes.
   2) Crossbar Tandem - Max. 3 Alternate Routes.
C) Final Trunk Groups - Last Choice - Backbone Routes.
D) A Call is routed (advanced), in a predetermined order, from one CSP to the next in the chain, in search of an Idle Trunk.



Possible ROUTES from PC (A) to Reach TC (B)

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Six (6) Possible Routes from PC (A) to Reach TC (B) - See Diagram Above.

Five (5) High Usage Trunk Groups, tested in order "from far to near."

(a)	Direct Route -	PC (A) to TC (B).)	(If no Idle Trunk,
(b)	First Alternate Route -	PC (A) to Distant PC)	(Call switched over
(c)	Second Alternate Route -	PC (A) to Distant SC) -	((f) Final Trunk
(d)	Third Alternate Route -	PC (A) to Distant RC)	(Group to Home SC.
(e)	Fourth Alternate Route -	PC (A) to Home RC)	

One (1) Final Trunk Group:
(f) PC (A) to Home SC.

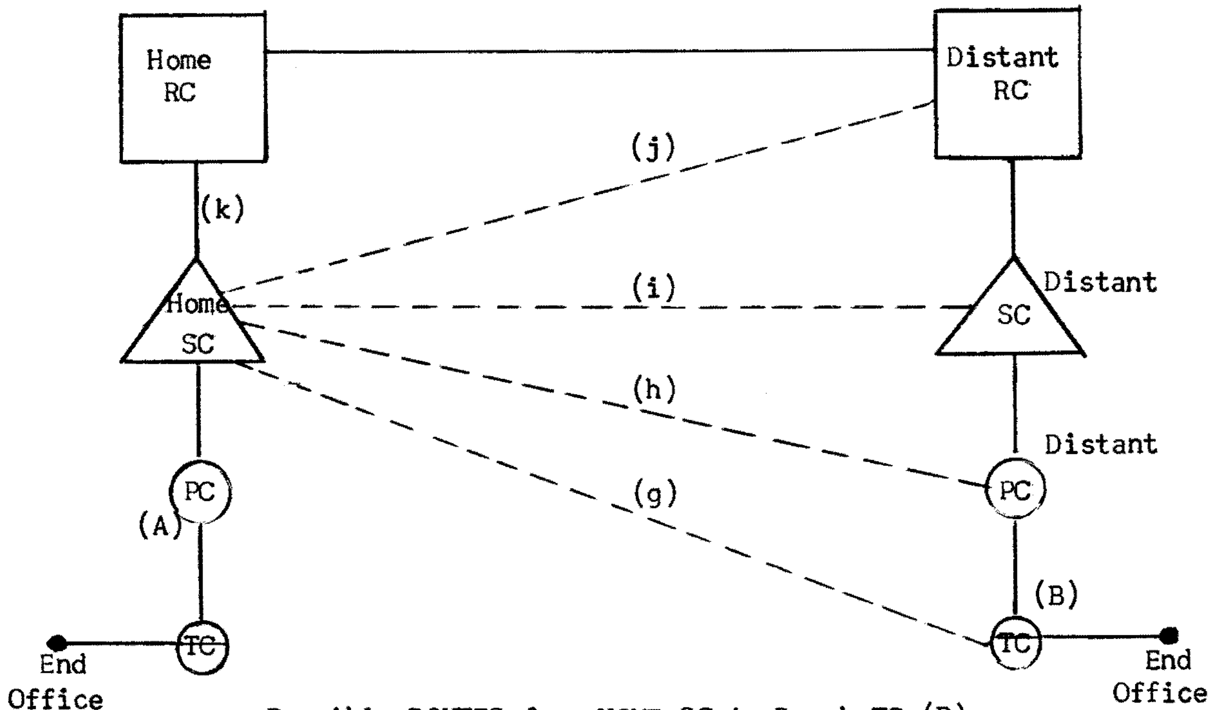
- - - - - -

Five (5) Possible Routes from Home SC to Reach TC (B) - See Diagram next page:

Four (4) High Usage Trunk Groups, tested in order "from far to near."

(g) Home SC to TC (B))
(h) Home SC to Distant PC) - If no Idle Trunk, Call switched over (k) Final Trunk Group to Home RC.
(i) Home SC to Distant SC)
(j) Home SC to Distant RC)

One (1) Final Trunk Group:
(k) Home SC to Home RC.



Possible ROUTES from HOME SC to Reach TC (B)

- - - - - -

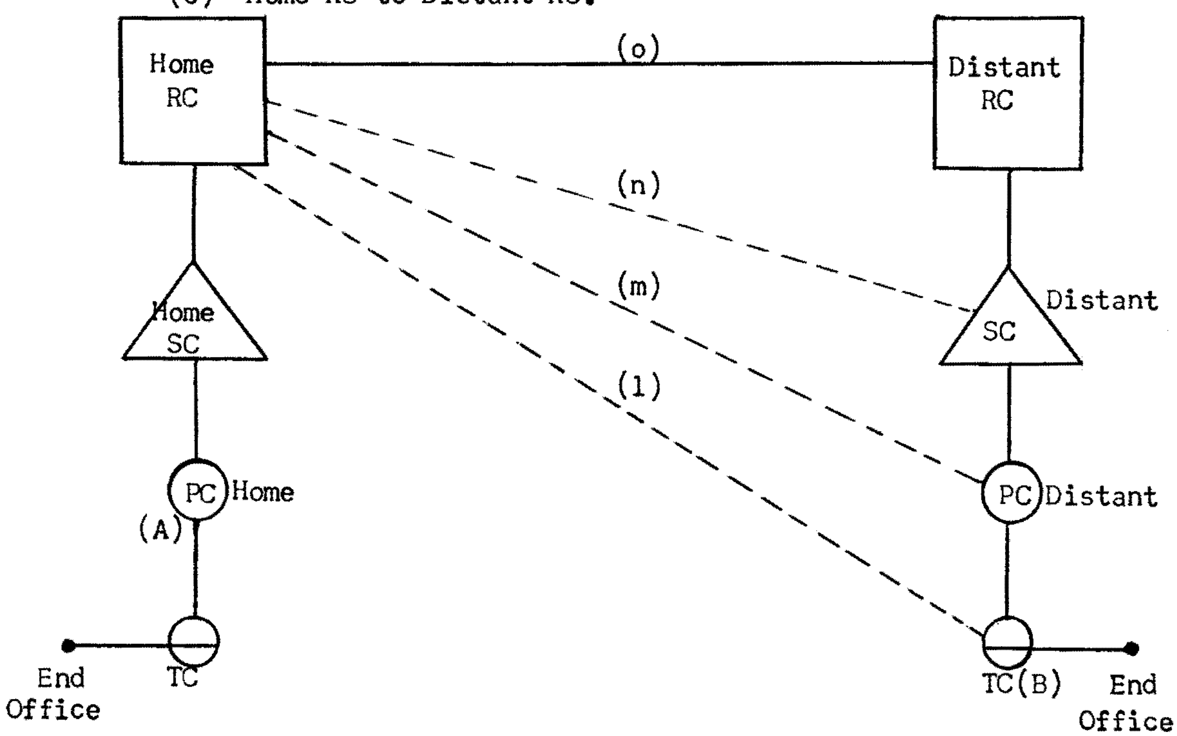
Four (4) Possible Routes from Home RC to Reach TC (B) - See Diagram Below:

Three (3) High Usage Trunk Groups, tested in order "from far to near."

(l) Home RC to TC (B))
(m) Home RC to Distant PC) - If no Idle Trunk, Call switched over (o)
(n) Home RC to Distant SC) Final Trunk Group to Distant RC.

One (1) Final Trunk Group:

(o) Home RC to Distant RC.



Possible ROUTES from HOME RC to Reach TC (B)

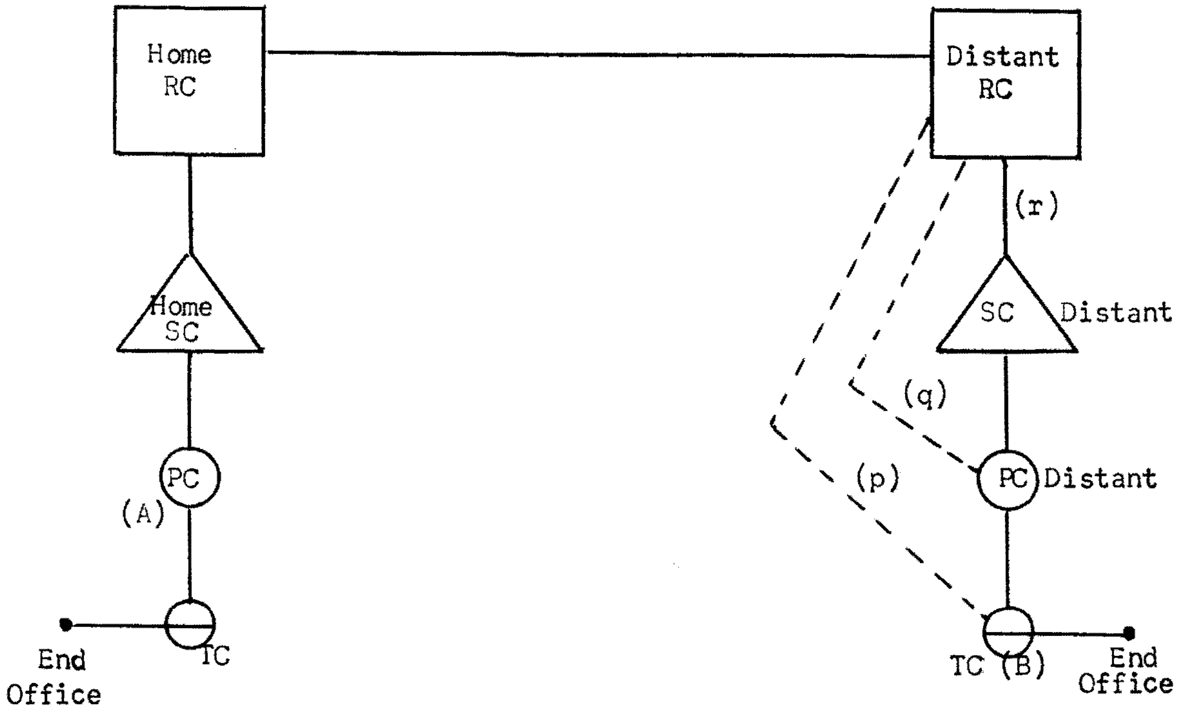
Three (3) Possible Routes from Distant RC to Reach TC (B) - See Diagram Below:

Two (2) High Usage Trunk Groups, tested in order "from far to near."

(p) Distant RC to TC (B)
(q) Distant RC to Distant PC) - If no Idle Trunk, Call switched over (r) Final Trunk Group to Distant SC.

One (1) Final Trunk Group:

(r) Distant RC to Distant SC.



Possible ROUTES from DISTANT RC to Reach TC (B)

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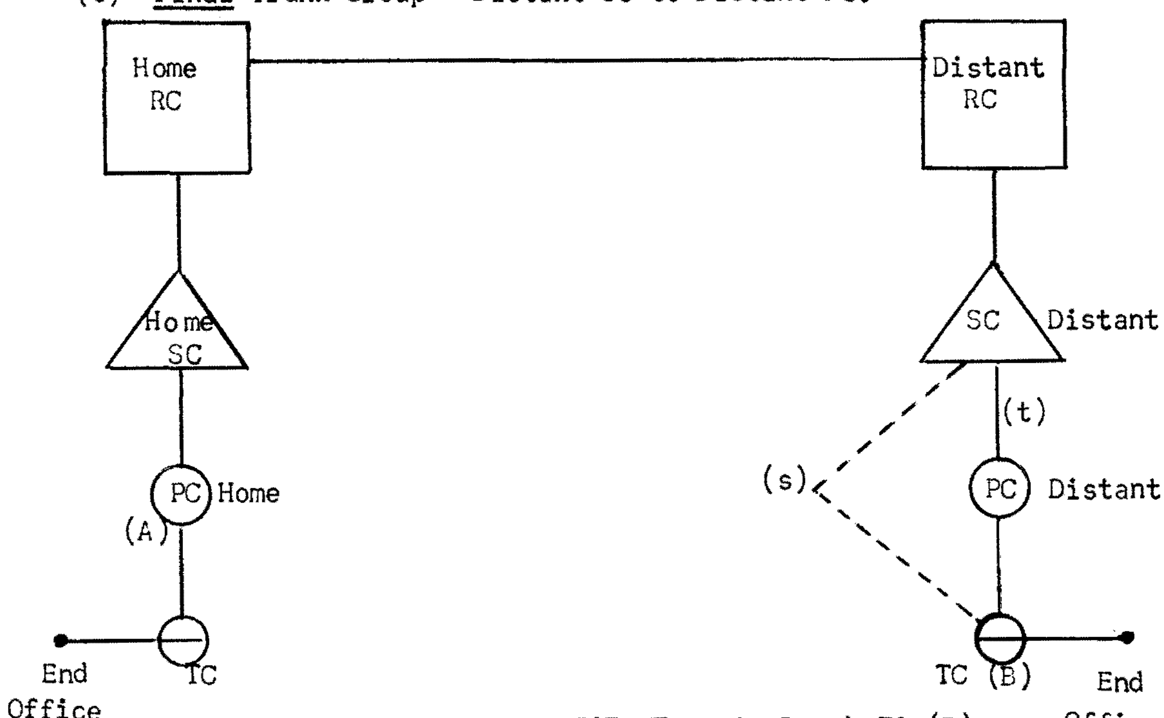
Two (2) Possible Routes from Distant SC to Reach TC (B) - See Diagram Below:

(s) High Usage Trunk Group - If no Idle Trunk Call switched over (t) Final Trunk Group to Distant PC.

(t) Final Trunk Group - Distant SC to Distant PC.

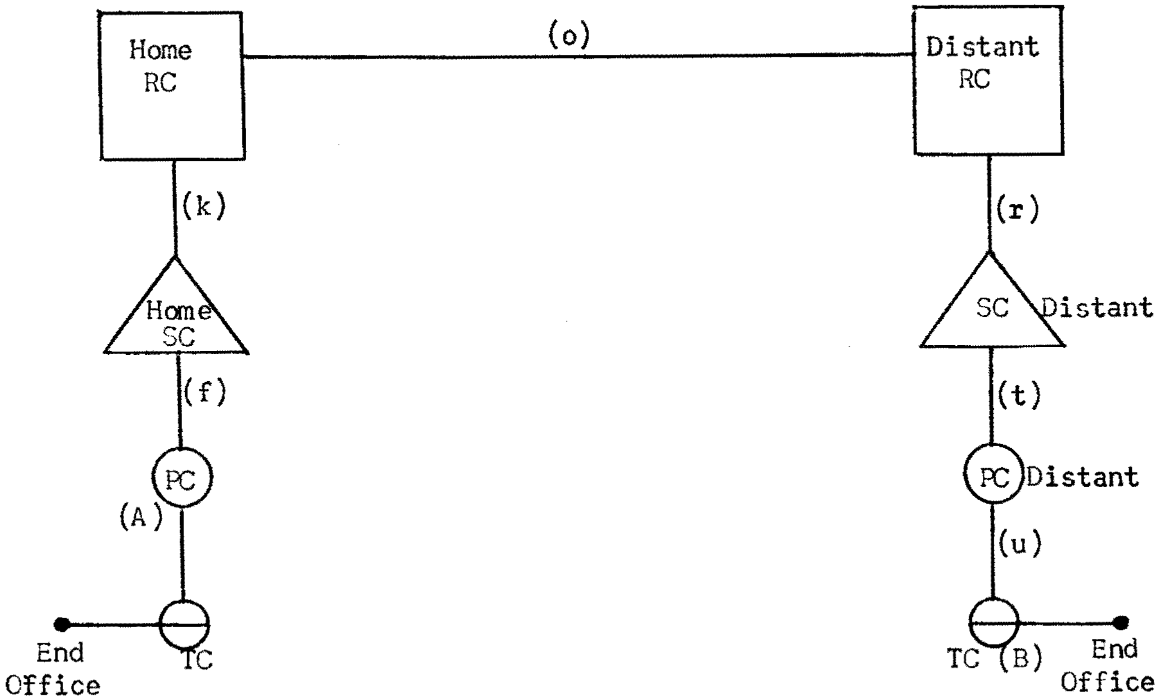


Possible ROUTES from DISTANT SC to Reach TC (B)

Backbone Routes - Call Routed entirely over Final Trunk Groups (Very Unlikely) - See Diagram Below:

(f) PC (A) to Home SC
(k) Home SC to Home RC
(o) Home RC to Distant RC
(r) Distant RC to Distant SC
(t) Distant SC to Distant PC
(u) Distant PC to TC (B)

Note: Checking available Routes requires about one second at each Office.



BACKBONE ROUTES - PC (A) to TC (B)

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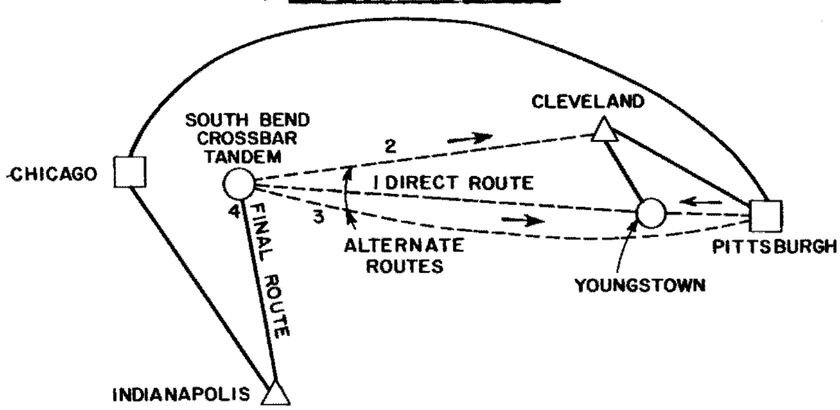
3a) ALTERNATE ROUTING

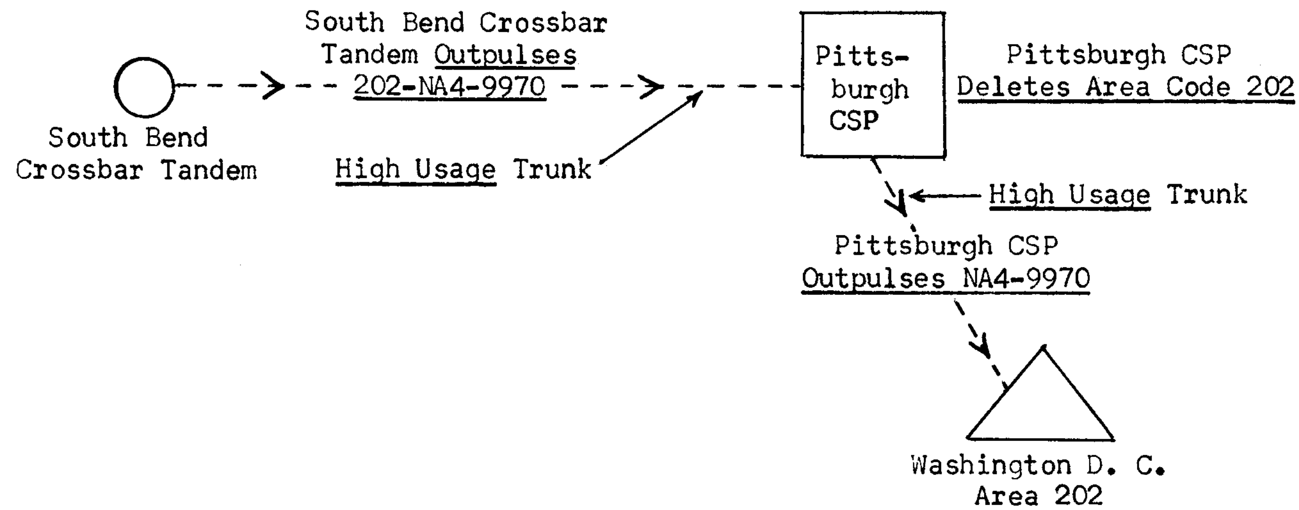


Possible ALTERNATE ROUTING - South Bend to Youngstown

1st Choice - Direct Route - South Bend to Youngstown.
2nd Choice - First Alternate Route - South Bend via Cleveland to Youngstown.
3rd Choice - Second Alternate Route - South Bend via Pittsburgh to Youngstown.
4th Choice - Final Route - South Bend via Indianapolis, Chicago, Pittsburgh and Cleveland to Youngstown - Backbone Route.

3b) STORING and "SPILLING FORWARD" (Outpulsing) Required Digits

CSP Switching Equipment: 1) Stores all Digits received.
2) "Spills Forward" (Outpulses) only those Digits required to complete the Call.



DELETION OF 3-DIGITS - South Bend to Washington, D. C. Call

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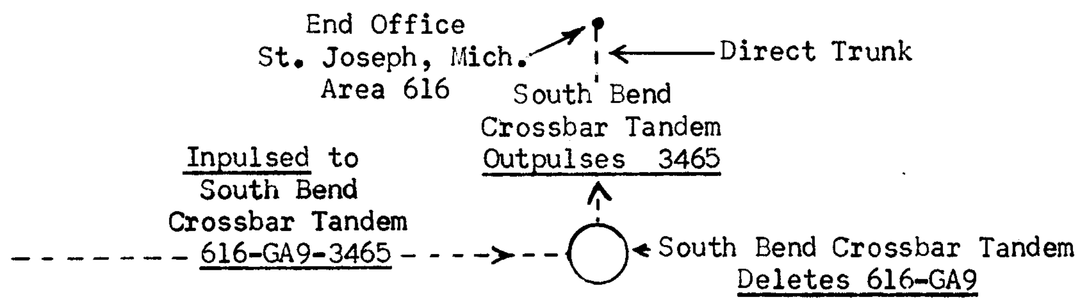

DELETION OF 6-DIGITS

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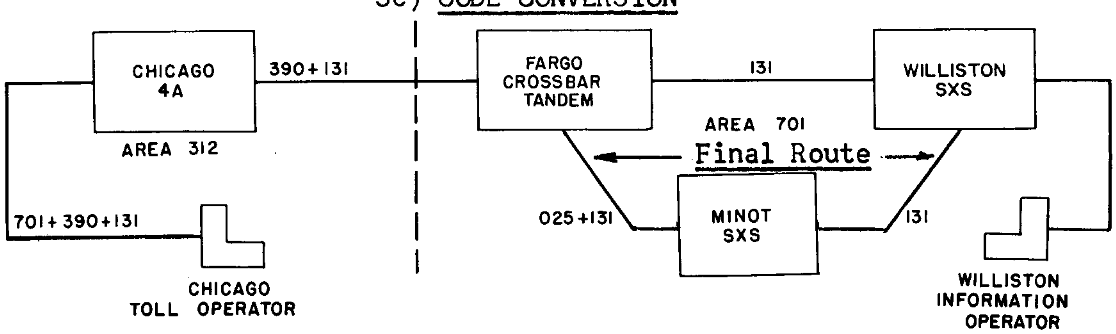
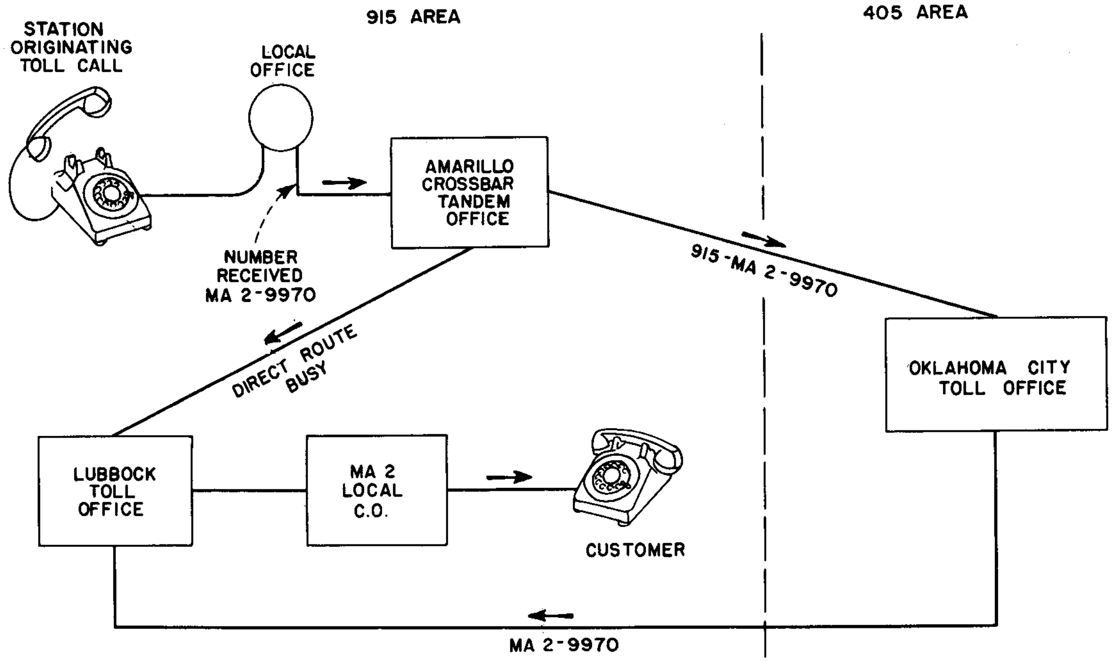
3c) CODE CONVERSION



Chicago Toll Operator Keys "701-390-131" into No. 4A Toll to reach Williston, N.D., Toll Information Operator.
Chicago 4A Toll seizes a Direct Trunk to Fargo, N.D., and Outpulses "390-131," Deleting the Area Code "701."
Fargo Crossbar Tandem checks All Trunks Busy in the High Usage Group to Williston.
Fargo Crossbar Tandem CONVERTS "390" to "025" to operate Step by Step Switches in the Minot Office, routing the Call via the Final Trunk Group.
Fargo Crossbar Tandem then Outpulses "131" into Williston Step by Step Equipment to reach the Williston Toll Information Operator.

3d) PREFIXING

A Call may be Routed from one Area to another and back to the Originating Area for Completion.



PREFIXING - Routing Through a Foreign Area

On a Call from Amarillo to Lubbock, Texas, within the Same Area:

1) All Direct Trunks to Lubbock are Busy.
2) Amarillo Crossbar Tandem PREFIXES Area Code "915" and Outpulses "915-MA2-9970," routing the Call via Oklahoma City in Area 405.

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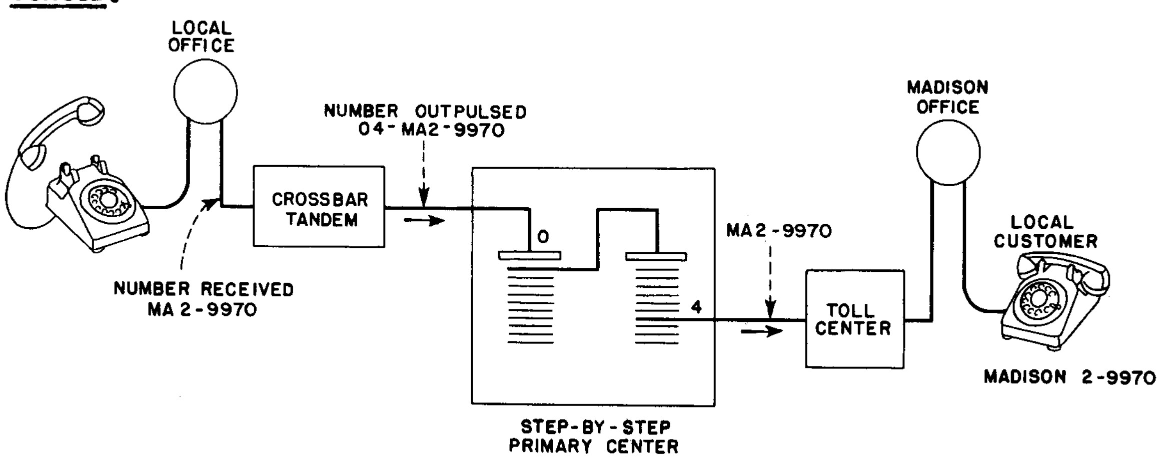
Prefixing Digits may be required to Route a Call Through a Step by Step Primary Center.

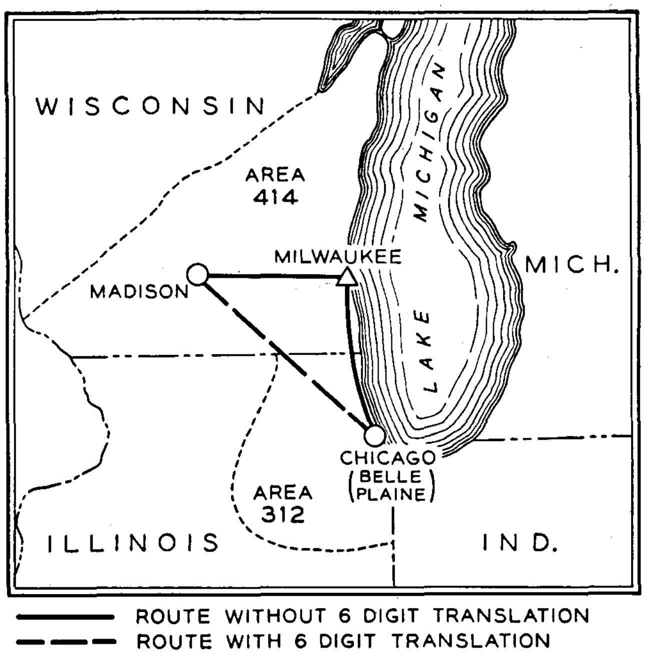


1) The Crossbar Tandem Office Registers "MA2-9970."
2) To operate the Toll Selectors in the Step by Step Primary Center, the Crossbar Tandem Equipment PREFIXES "04" to "MA2-9970," and Outpulses "04-MA2-9970."
3) The full 7-Digit Number, "MA2-9970," is passed to the Toll Center Switching Equipment.

3-Digit Translation Routes All Calls to a Foreign Area over a Single Route.

6-Digit Translation, using a Foreign Area Translator, Routes Calls over Two or more Routes, to or towards the Foreign Area involved.

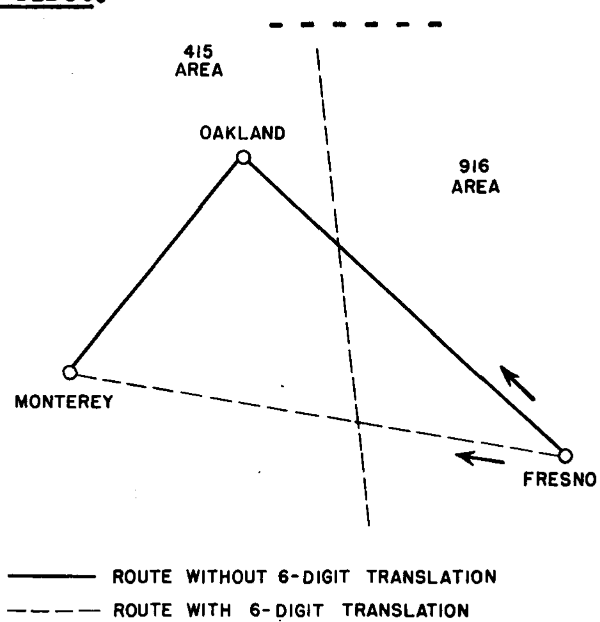
1) The Crossbar Tandem Marker, for example, Translates the Area Code.
2) Then the Marker Calls in the Foreign Area Translator to Translate the Central Office Code.



6-DIGIT TRANSLATION
Chicago Belle Plain Crossbar Tandem to Madison, Wis.

3-Digit Translation would Route All Calls via Milwaukee, involving extra Trunk Mileage and an additional Switching Point.

With 6-Digit Translation, High Usage Trunks direct to Madison are tested first.



3-Digit Translation - All Calls from Fresno to Monterey would be routed via Oakland.

6-Digit Translation - The Direct Trunks to Monterey would be tested first.

6-DIGIT TRANSLATION
Fresno to Monterey, California