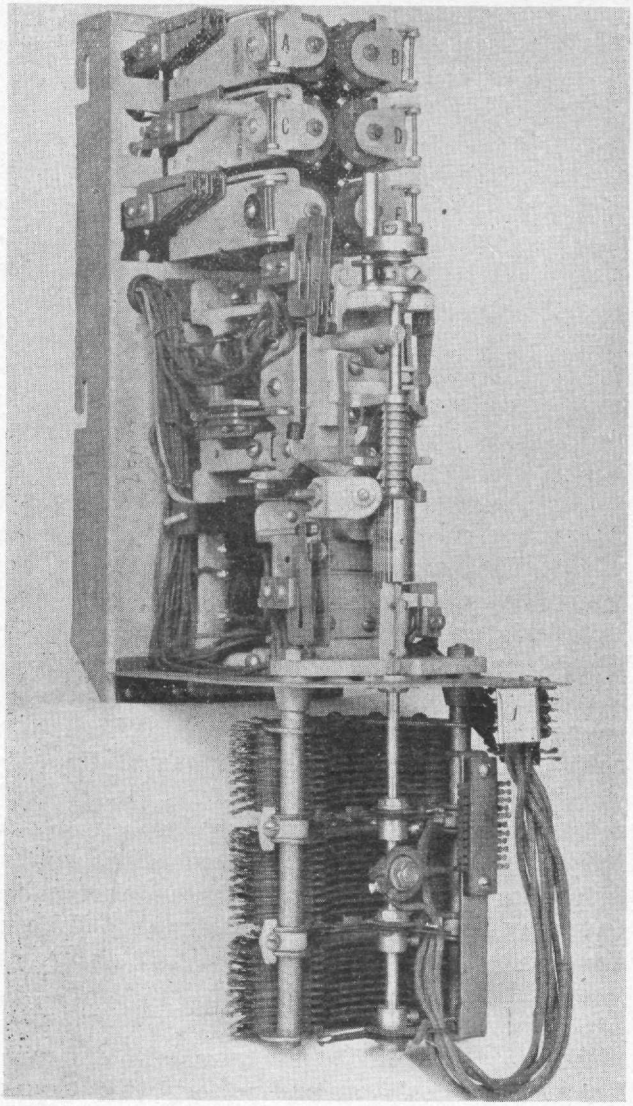
Dial Telephone Systems

By JACK A. TAYLOR, EE. IV

An automatic telephone exchange, as some cynic once remarked, is merely a device for placing the blame on the subscriber instead of the operator. The first automatic telephone system was patented only three years after Bell's invention of the telephone. The first practical system was developed by Strowger during 1889-91. This system, known as the *step-by-step* is still in use in the installations of The Automatic Electric Company, and in the smaller installations of the Bell System companies. By small cities is meant those with about 100,000 or less telephones.

At first, the step system required five wires to each phone which was rather expensive and clumsy. The system was gradually improved until today only two wires are required, the same number as is needed by a manual exchange. Since this system is so widespread—all large Ohio cities except Cleveland and Cincinnati using it—and since it is the least complex, its operation will be explained in detail.



—*Courtesy of Western Electric Company.*

Step-by-step selector switch.

The fundamental unit of equipment in the step system is the step-by-step switch, see fig. 1. It consists of two or three banks of contacts, a wiper arm to connect with these contacts, several magnets to operate the wiper arm and a frame to hold the various parts. Each bank has 100 contacts in it arranged in ten horizontal arcs with ten contacts to each arc. In the first set of dial pulses each pulse operates the vertical magnet and the ratchet lifts the arm up one step. During the interval before the next set of pulses another magnet operates and transfers the next set of pulses to the horizontal magnet. This magnet then rotates the arm one step horizontally for each pulse. At the end of the call the releasing magnet operates and springs bring the arm back to the rest position.

The next step is to trace a call through the exchange and see what happens each step of the way. First is the subscriber's handset including the dial. This generates the pulses which control the selecting mechanism. The line from the subscriber is connected to a simple rotary switch at the exchange which connects the caller to an idle first selector. As soon as the first selector is connected it gives dial tone in the handset and the number may be dialed. The first selector uses the first set of pulses and connects the phone to an idle second selector in the proper group. The second selector uses the second set of pulses from the dial and picks an idle third selector in the proper group and so on until the final selector is reached which uses the last two groups of pulses and connect the subscriber to the proper phone, or to be more exact, the number he dialed. The final selector then rings the called subscriber and when his handset is picked up the call is complete.

The dial is the device which generates the pulses and transmits them to the exchange to

(Please turn to page 26)

DIAL TELEPHONE SYSTEMS

(Continued from page 11)

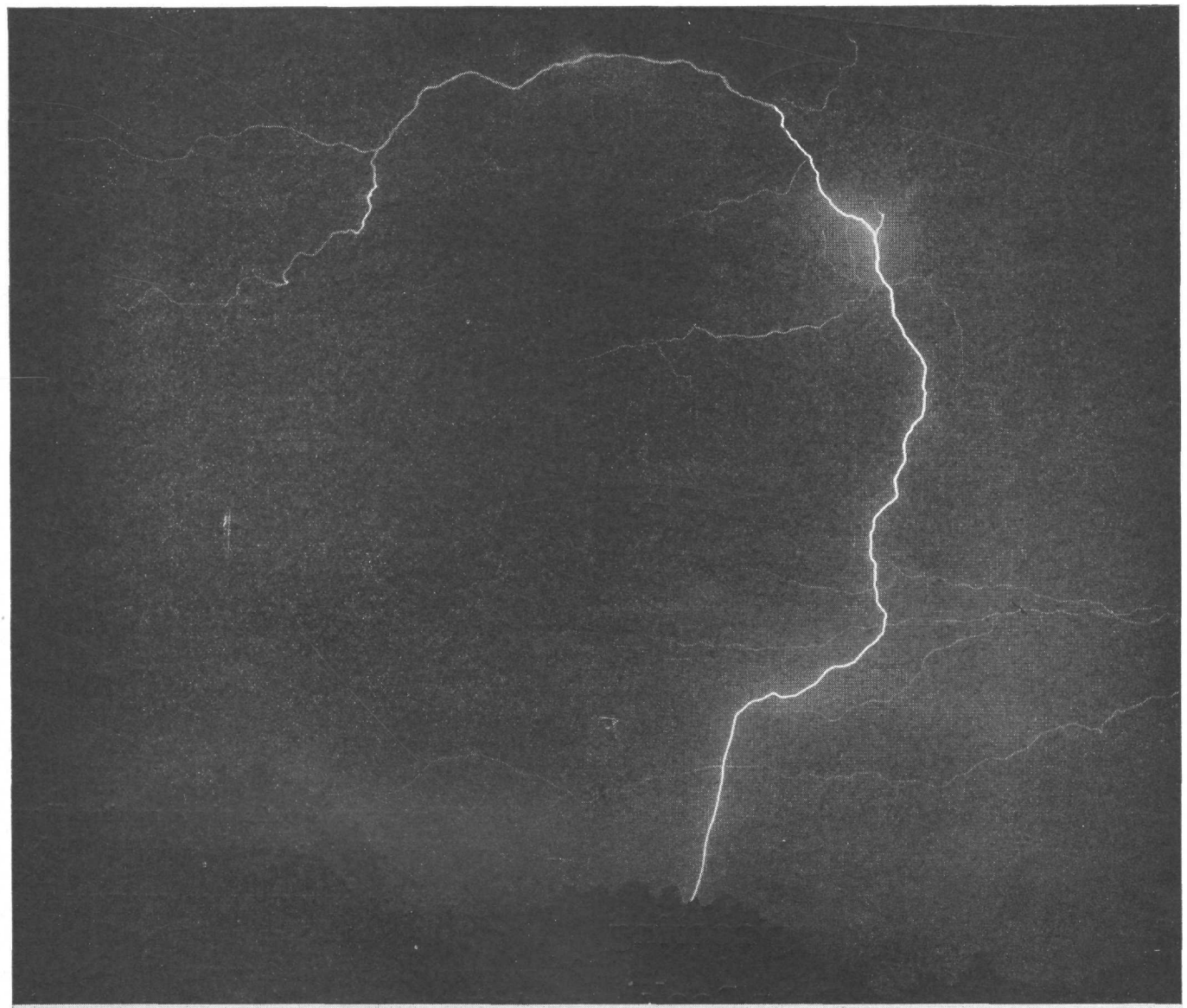
operate the switches. The external part of the dial consists of a disk with ten holes in it numbered from one to zero. Zero is given as ten pulses since naturally zero pulses would have no effect at all on the various switches. There are also letters marked on the dial but as far as the switching equipment is concerned there are only numbers. The letters are only used since it is simpler to remember two letters and four digits than it is to remember six numbers. Inside of the case is a gear train with a 5 to 1 ratio and a contactor which gives two pulses for each revolution of the wheel attached to the end of the gear train. If 9 is dialed the last gear revolves 4½ times and gives 9 pulses. The dial gives the pulses on the return to the rest position and a governor is attached so the pulse speed is about ten per second. The whole system is adjusted to this speed so forcing the dial to go faster will probably result in the switch missing a step and getting a wrong number.

If the standard switch was used for each subscriber it is easy to see that the total number of switches would be prohibitive in a 10,000 line exchange. Each person would need one switch for the first two digits, 100 switches for the next two digits, and 100×100 or 10,000 switches for the rest of the number. The whole exchange would thus take 101,010,000 switches. So a modification has been developed which requires only 4000 switches for the exchange.

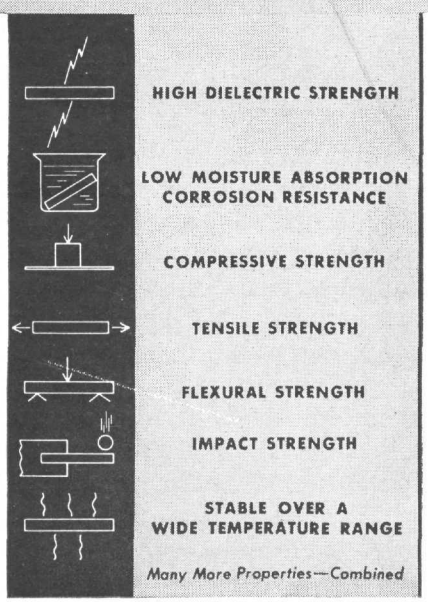
The modified switch works as follows. The first set of pulses send the switch up to the proper level and it then rotates automatically until it finds an idle selector in the next group. Thus instead of one-hundred second selectors for one first selector there need be one-hundred second selectors for one-hundred first selectors. To further reduce the cost and complexity every subscriber's line is connected to a simple rotary switch instead of a step-by-step switch. These rotary switches connect the calling party to an idle first selector.

Now if a subscriber were calling 852284, i.e. UN. 2284, the line switch would pick out an idle first selector, and this first selector would go up eight rows and pick out an idle selector in the 800000 group. The second selector would then go up five rows and pick an idle selector in the 850000 group. The next selector would pick an idle selector in the 852000 group and the next selector would pick the 852200 group. The final selector would then go up eight and over four and ring the number called.

(Please turn to page 30)



Franklin's $64 Question Gave Electricity a Job



LIGHTNING streaked through ages, feared but unchallenged. Then to Benjamin Franklin it flashed the answer to a question that unlocked the future of electricity.

Technical plastics, Synthane, for example have already answered many $1 to $64 questions for people who make things. And may for you. The question, of course, should come before the answer—for only you know, as *you* do, what your requirements are. If whatever you are working on suggests a material of excellent electrical insulating characteristics, resistance to corrosion, mechanical strength, stability at usual temperatures, easy machineability, or a variety of other interrelated properties, our type of technical plastics may readily be indicated. Our latchstring is always out to any inquiry.

SYNTHANE CORPORATION, OAKS, PENNSYLVANIA

Plan your present and future products with Synthane Technical Plastics

SHEETS • RODS • TUBES • FABRICATED PARTS **SYNTHANE** MOLDED-LAMINATED • MOLDED-MACERATED

DIAL TELEPHONE SYSTEM

(Continued from page 26)

Besides doing all this the line tests each connection before it is made and indicates any trouble on a panel. It also tells what this trouble is and where it is located and finally it gives the busy signal if any of the equipment is not idle.

There are three other systems in use besides the step-by-step. They are the Northern Electric's all-relay system and the Western Electric's panel and crossbar systems.

The all relay system is used only on small installations, as the amount of equipment needed is proportional to the factorial of the number of subscribers. However for installations of 10,000 phones or less it is a strong competitor of step-by-step.

Panel and crossbar are used only in large metropolitan areas, e.g. Cleveland and Cincinnati. The panel system was invented when step-by-step was becoming too unwieldy as the number of telephones increased. The crossbar is a more recent invention and is being used in all new installations instead of panel. The two are built so they can be used in the same set of exchanges, so panel is used now only to complete existing exchanges.

The distinctive feature of the panel and the crossbar systems is in the manner of selecting idle lines. Interrupters are used to give a code for each group. This code is applied continuously to the selector frame. When a certain digit is called the code for that number is put on the selector arm. The selector arm then moves until it finds an idle circuit with the same code on it. Since any number of contacts may have the same code on them, it is evident that the number of lines for each group may be varied to fit the traffic of that particular office. For instance the Walnut exchange would need a lot of connections for WA and UN but only a few for JE or FR as these exchanges are not called so often. Thus the adaptability of the panel and crossbar suits for large systems.

The real development in the future for dial telephones will probably be in the crossbar system, as the panel system is obsolescent, and it seems that only minor improvements remain to be made in the step-by-step and the all-relay systems.

"Why does the ocean roar?"

"You'd roar, too, if you had crabs on your bottom!"

NITROGEN takes Betsy's Best to the Fighting Front

Milk, too, is styled for modern war... streamlined by dehydration to save weight... armored by nitrogen to avoid deterioration. In fact, dehydrated foods of infinite variety are protected by Nitrogen and Carbon Dioxide, two of the many gases produced by Air Reduction.

In the food field these Air Reduction products are helping to build a new industry.

In other fields Airco products and processes are revolutionizing war production—providing faster manufacturing methods that will help build a better world after V day.

★ BUY UNITED STATES WAR BONDS ★

AIRCO

AIR REDUCTION

60 EAST 42nd STREET • NEW YORK 17, N. Y.

Air REDUCTION SALES COMPANY
MAGNOLIA AIRCO GAS PRODUCTS CO.
NATIONAL CARBIDE CORPORATION
PURE CARBONIC, INCORPORATED
THE OHIO CHEMICAL & MFG. CO.
WILSON WELDER & METALS CO., INC.

OXYGEN, ACETYLENE AND OTHER ATMOSPHERIC GASES • GAS WELDING AND CUTTING APPARATUS • CALCIUM CARBIDE
ARC WELDING MACHINES AND SUPPLIES • CARBON DIOXIDE • "DRY ICE" • ANAESTHETIC AND THERAPEUTIC GASES AND APPARATUS