Incoming register circuits
for No. 5 crossbar

In a No. 5 crossbar office, a call coming in from another office can be completed to the called line by a marker in a fraction of a second. A much longer time is usually required, however, to receive from the incoming trunk the number of the called line, since the several digits of the number are pulsed one at a time over the two wires of the trunk. To avoid holding the marker during the pulsing time, a circuit is required to receive and remember the various digits, and then to transmit all of them to the marker at once, using as many paths as needed. Such circuits are called incoming registers. In general function and purpose, they are thus like the originating registers.*

When an incoming trunk receives a call from its distant end, it signals a link circuit†, which connects it to an idle incoming register. The link transmits to the register a trunk class signal, a frame number, and, for tandem trunks, a number-group location. Classification indications give such information as whether the register should send dial tone over the trunk; the number of digits to be received; whether the trunk is arranged for local, tandem, or toll service; any restrictions which may apply to the trunk in completing to various groups of lines; and whether the trunk is of a special purpose type used by certain operators or test men. Some of these items will affect register functions, but most of them are merely recorded to be passed on to the marker after the line number has been received. The frame number is the number of the trunk-link frame where the trunk appears. It is required by the marker in connecting the trunk to a local subscriber. The number group location is used by the marker to obtain the line-link frame location of a

Fig. 1—A frame of incoming registers installed in the Laboratories for test: a dial-pulse register at A; a multifrequency register at B; and a recptive-pulse register at C.

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* See page 39. † See page 72.
tandem or toll trunk. Such trunks appear on both the trunk-link and line-link frames. The latter connection is used when the call is to pass through the office, and the former when it is to be completed to a local subscriber. The register records this information, checks for any possible double connection in the link, and then signals the trunk that pulsing may commence.

Incoming registers may receive pulses from a step-by-step subscriber's dial, from a sender, or from an operator's dial or keyset. Three types of pulsing are encountered: dial pulse, from a dial or sender; retractive, from a panel or crossbar sender; and multi-frequency, from a keyset or sender. Other types may be added as required without affecting the marker. A separate type of register is used for each type of pulsing. A frame with the three types of registers is shown in Figure 1 as installed in the Laboratories for test purposes.

Each dial-pulse digit is a train of from one to ten open-circuit pulses sent from the calling office; each retractive digit is a train of shunting pulses sent from the called office and stopped by a signal from the point of origin when the correct number has been sent; each multi-frequency digit is a single pulse containing two out of five frequencies in the audible range. A dial-pulse register need merely count pulses and recognize the end of each digit, while a retractive register must generate pulses, count them, and recognize an open circuit signal which marks the end of a digit. These functions are performed by relays within the registers; pulse generation as described in connection with retractive pulsing,* and counting as described for the originating registers.† Multi-frequency registers are not at present equipped with relays to sort out the a-c frequencies contained in their pulses, but instead employ an electronic multi-frequency receiver, shown in Figure 2, which amplifies the pulses, limits their amplitude, checks for spurious and missing frequencies, separates and detects the frequencies, and furnishes the register with d-c pulses on two at a time out of five leads. A sixth frequency and its associated lead are used only for start and stop signals and not for numerical digits.

As each successive digit is received, the register records it for future reference. Dial-pulse and multi-frequency registers use five relays to record each digit, two relays operating for each numeral from 0 to 9. This scheme matches both the two-out-of-five arrangement of frequencies in multi-frequency pulses and the pattern of grounded leads by which the digits will be transferred to the marker. Its main advantage is that it is self-checking, since ordinary trouble conditions would result in one or three out of five instead of two—a difference easily recognizable. These registers may be equipped for from four to eleven digits, depending on traffic requirements. In a single-office unit with only local incoming traffic, four digits are sufficient, while a No. 5 unit used as a combined local office and toll center may require eleven digits to accommodate a three-digit national dialing code, a three-digit local area code, four numerical digits and a party letter. Resecutive pulse registers at present re-

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* Record, August, 1943, page 448.
† See page 39.
cord only the pulses designating the four
digits of a line number, although plans en-
visage additional digits for tandem opera-
tion in the future. Instead of recording the
digits on sets of two-out-of-five relays as in
the other types of registers, however, the
revertive-pulse registers record them on a
crossbar switch, using apparatus and circuits
especially the same as those used in termi-
nating senders of the No. 1 crossbar system.

To determine when the last digit has been
received is no problem for revertive and
multi-frequency registers, since the former
are arranged for a fixed number of digits,
and the latter always receive an end-of-puls-
ing signal after the last digit. Dial-pulse
registers, however, may receive any number
of digits from three to eleven and do not
receive any end-of-dialing signal from the
trunk. Dial-pulse registers, therefore, must
look for every possible clue as to the number
of digits to be received. On calls from local
trunks, the trunk class indicates the expected
number of digits—either four or five depend-
ing on the class. On tandem and toll trunks,
an office code always precedes the line num-
ber. However, there may be both two and
three-digit codes within the numbering
area, and some offices reached by tandem
may have some lines with party letters. Still
more variation occurs on toll calls, since they
may be directed to either subscribers or toll
operators in either the local area or some
distant area.

To take care of these variations, the dial-
pulse register has facilities for looking at
the first one or two digits of the office code,
which may indicate the number of digits in
the code and also identify the code suffi-
ciently to tell whether the called office has
party letters. If it has or may have, there is
still no assurance that a letter will be dialed
on this particular call, but the register will
allow time for a possible additional digit. On
toll trunks, the code may be either a local
area code or a toll code. The register can
recognize the difference by looking for a
toll-indicating zero or 1 in the first or second
position. Local-area codes are treated as are
those received on tandem trunks, but most
toll codes may be followed by an indefinite
number of digits. When such a toll code is
recognized, therefore, the register times
after every digit received, and recognizes
the last digit by the lack of dialing within
the succeeding few seconds. An exception is
made for certain toll service codes that are
never followed by any digits. Such codes,
recognized by 1's in certain positions, indi-
cate the end of pulsing without timing after
the third digit.

When the register is satisfied that all digits
have been received, it must pass them to a
marker. The register signals a marker con-
nector circuit, which seizes an idle marker
and connects it to the register by a large
number of wires. Using these many paths
simultaneously, the register is able to tell
the marker in a few milliseconds all the in-
formation which it has accumulated in per-
haps as many seconds. Trunk class, frame
location, number-group location, and the
several digits go into the marker all at once,
enabling it to complete the call immediately
and to free itself so quickly that it can handle
thousands of calls per hour.