To provide business telephone service, Bell System installers connect over 100,000 wires each working day. A new quick-connect clip terminal has now been developed which reduces this effort to a simple push of a hand tool.

W. Pferd

Quick-Connect Clip Terminal

The most time-consuming task a craftsman faces while installing a telephone is placing and connecting the wires which run from the protector block to the telephone set cord. This task becomes particularly laborious in key telephone systems, where 25- and 50-pair cables are used. Since the advent of the CALL DIRECTOR Telephone and other new business telephones, there has been a very rapid increase in the number of more complex new installations and additions to service. To provide this type service, Bell System installers must connect over 100,000 wires each working day—skinning insulation, placing the wire on a terminal and tightening the nut of a screw fastener. Obviously, the total endeavor is time consuming and costly.

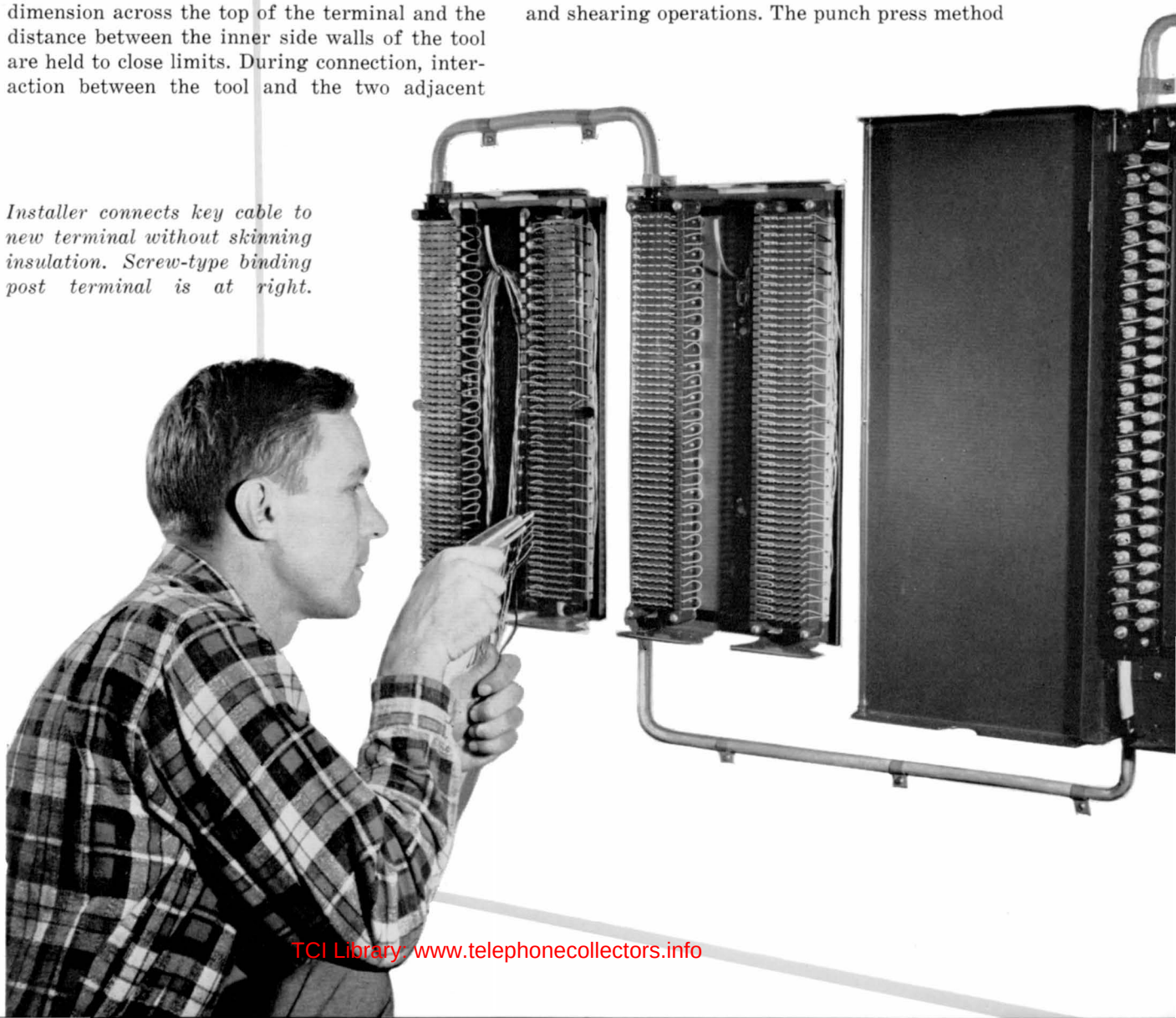
In fact, the increasing task of installation and rearranging, measured both in charges and in time on customer's premises, clearly established the need for quick-connecting devices which significantly reduce this effort and expedite the provision of service. A recent survey of terminating apparatus failed to disclose any device which satisfactorily met the particular requirements for station apparatus. To satisfy this need, a new quick-connect terminal has now been developed which meets installation needs more quickly than did the older binding-post distribution box and screw-terminal connecting blocks. Additionally, the terminal is smaller and less costly than previous terminals. An assortment of connecting block designs incorporating this terminal has been developed, and these are now available. One of the new connecting blocks, the 66A2-50 type, is shown being used by an installer on the opposite page. Because the connecting blocks are easier to use than previous equipment, and because of the wiring convenience to the installer, savings of over $2,000,000 yearly are forecast.

The older 30 and 31 type binding post connecting blocks, which have been in use for over 30 years, provide good contact reliability but are

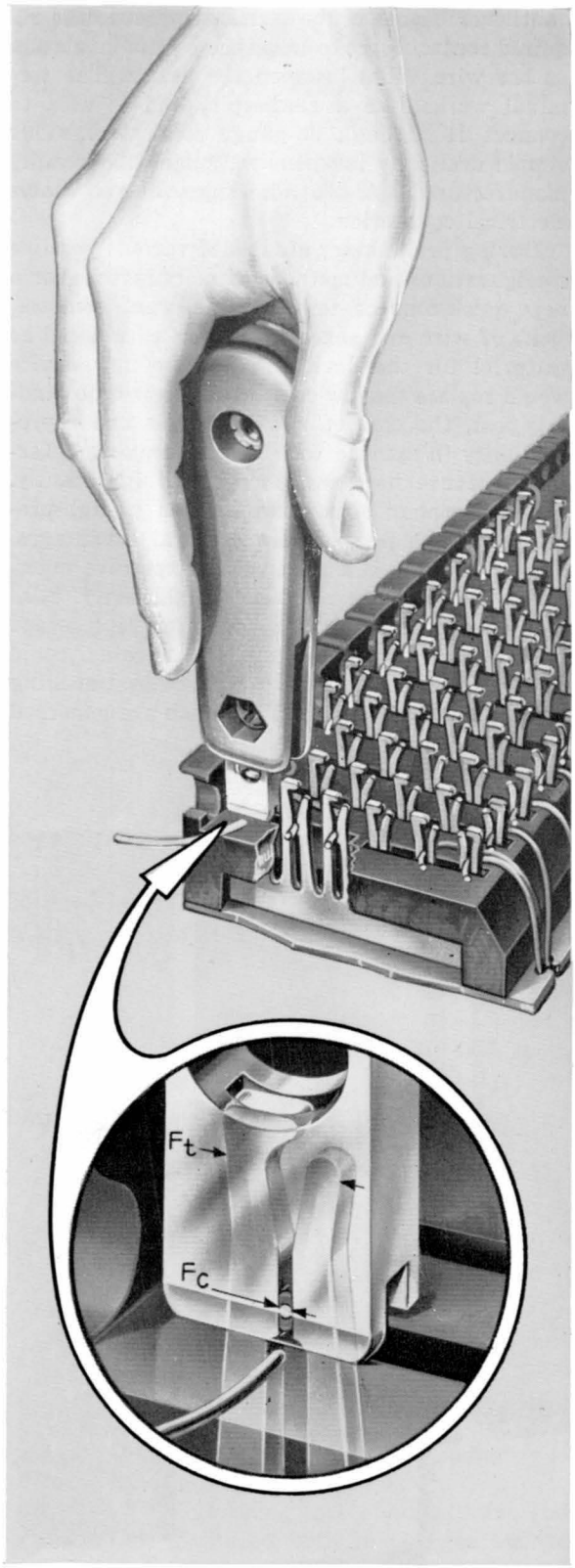
easily broken and require extra care when used to connect more than two cables. These blocks are a reference in comparing speed to make connections and serve as a standard in analyzing installer actions. On analysis, the installation procedure for terminating solid wire to binding-post assemblies breaks down into two major actions on the part of the installer: sorting wires and making connections. The sorting operation requires that the craftsman know both the color coding and the terminating point for each wire. The ease of connecting the wire is determined by the dexterity of the installer and by the design of the connecting device. With conventional terminals, three steps are necessary to make a connection—skinning, placing and tightening. Over the years, the job of removing the insulation has been the major obstacle to speedy operation. When plastic insulation became available, development of a terminal to which unskinned wires could be connected with a simple thrust of a hand tool appeared to be feasible.

The clip terminal shown on the next page was designed to meet this objective. The dimension across the top of the terminal and the distance between the inner side walls of the tool are held to close limits. During connection, interaction between the tool and the two adjacent cantilever beams of the terminal produce the required contact force to crush the plastic insulation as the wire slides between the beams. The terminal works like a clothespin, and is able to connect 18 through 26-gauge solid wire. This simple design is inexpensive, small, and readily manufactured. Above all, it provides a stable electrical connection.

During preliminary studies of various possible configurations and methods of manufacture for a new quick-connect terminal, different compositions of wire and sheet stock were considered as material for the device. Since the new device would replace the low-cost brass screw-type binding post, the cost of raw materials and reproducibility in manufacture became important factors, because both influence costs significantly. Sheet phosphor bronze, worked on a high-production punch press, offered several advantages. For example, it is a relatively inexpensive material with adequate electrical conductivity. Also it has the excellent spring characteristics needed in a quick-connect terminal. The terminal could be manufactured to close tolerance by punching and shearing operations. The punch press method



Installer connects key cable to new terminal without skinning insulation. Screw-type binding post terminal is at right.



Inset shows the forces developed on wire, insulation and clip as connection is made with tool.

of manufacture also made production of great quantities of terminals of a single basic design practical. This capacity will be valuable, since the estimated production rates for all the varieties of connecting blocks using the terminal will require over 300 million terminals yearly.

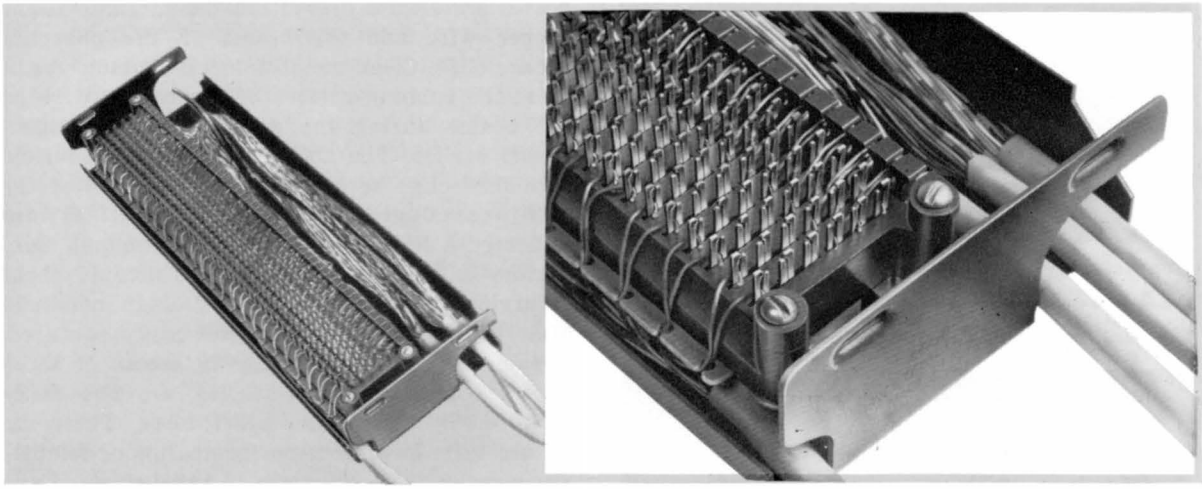
New Plastic for Terminal Mounting

The mounting for the terminal also presented challenging design problems. After evaluating many other plastics, injection molded acetal resin (such as Delrin) was chosen because of its relatively low cost, electrical properties, resistance to low temperature shock, and hardness. The last characteristic is very important, since the block serves as an anvil when excess wire is cut off by the connecting tool. The high strength and resilience of acetal permits the assemblies to withstand the rough handling and dropping experienced in field use. The low water absorption rate of the plastic aids in maintaining high volume resistivity. The material is ideally suited for a connecting block where good electrical properties are required in conjunction with excellent mechanical properties. In this regard, the material used in the new block is far superior to that in the older binding post terminal.

A new connecting block for station wire distribution, designated the 66A2-25, which permits joining six inside wiring cables, is shown on the opposite page. These connectors are designed for cross-connecting and bridging inside wire cables. In use, distribution cable from the key telephone apparatus is connected without slack to a column of clips. Cables to telephones which may be subsequently changed are then connected through the fanning strip to the remaining five columns of clips. A six-cable capacity was considered adequate for all but exceptional installations. Where the connecting block is to be mounted within the business office, an attractively styled snap-on enclosure is provided.

For 25-pair cable installations a container holding one connecting block is used. This assembly is coded 66A2-25. An assembly of 2 blocks and container, coded 66A2-50, is available for larger 50-pair cable installations. These containers consist of a sheet-steel base and cover, styled and finished to harmonize with the surroundings. They provide proper space for storing the slack wire and permit easy mounting plus quick removal and replacement of a snap-on cover.

The over-all design of the new connecting blocks and containers resulted from development work at the Murray Hill and Baltimore locations of Bell Laboratories, as well as production con-



The 66A2-25 connecting block permits joining six inside wiring cables. Closeup shows actual clips.

sideration by the Western Electric engineers at Baltimore and field studies in six operating telephone company areas. Since the advantages anticipated in using the terminal derive from simplified repetitive work operation, human engineering factors were also carefully evaluated during these studies. The terminals, when mounted row-on-row in the block, had to be readily accessible and convenient. Laboratory tests to establish the spacing between terminals to permit orderly wiring plans dictated the block design. These tests also indicated that connections could be made with the clip terminal in from one-half to one-third the time required with conventional binding post connectors. Subsequent tests confirmed the laboratory results, and showed the new design to be extremely easy to use.

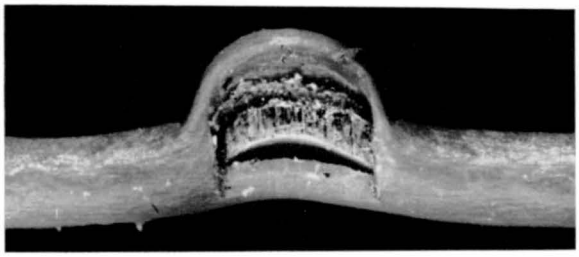
One Wire Connection per Clip

To insure reliable connections, only one wire is connected to each clip. A wire change can be made as quickly as a new installation, by merely pulling the unwanted wire out of the terminal in the direction of the clip opening and reinserting a new wire with the hand tool. Because an individual terminal is used for each wire, connecting or removing any one wire does not disturb other connections. This also permits orderly wiring and provides adequate space for wire manipulation.

A craftsman making a connection positions an unskinned wire around the hook on one of the adjacent cantilever beams of the terminal and pushes it down with the hand tool, designated the 714B. When the wire is forced into the terminal, the beam ends deflect outward and make contact with the inner walls of the tool. The terminal beams are thus loaded as end supported cantilevers. As shown on the opposite page, a tool force, F_t, is imparted at the ends of the beams and a contact force, F_c, is developed to crush the insulation on the wire. This force is effective even at temperatures below freezing, when the insulation hardens and the effective diameter of the insulation increases. As the insulated wire advances, the beams are progressively deflected, increasing the contact force and compressing the insulation until it shears. Continued movement of the wire further increases the contact force, scraping the bare copper wire against the inside walls of the beams. This action dislodges any corrosive films present on either the beams or the wire. The final contact is made over rectangularly shaped areas on each side of the wire. (Typical contact areas on 24-gauge polyvinyl chloride "D" wire and bare wire are shown on page 206; they measure approximately 0.015 x 0.045 inches on each side of the wire.) The craftsman then makes a final push, which forces a knife edge on the tool to cut off the excess wire against the plastic block. Tool cut-off is permissible for wire up to 22 gauge.

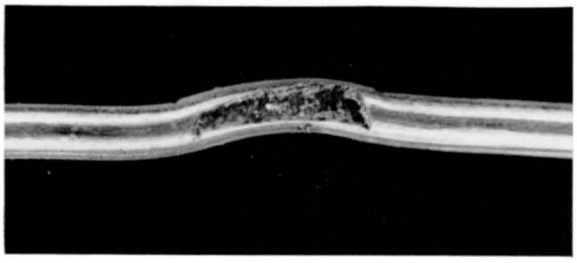
The tool bit is double ended; if the wire is not to be cut off, the opposite end is used simply to force the wire into place. This procedure is used when wire cables are to be looped through the terminal block, a wiring plan which permits minimum installation time for two telephones.

Connecting without cut-off is also employed when terminating 20 gauge steel JKT and 18, 19, and 20 gauge copper wire to avoid reduced blade life. After positioning these wires around the hook on the terminal, the excess is cut off with a wire cutter. The connection is then made by pushing the wire into the terminal with the looping end of the tool.



Contact area on 24-gauge, PVC insulated wire.

Contact area on 24-gauge bare copper wire.



Following installation, there must be sufficient force to maintain reliable contact during subsequent wire movement caused by the installer as he continues his work. However, there must not be so great a force as to prevent purposeful removal of the wire. This contact force must also prevent the separation of the wire and clip due to the buildup of contaminating films, and to maintain a gas-tight connection. A contact force of nominally 5 pounds, exerted on 26-gauge wire, meets these requirements. The contact force increases for larger diameter wire, reaching 12 pounds on 18-gauge wire. These forces, coupled with the large deflection of the beams, produce a terminal with great elastic reserve; the device can thus withstand considerable handling while still performing satisfactorily.

The large beam deflection naturally produces high stress in the clip beams, as well as a resultant compression in the wire. The possibility of a gradually progressing snipping-off action on the wire by "scissoring" over a long time has been thoroughly explored. For 24-gauge wire, only a ¼ mil reduction in wire diameter is expected in 20 years due to the relatively low contacting pressure; during the same period, the clip beams will relax only 1½ mils because of the stress relaxation characteristics of phosphor bronze. Tests show that these changes are not large enough to be troublesome.

Because of the various processing and storage conditions, insulating films of different thicknesses are always present on the surfaces of the copper wire and the beams of the phosphor bronze clips. Clean metal-to-metal contacts result from the rubbing actions of the copper wire on the beams during the connection stages mentioned earlier. The action is as effective on old tarnished clips as on new parts. Studies of the resistance of aged terminals and connections have indicated a long life for the clip terminal. Laboratory-induced oxide films as thick as those occurring on phosphor bronze details in industrial atmospheres after 20 years are easily ruptured. Copper sulfide films, greatly in excess of those expected during normal service, are also easily ruptured by the high contact force. These exposure tests have been performed under temperature cycles from 0 degrees to 140 degrees F and under dry and humid atmosphere. The results of these and other electrical tests on 24-gauge PVC "D" inside wire are summarized below and are consistently good.

Because of the favorable results experienced in the laboratory and field with the early development models, plans for an accelerated program to provide large quantities of the connecting blocks were begun even while some testing was still under way. The potential savings in using the clip terminal were so great that Western Electric was authorized to proceed with plans for full

Table shows results of electrical and other tests.

TEST	RESULTING CHANGE
1. Initial Contact Resistance	$\bar{X} + 3\sigma = (0.5 + 1)$ Milliohm
2. Oxide Film Contamination	Less Than 1 Milliohm Increase
3. Sulfide Film Contamination	Less Than 1 Milliohm Increase
4. Environmental Cycle	Unchanged After 6 cycles
5. Two Year Severe Industrial Exposure	
Undisturbed	No Change In Resistance
Disturbed 5 times	Average Increase— 5 Milliohms
6. Aging of Plastic	Satisfactory Connections
7. Low Temperature Utility	Satisfactory Connections
8. Vibration Test	No Change In Resistance

production. Connecting blocks and containers for 25- and 50-pair cable were made available in limited quantity during the latter part of 1961. Since then, field experience has been overwhelmingly favorable and has prompted the adaptation of the clip terminal to solve other connecting problems. The terminal offers distinct advantages wherever 20- to 26-gauge plastic insulated solid wire is used and additionally, can be used to quick-connect any bare wire of 18 gauge or smaller.

To take advantage of the quick-connect features of the clip terminal in various applications, other sizes of connecting blocks have also been developed. For connecting distribution cable to the new 759A PBX, a connecting block coded 66E1-32 provides a 2-clip multiple for use with cables having as many as 32 pairs. Also a 25-pair, 6-clip multiple connecting block, coded 66B1-25, is mounted in the 300 type key telephone units to permit rapid connecting of distribution cable. A 66E3-25 assembly for connecting plug-ended telephones to inside wire cable will be available shortly, as will a six-pair connector for residence telephone use. Application of the terminal to central office main frames and outside plant distribution is being studied.

Some of the different designs incorporating the new connector are shown below, and it is expected that this new, quick-connect device will soon find additional uses. The low cost of these terminals, their ease of use and proven contact reliability fulfill the requirements for a major new terminating device.

P. P. Koliss (left) discusses new designs of connecting blocks using the clip connector with author Pferd.