Equipment Aspects of Packaged N2 Carrier System Terminals

By D. T. BELL, L. H. STEIFF and E. R. TAYLOR

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Packaging the N2 carrier terminal has significantly reduced space requirements, the number of interbay wiring connections, and the number of wired options as compared to former N-type carrier equipment. At the same time noise and crosstalk performance has been improved, and ease of maintenance and operation has been provided. Isolation of "noisy" (high signal level) leads from "quiet" (low signal level) leads has been effected by routing the two sets of leads in separate ducts on newly developed double-bay duct-type frames. Wired options are simplified by furnishing optional equipment on a plug-in basis, with wiring confined to simple strapping. Automatic alarm, circuit condition and restoral equipment is furnished as part of the packaged terminal. Maintenance of multichannel equipment can be performed on an in-service basis

I. INTRODUCTION

The N2 carrier system provides twelve two-way message, program or narrow-band data channels over two pairs of a single toll or exchange plant cable. Occasionally, a two-way wideband channel for 40.8-kilobit data will be used in lieu of six narrow-band channels. Like the earlier N1 carrier system, double-sideband transmitted carrier signals in the 36- to 268-kc frequency band are used with repeaters at intervals up to eight miles, depending on the type of cable.

This paper describes the operational, functional, and mechanical aspects of N2 carrier terminals packaged to include not only the carrier circuits but also the signaling, circuit conditioning, patching and monitoring circuits required for the complete channels derived from the N2 system. Transmission performance, ease of maintenance and economy are optimized by the use of a packaged terminal framework containing mounting shelves, connectors and shop wiring such

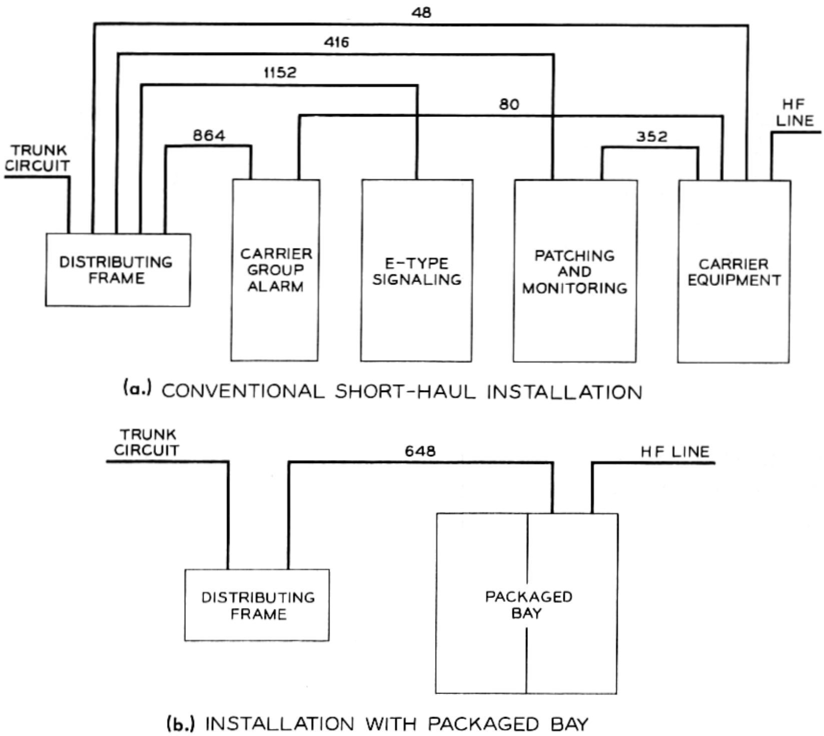

Fig. 1 — (a) Earlier N-type carrier installation (96 channels) with equipment mounted on separate installer-connected bays; (b) N2 packaged shop-wired frame installation (72 channels).

that any desired combination of circuits for message or program service may be obtained by the choice of suitable plug-in units and the placing of option strapping in accordance with standard templates.

Fig. 1 compares a 72-channel packaged frame installation to an early 96-channel installation wherein the carrier, patching and monitoring, E-type signaling and circuit conditioning equipment was located in four or more different frames. The 648 wires (9 per channel) from the distributing frame to the packaged terminal frame are about one-third of those required in the earlier installation. This is indicative of the savings in distributing frame space and installation effort because numerous long interconnections via the distributing frame are no longer required.

II. OBJECTIVES

The nature of type-N carrier systems and the numerous services using the channels derived therefrom result in wide ranges in frequencies, signal energy and susceptibility to interference, as well as numerous combinations of carrier, signaling and circuit conditioning options. Many of these options cannot be determined before a terminal is engineered and installed. Frequently, new options must be chosen to provide new services from time to time during the life of the terminal. In many cases, individual channels must be rearranged without affecting services using the remaining channels.

Consideration of these conditions and of economy in manufacture, installation and maintenance leads to the following objectives:

(a) transmission performance of terminals and office wiring suitable for all combinations of services with negligible contributions to impulse noise or crosstalk. This requires shielding, lead segregation, balancing and pairing, as well as the use of click-suppression networks.

(b) automatic circuit conditioning and alarms during failure of the carrier line between offices. This affords release of individual message channels, prevents billing for unusable time and seizure of disabled circuits.

(c) flexibility in message channel uses — same capability for all twelve channels.

(d) alternate use of wideband data channels in lieu of six message channels.

(e) universal terminal and office cabling suitable for all normal services.

(f) office engineering of economical numbers of system terminals before options are determined and with deferred expenditures for main optional (plug-in) units.

(g) functional compatibility with existing N2 carrier terminals. The inherent limitations of existing terminals still apply when a system includes both existing and packaged terminals.

(h) use of existing designs of E-type signaling units and tone supply panels.

(i) plug-in units for optional circuits and those requiring periodic maintenance adjustment. This not only aids trouble location and the substitution of spare units, but also permits expenditures for main circuit components to be deferred until needed.

(j) packaged terminal frames arranged for all of the plug-in units, circuit conditioning, signaling tone supplies, alarms and fuses normally required for an economical number of systems.

(k) close association and simple identification of the components of each system or channel by physical proximity and numerous designations. This simplifies maintenance and restoration of service, minimizes exposure to electrical or maintenance interference, and facilitates meeting of strict resistance limitations between signaling and switching circuits.

(l) in-service monitoring of circuit performance and in-service switching of common units.

(m) portable test sets for in-service switching and testing of channel units and alarm and restoral unit.

(n) simplified circuit options through the use of option screws or wiring templates.

(o) seldom-used options obtainable with negligible effect on the cost or performance of the more usual options.

(p) optional high impedance monitoring and maintenance talking circuits.

(q) optional circuits for access to and remote control of centralized transmission or noise measuring equipment.

(r) separate power filters and fuses for odd and even numbered terminals so that a single failure will not affect more than half the terminals.

(s) application schematic covering all the options in the packaged terminals and all associated office wiring.

III. ELECTRICAL DESIGN FEATURES

In this section the electrical design of the packaged terminal and its external connections are discussed. Many of the requirements stem from the over-all system objectives discussed in a companion paper.[1] The electrical design of most of the plug-in units, both carrier and signaling, is discussed in other papers.[2,3]

Plug-in units for line terminating and for alarm and restoral functions are discussed with associated terminal circuits below.

3.1 *General*

A major factor in the electrical design is the control or avoidance of electrical interference or crosstalk. As indicated elsewhere,[1] nominal level differences between carrier frequencies may be as high as 65 db. This may be increased by as much as 30 db by differences in talker volume. In most installations this is alleviated by the use of separate frequency bands for transmitting and receiving, but some systems in a terminal frame occasionally may use transmitting frequencies which are in the same band as receiving frequencies in other systems and vice versa. This occurs in rare junctions of carrier routes. In any case, however, received carrier frequency energies may be low enough for interference energies as low as −120 dbm to be significant.

Nominal voice-frequency level differences may be as high as 26 db and may be increased by as much as 60 db by talker volume differences. Interference energies as low as −100 dbm may be significant. The benefits to be obtained by lead segregation are limited because the same voice-frequency conductors are used for both transmitting and receiving in many types of message switching circuits to which the carrier-derived channels may be connected. Furthermore, many types of signaling and supervision circuits use the same conductors for speech (or data) signals and for low-frequency signaling and supervisory signals. This results in sizeable limitations on the degree of balance to ground obtainable in transmission conductors and correspondingly increases the susceptibility to crosstalk and interference.

It is evident that the electrical design of packaged terminals, including signaling and direct connection to switching circuits, is much more complicated than it was in the older terminals without signaling or direct connection. However, the same problems existed elsewhere in the telephone office and were aggravated by the long cables between the various locations of carrier, signaling and circuit conditioning equipments. The compactness and shop wiring of the packaged terminals afford much closer control of the end results.

Another factor in the electrical design is the control of conductor resistance and potential differences between signaling units, circuit conditioning equipment and switching circuts. Many telephone offices were designed and cabled to meet strict conductor resistance limits between signaling and switching circuits without allowance for circuit conditioning equipment inserted between them, because the latter had not been needed or invented. Accordingly, the packaged terminals, including both signaling and circuit conditioning equipment, are designed and cabled to the distributing frame to meet the same requirements as the older signaling equipment. This avoids expensive recabling of existing offices or the redesign of switching circuits.

3.2 *Packaged Terminals*

This section will make reference to the circuit units indicated on Fig. 2, which is a block schematic of a packaged N2 carrier terminal arranged for message use and includes common equipment for as many as six terminals (72 channels) within the same framework. The carrier group alarm (CGA) unit includes the circuit conditioning circuit for the twelve channels derived from one carrier system, and the 2600-cycle oscillator and transfer unit furnishes signaling tone for the entire frame. Other boxes marked UNIT rather than PANEL are plug-in units which may be replaced with other units for different services or frequencies or are removable for maintenance purposes.

High-level carrier- and voice-frequency pairs, and signaling tone supply, alarm, and power leads are run in so-called "noisy" ducts at the outside of the packaged terminal frame, as described in Section 4.3. Low-level pairs are run in a "quiet" duct in the center of the frame and are automatically shielded from "noisy" leads or circuits which may be in adjacent bays. Carrier-frequency pairs are normally balanced and individually shielded. Voice-frequency transmission and signaling tone supply leads are paired and balanced by twisting and by the use of similar resistors, relay contacts, etc., in both leads.

Exceptions are voice-frequency connections between compandor, modem and restoral oscillator units and carrier-frequency connections between modem and group units via the line terminating unit. These connections are two-wire, but are unbalanced in the interest of economy in the plug-in units, particularly in the filters. This is made possible by the physical arrangements shown in Fig. 3 and diagrammed in Fig. 4. The group and line terminating units are located together and close to the modem units. Each modem is located adjacent to its compandor and on a shelf immediately above or below the shelf containing the group units. Wiring and wiring terminals for the transmitting path are well separated from the receiving path. Wiring between shelves is shielded. The restoral switching relays for switching channel position A and B modem connections from compandors to the alarm and restoral unit and the restoral oscillator unit are located within inches of the compandor and modem connectors. Shielded pairs are used between these relays and the restoral units.

Common impedance between circuits in the two directions of transmission is minimized by the low impedance of the regulated 48- to 21-volt convertor and by the use of individually paired battery and ground leads from the power supply unit to each shelf.

Transmission leads traversing the CGA unit are subject to numerous options depending on the type of service, type or omission of signaling unit, etc. A terminal strip containing groups of terminals which are individual to each channel are provided for these options and for con-

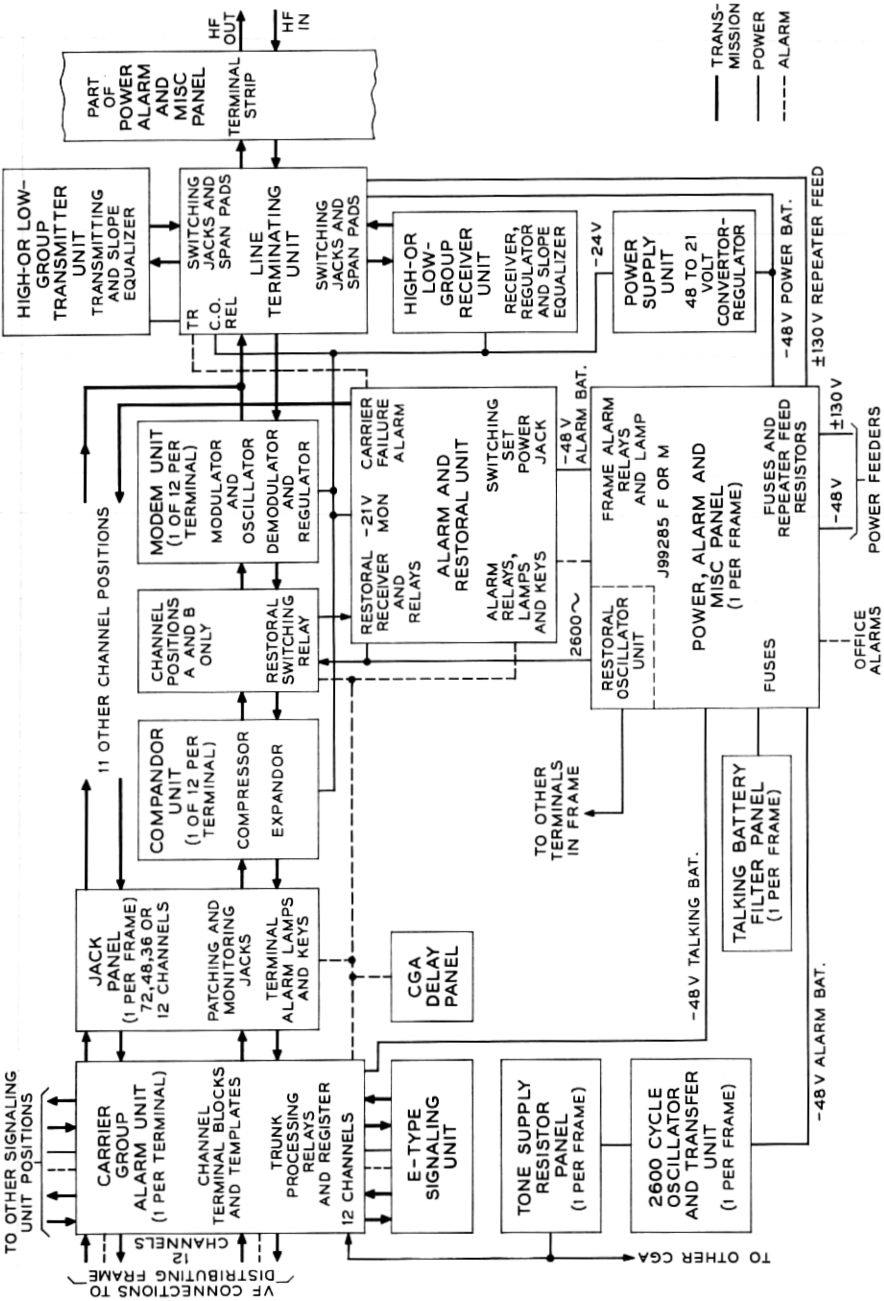

Fig. 2 — Block schematic of packaged N2 carrier terminal arranged for message use.

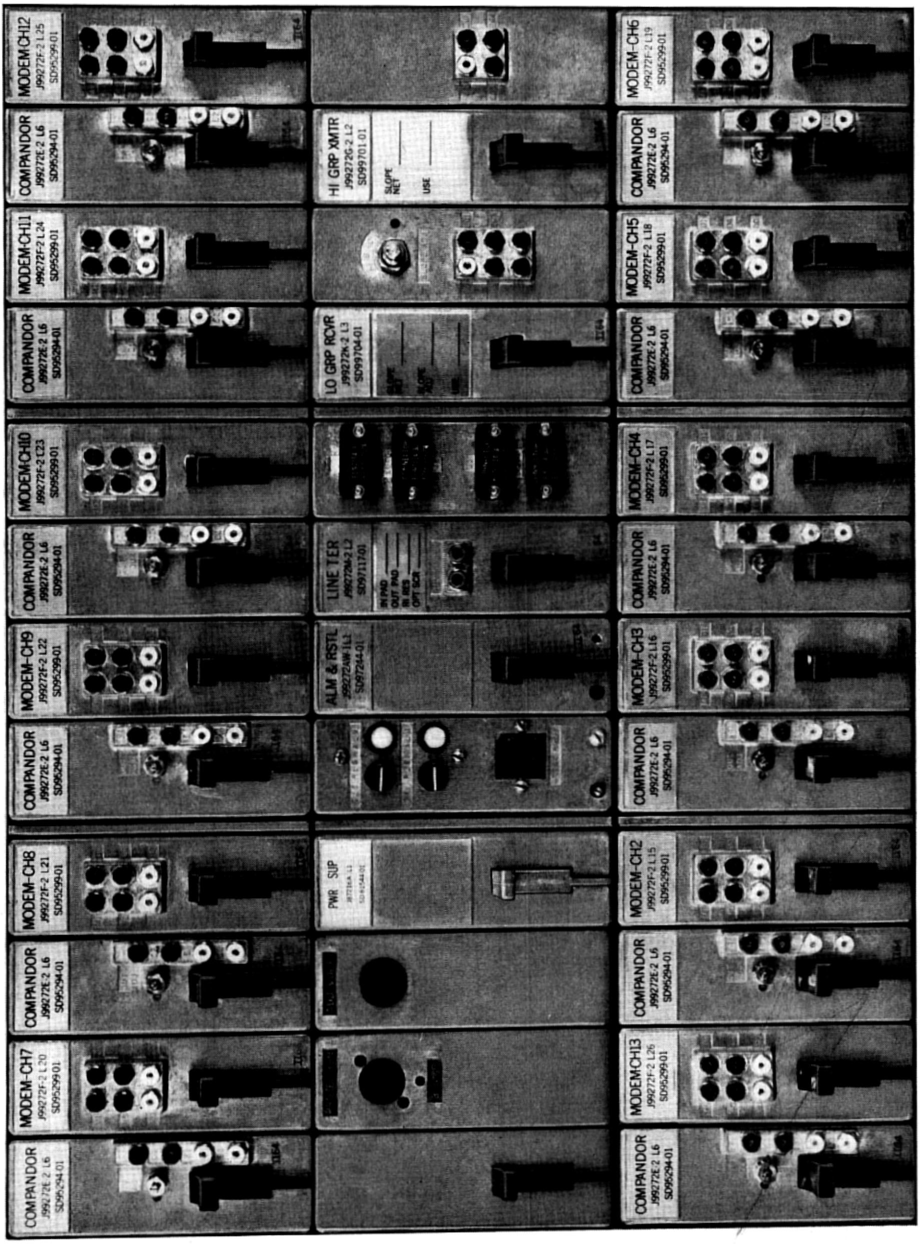

Fig. 3 — N2 carrier terminal, front view.

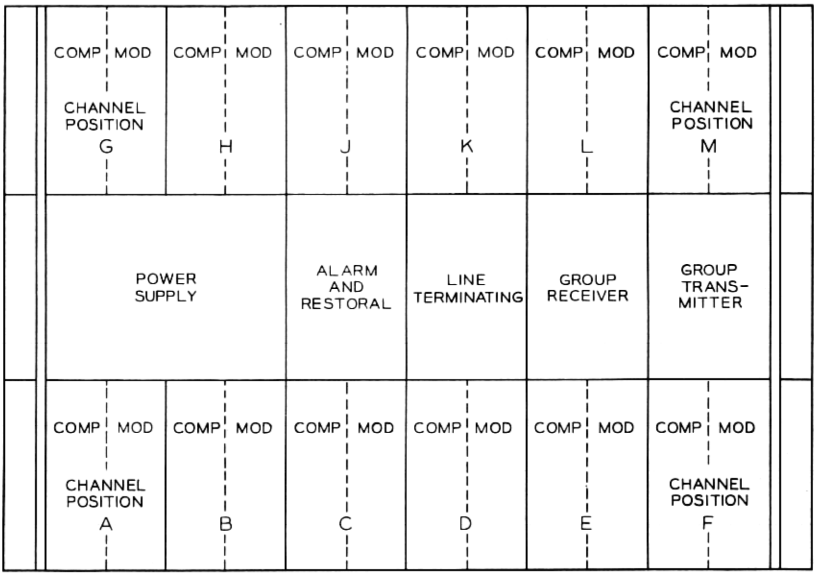

Fig. 4 — Diagram of N2 carrier shelf positions.

nections into and out of the CGA. These groups of terminals are located close to associated relays and signaling unit connectors to minimize noise and crosstalk exposures. Wiring terminals for executing the options in the transmission paths are separated from those for signaling or supervision options and are located close together for each direction of transmission. Normal option straps are less than one inch long. This is in contrast with optional cross connections for similar purposes in the older multibay arrangements, which often were many feet long and exposed to many interfering circuits.

Many types of signaling units connect battery to transmission pairs, making the transmission circuits vulnerable to noise on the power leads. Accordingly, a filter is provided to attenuate noise on the power feeders and to reduce the impedance common to signaling units. This and pairing of battery and ground feeders is helpful in meeting No. 1 ESS office objectives for preventing interframe interference. Separate power feeders, filters and fuses are used for odd- and even-numbered terminals to lessen the chance of a single failure affecting more than half the systems.

3.3 *Connections to and from Packaged Terminals*

Individually shielded pairs are used for carrier-frequency connections to and from the packaged terminals. The shields of these pairs are connected to those of corresponding pairs in the terminal. In small offices, these pairs connect directly to the high-frequency interoffice cable protectors which may be located in one of the packaged frames. In somewhat larger offices, where the length of these pairs would exceed 200 feet, the individually shielded pairs terminate on a distributing terminal strip for connection to a multipair aluminum shielded cable which in turn is connected to the protectors or to a high-frequency cross-connecting cabinet which includes the protectors. In these cases, the shields of the individually shielded pairs connect to the shield of the ABAM cable which is connected to the shield of the interoffice cable. In any case, physical separation on the cable racks is specified between carrier pairs and noisy pairs or pairs carrying the same frequencies at substantially different levels. These provisions protect against carrier-frequency noise or interference from other circuits in the office.

Voice-frequency connections between the packaged terminals and the distributing frame are protected from noise and crosstalk by segregation of low-level pairs from high-level pairs or noisy conductors. This segregation may be obtained by the use of separate cables or by separate layers in the same cable.

3.4 *Wiring within the Packaged Bay*

Universal shop wiring is used in each frame for all of the options that may be required in the channels and terminals contained therein. This is made possible by liberal use of plug-in units — usually 41 per terminal or 247 per frame. The connectors for the plug-in units are multiconductor — 18 for signaling units, 20 for carrier units and 40 for line terminating or alarm and restoral units. With a few exceptions, the circuits assigned to the contacts of the connectors are chosen so that inadvertent insertion of a wrong unit into a position on a working terminal will not cause component failure or major service reaction. The exceptional positions where this electrical protection is not feasible are safeguarded by simple mechanical keying which is also used in the test stand.

The eighteen conductors for signaling unit connectors are required for the twelve different types of signaling units which may be used. The twenty conductors for carrier unit connectors are often more than are required for circuit connection, but the extras afford valuable lead segregation or shielding. In other cases, the extras permit close association of restoral switching relays or optional use of broadband data modems. The conductors of the carrier connectors are chosen so that much of the critical wiring is run directly between adjacent positions avoiding the exposure to interference of more circuitous wiring.

3.5 *Alarm and Circuit Conditioning*

Relays common to all the terminals are used for both major and minor office alarms. They are multipled to fuses and individual terminals through isolating diodes. Separate relay contacts are provided for the numerous combinations of ground or battery and series contacts required for the variety of office alarm circuits which may be encountered in local and toll offices.

During complete system failures such as interruptions to the carrier line, alarms are brought in at both terminals of the system for two purposes — first, the customary alerting of maintenance personnel and second, circuit conditioning whereby the effects of the failure are minimized for the users or prospective users of the individual channels of the system. When the failure is corrected, the alarm indications are automatically restored and the channels are again offered for service. The circuit conditioning circuits have been designated "carrier group alarm" (CGA) because the alarms originate from loss of the group carrier energy. Subsequent testing and restoral to service processes are designated "restoral."

The circuit conditioning and restoral elements of Fig. 2 are CGA unit, alarm and restoral unit, restoral oscillator, CGA delay and restoral switching relays in channel positions A and B. These and similar elements at the distant terminal automatically proceed as follows:

(a) recognize carrier system failure,

(b) force transmission failure in other direction to start alarm sequence at distant terminal,

(c) alarm and start trunk conditioning at both terminals of the N2 system,

(d) transmit restoral tone (2600 cycles) over the carrier channel associated with channel position A and observe the restoral tone-to-noise ratio at the distant terminal,

(e) when this ratio has been satisfactory for an adequate time, transmit restoral tone in the opposite direction over the carrier channel associated with channel position B,

(f) restore alarms simultaneously at both terminals when restoral tone transmission is satisfactory over both channels in both directions of transmission, and

(g) return trunks to service at both terminals at the same time.

The alarm and restoral circuits include lamps which provide visual indication of the direction of transmission in which a carrier failure occurs and a counter which indicates the number of failures. These are maintenance aids obtained as byproducts of the restoral functions. The lamp is controlled by a CGA relay which is operated during the interval from failure to the receipt of satisfactory restoral tone at channel position A. Accordingly, the lamp lights on both carrier failure and carrier interruptions produced automatically to alarm the distant terminal. However, the latter lasts for less than a minute, so continued operation indicates a real receiving failure. The counter or register is controlled by a thermistor and CGA relay contacts to advance one step each time restoral tone is not received at channel position B immediately after satisfactory reception of restoral tone at channel position A. Accordingly, it ignores the forced interruptions and counts the real failures. This can be a real aid to detecting and locating intermittent troubles which otherwise would cause intangible service reactions.

3.6 *CGA Options*

Each message channel and associated supervision as well as each program channel passes through the CGA unit to a cable to the distributing frame. Any one of 33 different circuit configurations may be required and severe requirements on crosstalk and interference exist, as indicated in Section 3. The 54 leads required for the 33 configurations are connected to a terminal strip in a pattern which preserves pairing and level segregation and thus the optional straps which complete the circuit configurations are rarely more than a half-inch long. As described in Section 4.5, templates depicting the straps for each configuration are furnished for each channel.

IV. MECHANICAL DESIGN

This section discusses the general plans for mechanical design and describes the plug-in units designed specifically for N2 carrier terminals, the packaged terminal frames in which they are mounted, and the associated equipment common to several terminals.

4.1 *General Plans*

The flexibility and office engineering objectives discussed in Section II indicate liberal use of plug-in units. Detailed study of the circuit options determined the circuit subdivisions for the plug-in units. Approximate volume requirements for each unit were determined after selection of the smallest reliable apparatus components economically obtainable and consideration of feasible packaging techniques, such as printed wiring and AMPLAS.

The requirement that existing E-type signaling units be used indicated the use of 23-inch bay frameworks. Later studies of frame sizes and capacities confirmed the desirability of using this standard along with the 12-inch standard for frame depth.

More detailed study of these factors and of manufacturing costs resulted in the use of die-cast aluminum mounting shelves, each divided into twelve modules $1\frac{5}{8} \times 4\frac{7}{8} \times 11$ inches, and the packaging of the plug-in units in 1-, 2- or 4-module sizes to afford the desired flexibility, interference-free interconnections and compactness. The twelve-module shelf is well adapted to a twelve-channel system, as the channel units are single module size — two per channel completely filling two shelves. The twelve single-module units on one shelf are replaced by four two-module and one four-module units when wideband data replaces six voice channels. A third shelf contains the common units of the terminal consisting of four two-module units and one four-module unit.

4.2 *Plug-in Units*

A full complement of terminal plug-in units consists of 12 compandors, 12 modems, a group receiving unit, a group transmitting unit, an alarm and restoral unit, a line terminating unit, and a power supply unit. In addition, a number of special-service units, such as schedule A and B program channel units, schedule C and D program channel units, voice-frequency amplifier unit and wideband data units either are or soon will be available to the field, to be plugged in to meet service requirements.

Most of the circuitry in the plug-in units is contained in AMPLAS assemblies. The word "AMPLAS" is an acronym of "apparatus mounted in plastic."

The AMPLAS process, developed by the Western Electric Company at the Merrimack Valley Works, begins with the casting of a cellulose acetate butyrate mold in the shape of a shallow tray, as shown in Fig. 5. Cellulose acetate butyrate is a thermoplastic material. In its solid state, the particular formulation used is waxlike, flexible and translucent. The mold is placed over a full-size assembly drawing which shows the locations and positions of all the components of that particular assembly. The translucency of the material permits the operator to view the layout through the bottom of the mold. Components are furnished to the operator with their leads cut to length and formed. The

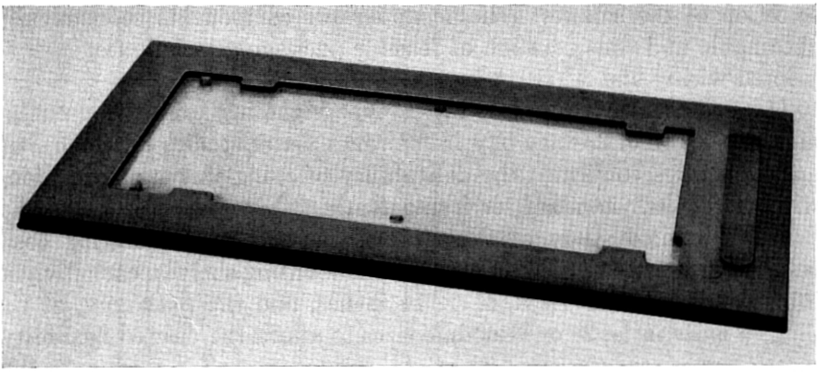

Fig. 5 — Cellulose acetate butyrate mold for Amplas process.

operator inserts the components by pressing the leads into the floor of the mold in the positions indicated by the assembly drawing. The insertion operation is shown in Fig. 6. The leads easily pierce the wax-like cellulose acetate butyrate and extend through to the bottom surface of the mold. After the last of the necessary components is inserted into the mold, a properly proportioned mixture of epoxy resin and hardener is metered into the mold. The mold, full of components and epoxy resin, is placed in an oven at 150°F for one-half hour, during which the epoxy cures into a hard, tough substrate. After cooling, the cellulose acetate butyrate is stripped away, leaving an epoxy substrate to which all of the component leads are bonded. The thickness of the substrate now corresponds to the depth of the tray-like mold, and the length of the protruding leads corresponds to the thickness of the floor of the mold. Pencil wiring is applied to the protruding leads to provide circuit continuity as shown in Fig. 7. Completed AMPLAS assemblies are shown in Fig. 8.

Special die-cast aluminum unit frames were designed to carry the circuit-laden substrates. The unit frame slides into tracks in the mounting shelf, which provides precise alignment of the plug-in unit with its mating connector. The front of the unit frame is a face plate which provides space for unit identification, test jacks, and a latch. When placed side-by-side in a terminal, the face plates provide an attractive facade for the terminal.

Each message channel requires two units — a compandor and a modem. The compandor and modem units occupy alternate spaces in and completely fill the top and bottom shelves of a three-shelf stack which constitutes a complete terminal housing. Each channel unit is

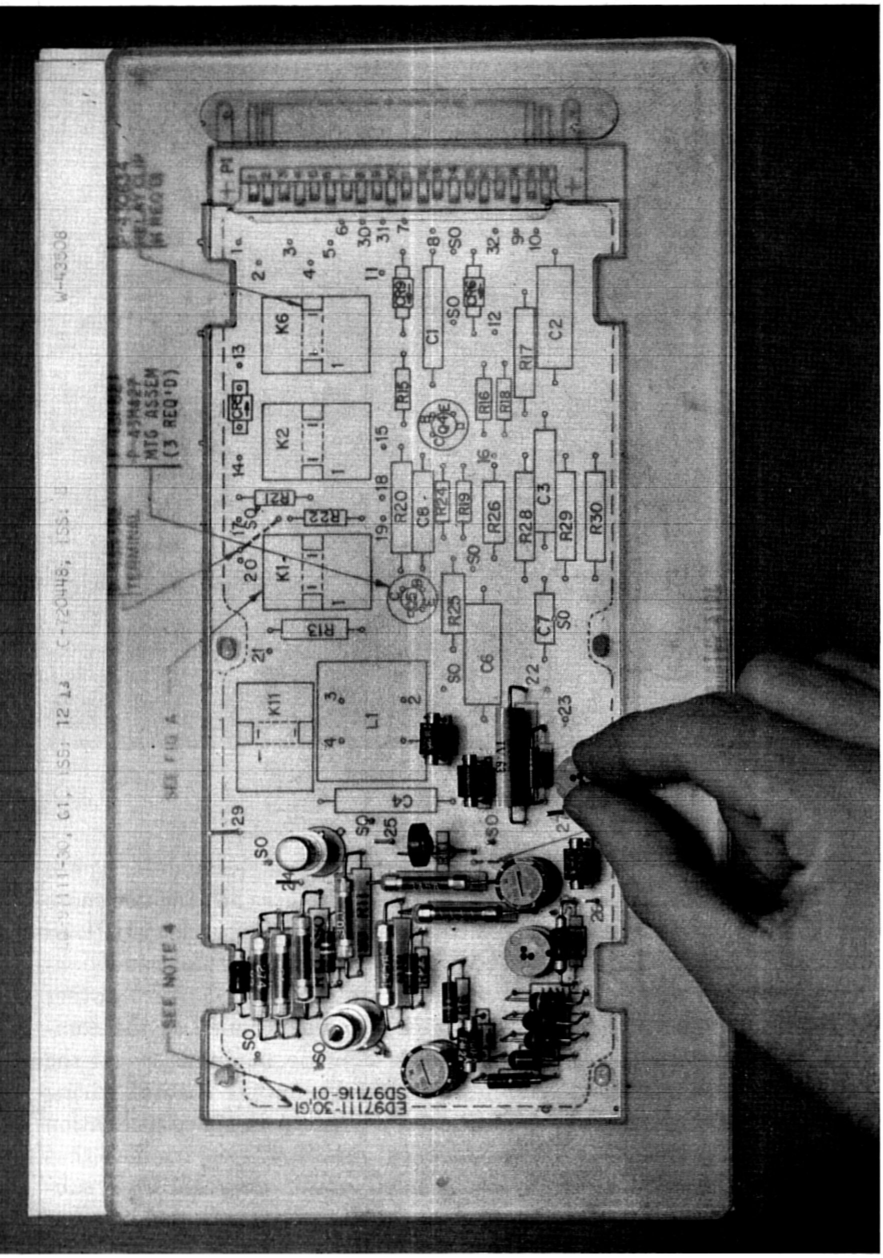

Fig. 6 — Insertion of components in mold.

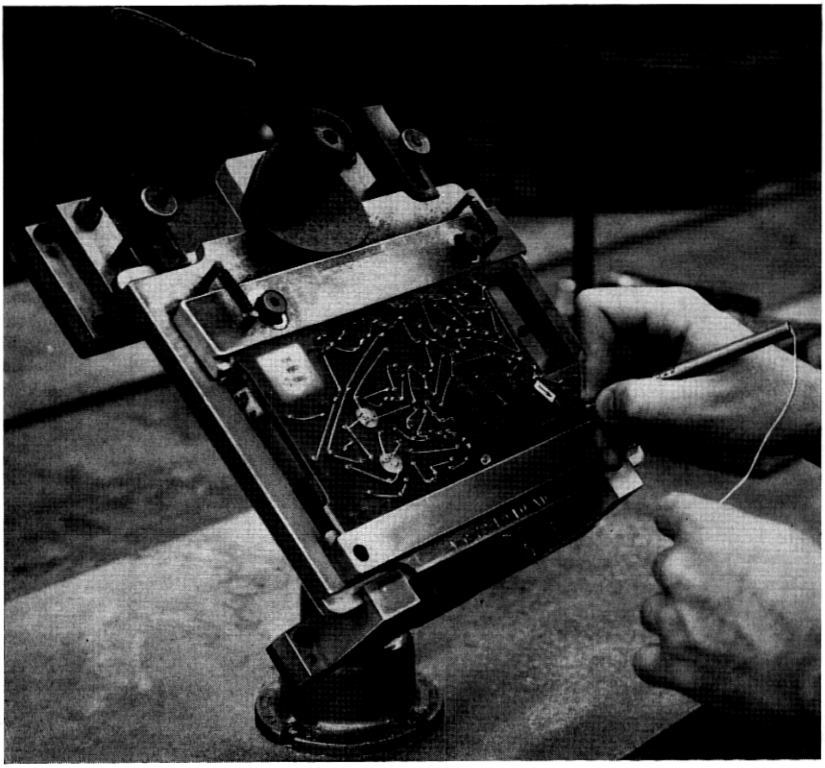

Fig. 7 — Application of pencil wiring to component leads in AMPLAS subassembly.

mounted on a single-unit frame and occupies a single modular space on the shelf. The compandor and the modem circuits each include more components than could be conveniently mounted in a single AMPLAS assembly. This problem was resolved with a rather unusual sandwich-type structure, wherein one subassembly was suspended over another with their component faces toward each other. Inasmuch as the complete structure was designed to fit into a single modular space, the distance between the subassemblies was severly limited. Printed wiring assemblies are lighter and somewhat more efficient in space utilization than are equivalent AMPLAS assemblies; and it was determined that a printed wiring subassembly, suspended above an AMPLAS subassembly, would fit into the available space. Hence was effected a rather neat marriage between AMPLAS and printed wiring. To assure interference-free positioning of the sandwich halves, care was taken to lay

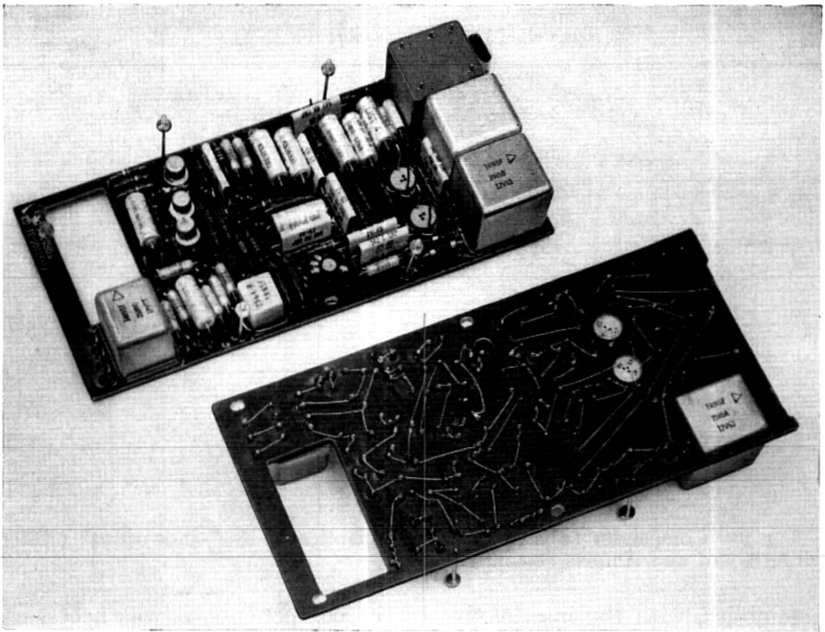

Fig. 8 — Completed AMPLAS subassemblies.

out the circuity in such a manner that tall components on either subassembly fall opposite short components on the other subassembly. This caused some difficulty in incorporating changes after the initial layouts were finished but was not an insurmountable obstacle.

Care was taken to keep intersubassembly wiring within the "sandwich" to a minimum. In the compandor, this was accomplished by putting the entire expandor circuit on the AMPLAS subassembly and almost all of the components of the compressor circuit on the printed wiring subassembly. All interboard wiring was dressed to a common edge of the structure so that the halves of the sandwich could be opened like a book for servicing.

The design of the modem is similar to that of the compandor. Here the wiring between the subassemblies was minimized by placing the entire demodulator circuit on the AMPLAS subassembly, and most of the components of the modulator circuit on the printed wiring subassembly. A compandor and a modem are shown in Fig. 9.

An electrostatic shield is placed between the two circuits of the modem to inhibit crosstalk. Because of the contours of the two sub-

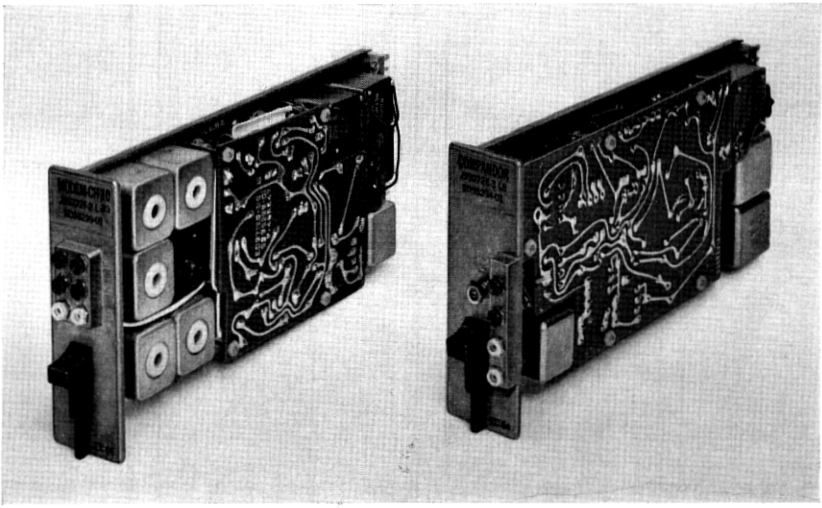

Fig. 9 — Compandor (a) and modem (b) fabricated by "sandwiching" printed wiring board and Amplas assembly.

assemblies, with the interleaving of the components, it was necessary to form the shield to the contours of one of the subassemblies. It was decided to form the shield to the contour of the printed wiring subassembly, the smaller of the two. A rigid vinyl sheet is vacuum formed to the contour of the printed wiring subassembly. Two-ounce copper foil is formed by hand over the formed rigid vinyl sheet, and a second rigid vinyl sheet is vacuum formed over the copper foil. The resulting product is a shield, which consists of a copper foil between two rigid vinyl sheets, and which conforms to the contours of the printed wiring subassembly. The shield is shown in Fig. 10.

The middle shelf of a terminal houses the common units. These are the power supply, alarm and restoral, line terminating, and two group units — either a high-group receiver and a low-group transmitter or a low-group receiver and a high-group transmitter. The group units are double units: that is, they occupy two modular spaces in the terminal housing. The group unit circuity is contained in two AMPLAS subassemblies, each supported on its own die-cast unit frame. The frames are attached to each other and accurately spaced by means of four specially designed brackets. Accurate spacing is essential to enable the two frames to slide in adjacent tracks in the housing without binding. Here again, all intersubstrate wiring is dressed to a common edge so that the units can be opened for servicing. For the sake of

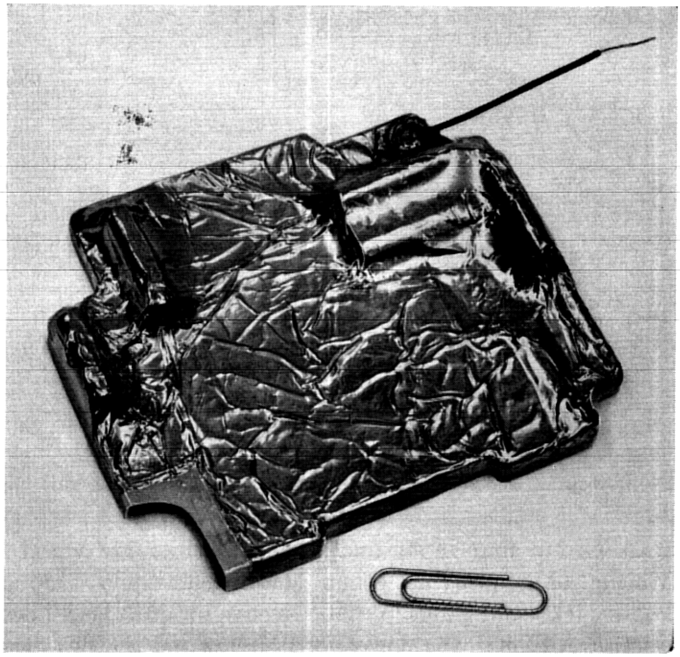

Fig. 10 — Electrostatic shield to isolate subassemblies of modem.

simplicity, the two substrates are referred to as "lower substrate" and "upper substrate," the lower being the one the components of which fall between the two substrates. Plug-in slope equalizers are carried on the lower subassembly, and can be inserted or extracted through the side of a completely assembled group unit. The group units are equipped with only one connector, and it is carried on the lower subassembly.

The line terminating unit, like the group units, is a double-module unit, but unlike the group units houses part of its circuitry in an AMPLAS subassembly and the remainder on an aluminum panel, and is equipped with two connectors. The two subassemblies are electrically independent of one another; there is no intersubstrate wiring. The aluminum panel carries a slide-wire resistor and screw-operated power options for feeding dc power to either one electron tube line repeater or one, two, or three transistorized line repeaters. The AMPLAS subassembly carries the line terminating circuitry. Suspended in the epoxy substrate are two tube sockets into which line build-out span pads can be plugged. The face plate of the unit frame on which the amplas substrate is mounted is equipped with two pairs of paralleled

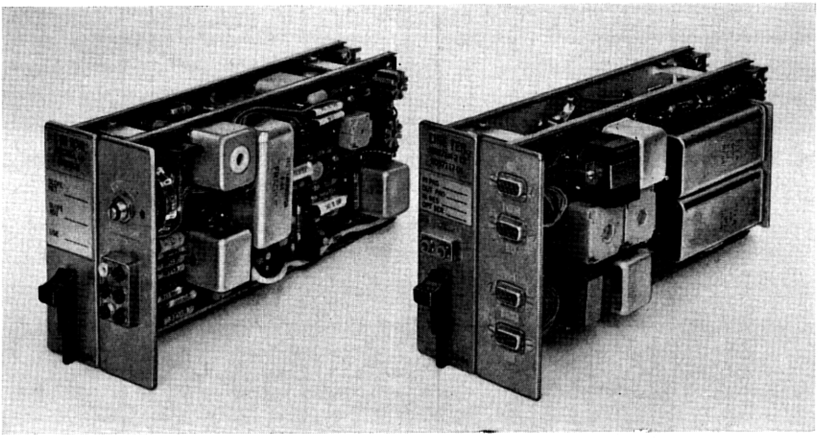

Fig. 11 — Low-group receiving unit (left) and line terminating unit (right).

9-pin jacks. Group unit input and output circuits are wired to the jacks. Mating plugs provide group circuit continuity through the jacks. These jacks and plugs provide access for in-service switching of group units. Although the power feed circuit and the line terminating circuit are carried on separate unit frames and are electrically independent of one another, they are tied together mechanically simply because the four switching jacks on the face plate on the line terminating unit frame leave no room for a latch. The power feed unit frame is equipped with a latch, and when tied mechanically with the line terminating unit frame, the pair is treated like an ordinary double unit. A low-group receiver unit and a line terminating unit are shown in Fig. 11.

The alarm and restoral unit, another double unit, contains its circuitry on printed wiring boards only. Because of the very high component density and the complexity of the printed wiring pattern, the upper subassembly consists of a "mother" board and four "slave" boards. Two of the slave boards contain no components — only wiring — and provide numerous crossovers. The alternative would have been either double-sided printed wiring boards, with the attendant through-connection problem, or many surface wires, always susceptible to operator error. The slave board approach to the crossover problem provides a compact, reliable, easy-to-manufacture solution which is virtually immune to operator error. The alarm and restoral unit is shown in Fig. 12.

Shown in Fig. 13 is the power supply unit. Occupying four modular spaces, it is the largest plug-in unit in the N2 terminal. The circuitry

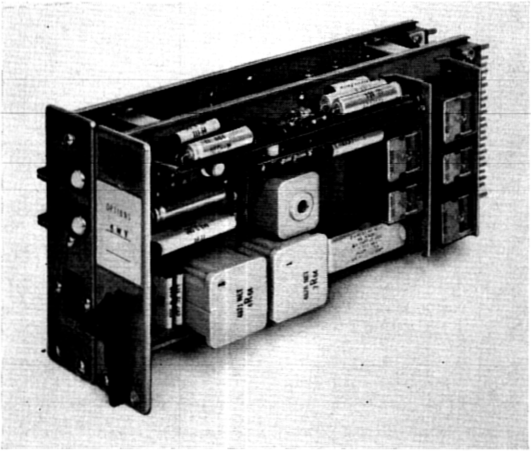

Fig. 12 — Alarm and restoral unit.

is mounted on a steel panel except for the power transistors. These are mounted on a massive heat sink at the connector end of the unit where they are free to generate convection currents.

Laboratory tests have indicated that the N2 terminal is capable of withstanding acceleration forces considerably in excess of the 3g

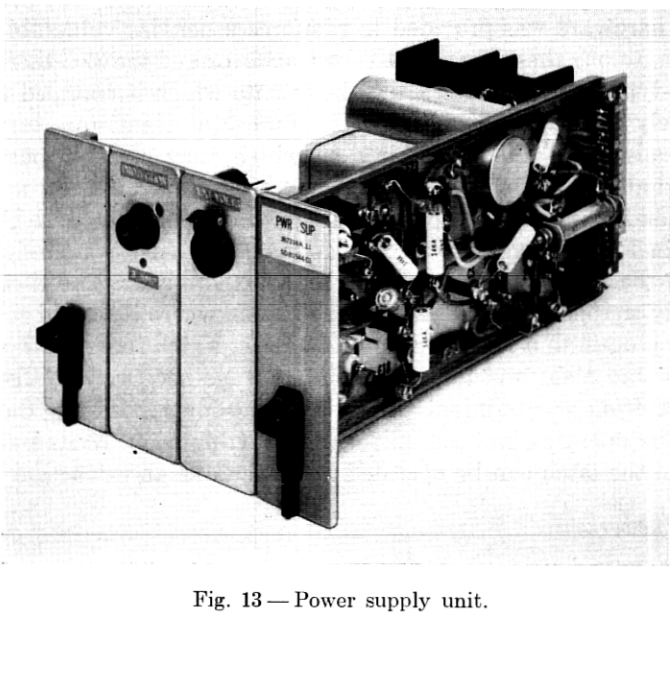

Fig. 13 — Power supply unit.

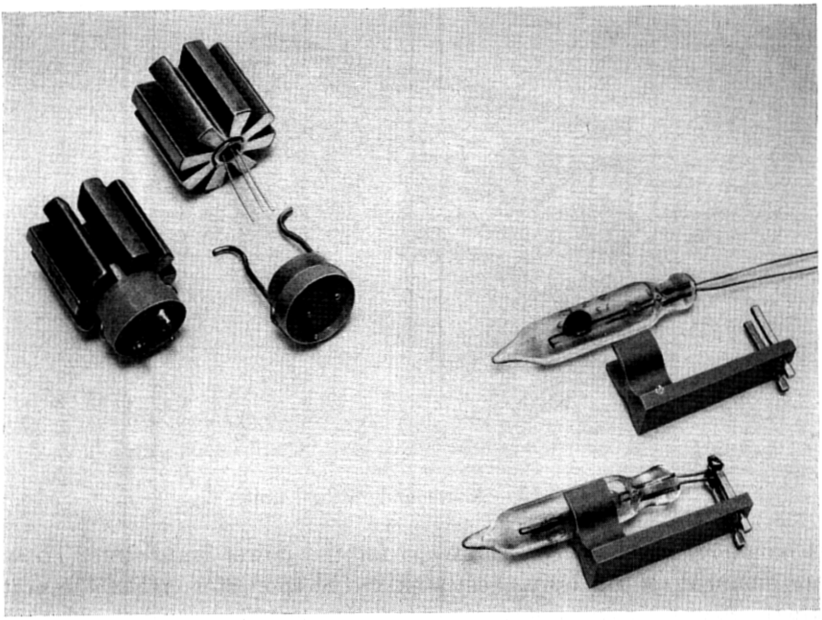

Fig. 14 — Socket and clip for 24-type transistor (left) and plastic clamp for 37C thermistor.

required of all new Bell System equipment. In hardening the equipment, special hardware was provided to reinforce otherwise vulnerable components. Among these are the 24-type transistor and the 37C thermistor. The 24-type transistor has a tiny body onto which is clamped a comparatively massive heat radiator. A number of transistors tore from their leads when the assemblies of which they were a part were vibrated at slightly more than 3g. To overcome this difficulty a special socket and reinforcing clip were designed. The socket and clip are shown in Fig. 14 together with a plastic clamp which was designed to provide the necessary support for the 37C thermistor. The thermistor is simply snapped into the jaws of the clamp, where it is held securely.

Each plug-in unit is equipped with a latch, which serves both to lock the unit into place and to provide the leverage necessary to disengage the unit from the terminal. In the pushed-down position, the latch cannot be operated and the unit is locked in position. In its pulled-up position, the latch can be operated and serves as an extraction tool.

4.3 *Frameworks*

The newly developed double-bay duct-type framework, shown in Fig. 15, as used for all packages containing more than one twelve-chan-

Fig. 15 — Double-bay duct-type framework: (a) front, (b) rear.

nel terminal. Use of a double-bay rather than a single-bay framework is more economical and permits much more efficient utilization of space. The frame uprights are drilled for mounting plates both front and rear. This affords more efficient utilization of bay space through location of some units in otherwise unused space in the rear of units mounted on the front. The frame will be shipped and installed without plug-in units, so the extra size and weight are not objectionable.

The five-inch deep uprights, with wide flanges in front and narrow flanges in the rear, form cable ducts at the sides and in the middle of the frame. The narrow flanges afford access for shop wiring or installer cabling. Low-level wiring is placed in the middle duct and is automatically shielded from the high-level or noisy wiring in adjacent bays or in the outside ducts of the frame. The wide front flanges not only afford duct space, but also permit the use of assignment card holders adjacent to shelves for plug-in units or jack strips as shown in Fig. 17 (Section 4.4).

The single-bay 7-foot framework used for the twelve-channel packaged terminal is similar to the double-bay except that the cable ducts are between frames and automatic shielding is not feasible. The bases of the frames include guard rails and commercial power outlets both front and rear for convenience in powering maintenance and installation equipment. The bases and the upper sections of the frameworks are designed for ready attachment of tools to facilitate handling in the shop and in the telephone office during installation. These tools permit upending the frame and rolling it into position between other frames separated by only nominal tolerances.

4.4 *Packaged Terminal Frames*

Fig. 16 is a photograph of the six-terminal (72-channel) packaged terminal frame which is diagrammed in Fig. 17. The main components of a twelve-channel N2 terminal — the carrier units, the CGA and E-signaling units — are located as close to one another as economy of space and shelf capacities permit. For example, positions for channel units 1A to 1M, CGA No. 1, E-type signaling unit positions 1A to 1M, all in the lower part of the frame, and the lowest of six horizontal jack strips in the patching and monitoring jack field, are all components of terminal No. 1.

The patching and monitoring jack field includes a horizontal group of patching and monitoring jacks and associated terminal alarm lamps and keys for each twelve-channel terminal. Monitoring and talking jacks, keys and lamps; transmission and noise measuring control switch, keys and lamps; and trunk jacks and lamps, when required, are mounted at one end of the horizontal groups mentioned above.

4.5 *Carrier Group Alarm (CGA) and Associated Signaling Shelves*

Fig. 18 shows how the CGA is designed and located to take advantage of otherwise unused space and to permit short wiring runs between the terminal blocks, the CGA relays, and the majority of the connectors for the signaling units. This is not only economical, but also affords minimum crosstalk and noise exposure for the numerous critical leads which have been sources of trouble in other installations. The CGA relay and register strip is located immediately below the lower mounting of the shelf which mounts ten signaling units associated with the

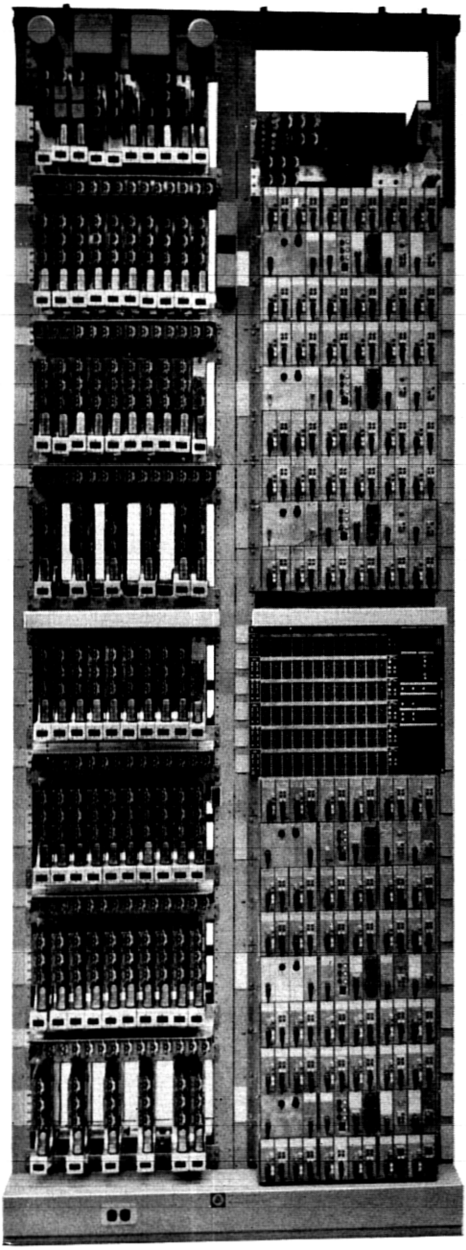

Fig. 16—Front view of six-terminal (72-channel) packaged carrier terminal frame.

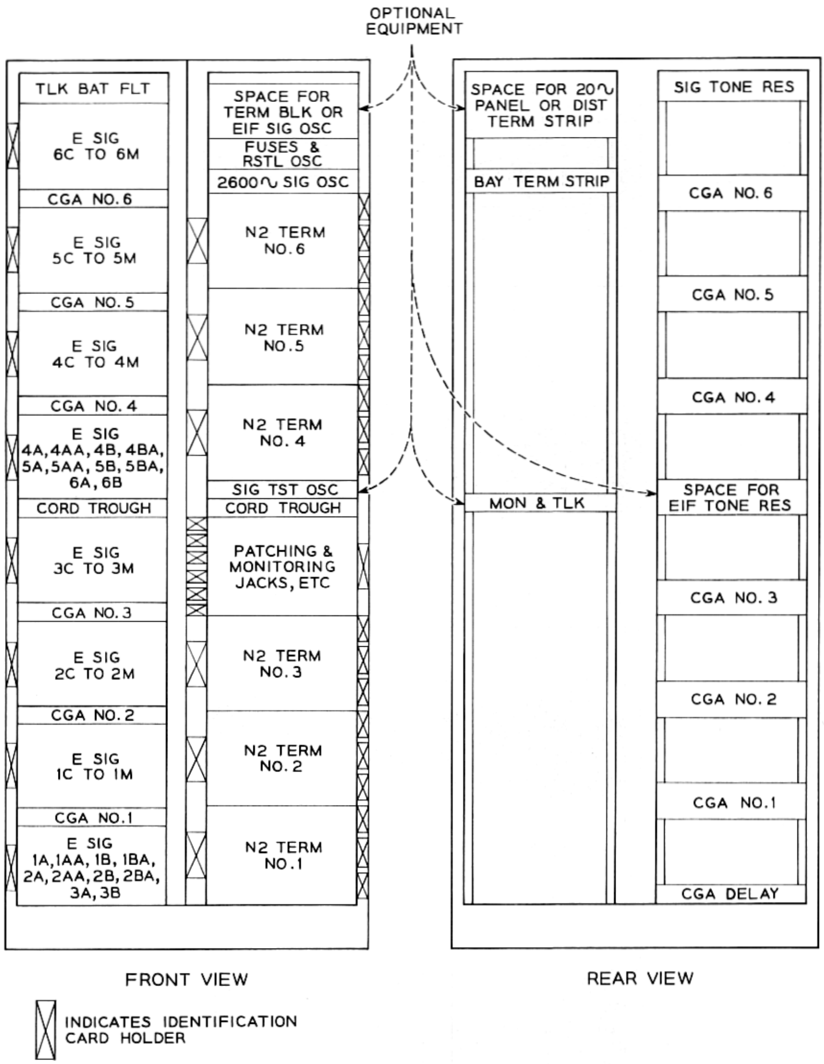

Fig. 17 — Equipment arrangement of 72-channel packaged six-terminal frame shown in Fig. 16.

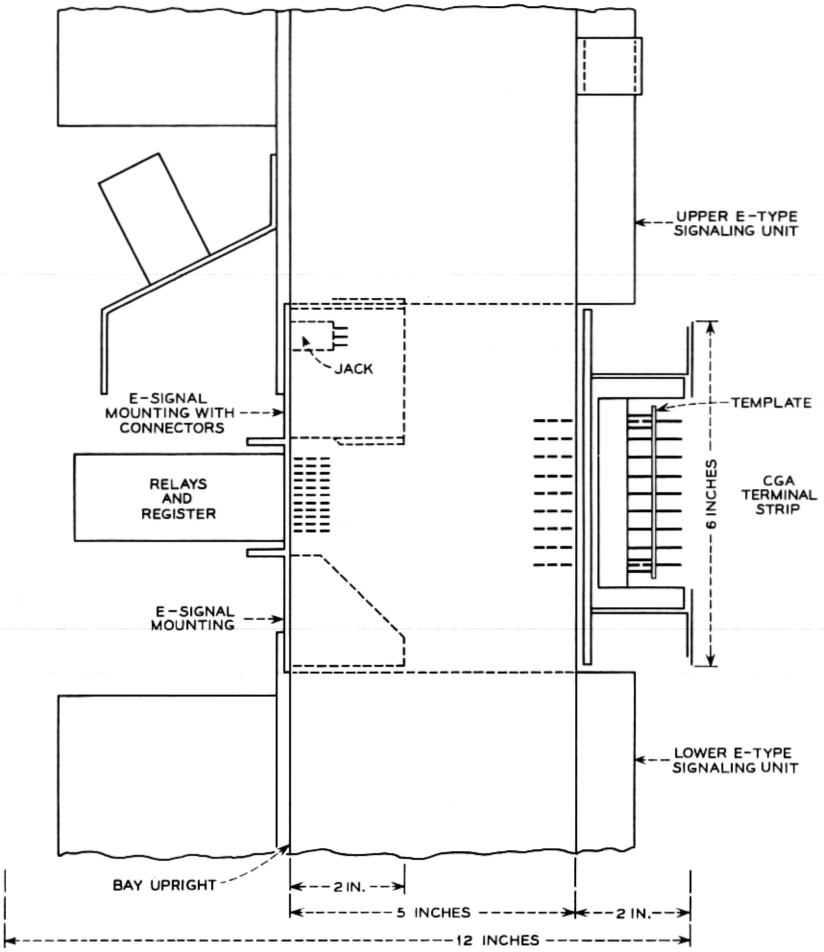

Fig. 18 — Carrier group alarm and E-type signaling shelves, showing arrangement of equipment.

CGA, and immediately above the upper mounting of another shelf. The terminal strip and cabling of the CGA occupy the space behind the two signaling shelf mountings and the relay and register strip. The terminal strip is hinged to give wiring and maintenance access to the relay and register terminals and the shop-wiring side of the terminal strip.

Fig. 19 shows how each CGA terminal strip is divided into twelve regular channel blocks, three spare channel blocks, and a miscellaneous

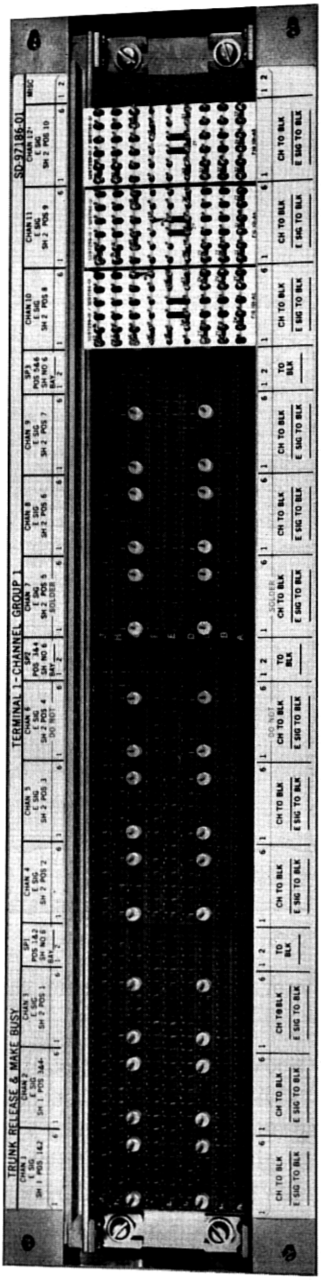

Fig. 19 — Arrangement of carrier group alarm terminal strips and wiring templates.

block, thereby providing for the twelve channels of an N2 terminal and for three spare signaling channels which may be used for circuits requiring auxiliary as well as regular signaling units, i.e., two signaling unit positions per channel. These auxiliary signaling units and those for the A and B channels cannot be accommodated on the nearby signaling shelf and are wired with shop cabling to connectors on other signaling shelves (refer to Fig. 17). The shelves for the A and B channels are located in the same frame as the CGA, but the spares may or may not be in that frame. Fortunately, the spare or auxiliary unit channels have less critical noise and crosstalk requirements.

The regular CGA channels may be used with any one of eleven different signal units, program or noncompandored channels and with a wide variety of office trunk circuits. Accordingly, the CGA's are universally wired so that any condition may be established by suitable straps between terminals on the terminal blocks. This includes optional straps to tone supply resistors for E1F signaling units and for 20-cycle ringing supply which may be required for E1S units.

Only wire-wrapped connections are used on the side of the CGA terminal blocks where the optional strapping is done. Solder connections are avoided because a terminal once soldered cannot be wire-wrapped. Option changes on a working CGA are often required because it is impracticable to "turn down" twelve channels when one is reassigned. Soldering of option straps on a working CGA unit would constitute an unnecessary service hazard. Changes in wire-wrapped connections may be made with negligible hazard because the tool is insulated and pliers are not required.

Plastic templates for use with the CGA unit afford a simple guide for applying optional strapping between terminal block terminals to provide the various trunk circuit and signaling features for the different channels. These templates are perforated so they may be slipped over the terminals of the CGA terminal block of the desired channel after installer wiring has been connected, but before the option straps are placed. Each template is designated as to the channel use, the associated E-type signaling unit, and the trunk condition to which it applies. As illustrated in Fig. 19, the desired straps are indicated by heavy lines and option letters between the terminals which must be strapped. When a new or different type signaling unit or trunk circuit is to be used, existing straps must be removed using an unwrapping tool, the existing template removed, the new template added, and then new straps following the option lines will be added using a hand-actuated or power-driven wrapping tool. Visual inspection at any time can determine whether the template, strapping, signaling unit, and trunk circuit have been coordinated.

V. MAINTENANCE AND LINE-UP FEATURES

Maintenance and line-up are considered together because many of the provisions for one are used for the other and both are performed by operating company personnel. Line-ups may be a part of routine maintenance but they also occur when systems or channels are first put into service or are rearranged for changes in type of service. They include the choice of plug-in units and the administration of circuit options as well as the adjustment of controls.

5.1 *Portable Test Stands and Switching Sets*

All twelve channels of the N2 terminal depend on the proper operation of the group units and the power supply unit. Therefore it is essential to provide the means for routine maintenance of these units without interrupting service. Accordingly, portable switching sets capable of effecting in-service switching of group units, power supply units, and wideband 40.8-kilobit data channel units which operate in conjunction with the 301-type DATAPHONE data sets are available to the operating companies. The switching set is powered from the power receptacle on the face plate of the alarm and restoral unit.

The routine for in-service switching of group units begins with the removal of one of the plugs from either of the paralleled receiving 9-pin jacks or either of the paralleled transmitting 9-pin jacks (depending on which group unit is being switched) on the face of the line terminating unit. The group circuit is maintained intact by the remaining plug. The group-switching cord of the switching set is plugged into the vacated jack, and an alternate group unit is plugged into the switching set. At this point, the switching set and the remaining plug provide parallel paths for the group circuit. Now, upon removal of the plug, group circuit continuity is maintained by the switching set. Controls are provided so that the output of the alternate group unit in the switching set can be adjusted to the level of the regular group unit in the in-service terminal. When the levels are equal, a switch is operated, removing the regular group unit from service and simultaneously inserting the alternate unit. The regular group unit is now removed from its position in the terminal and a spare regular group unit inserted in its place. The output level of the alternate group unit is readjusted, if necessary, to match the output of the unit now in the terminal shelf. The switch is returned to its original position, removing the alternate group unit from service and simultaneously inserting the spare regular unit. The plug is replaced in the line terminating unit, the group switching cord is removed, and the second plug is replaced, completing the process. In-service switching of group units produces a 1-db hit per channel on the system.

In-service switching of power supply units is completely hitless. The procedure begins by powering the switching set from the power receptacle on the face of the alarm unit. An alternate power supply is plugged into the switching set. Controls are operated, adjusting the output voltage of the alternate power supply to the level of the regular power supply. A switch is thrown, removing the regular supply from service and simultaneously inserting the alternate supply. The regular unit is removed from its position in the terminal, and a spare unit is inserted into the vacated position. The output voltage of the spare unit is adjusted, the switch returned to its normal position to transfer the load to the new regular unit and the switching set is disconnected from the terminal. The switching set is shown at the left in Fig. 20.

A portable test stand — capable of routine tests on channel units, the alarm and restoral unit and the restoral oscillator unit — is also available to the operating companies. The test stand serves as an extender, providing convenient access to each contact of any plug-in unit connector into which it is plugged. Tracks and connectors are provided into which one or more plug-in units can be inserted. This permits testing or trouble shooting the units in question in a convenient fixture while the units are electrically connected to the terminal circuit. Jacks, keys, lamps, switches and fuses provide the capability for a number of tests, including a compandor-modem loop-around test, permitting one end of a channel to be tested by itself.

Alarm and restoral units and restoral oscillator units can be tested and adjusted in the test stand without connection from the stand to the alarm or oscillator positions in the terminal. These tests require only a power connection to an N2 terminal. These plug-in units may be replaced with spares during the tests or the terminal may be operated without them, providing a failure requiring circuit conditioning does not occur. The test stand is shown at the right in Fig. 20.

The performance of signaling units is monitored by a portable set which may be plugged into a connector located on the face of each signaling unit. Adjustment and minor repairs are made with the unit removed to a more elaborate test set.

Signaling tone oscillators are furnished in pairs so that either may

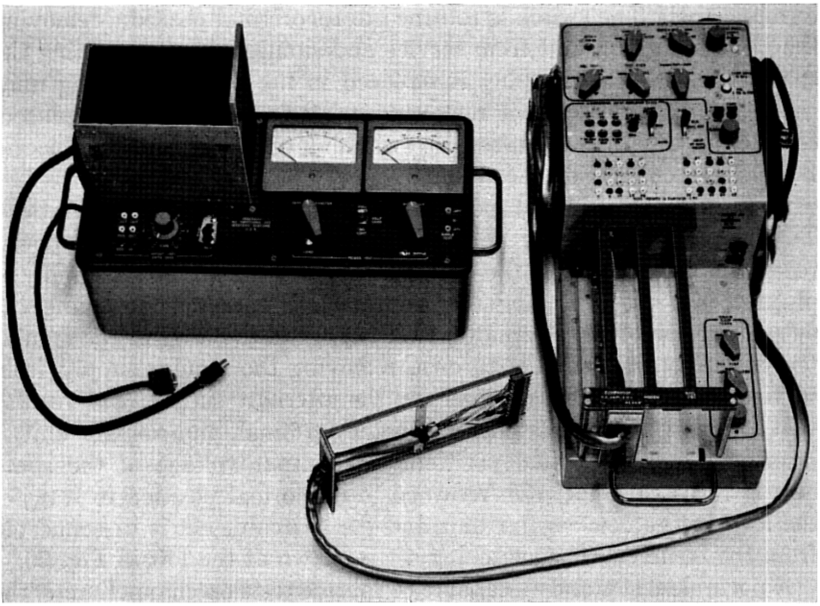

Fig. 20. — Portable switching set (left); test stand (right).

carry the entire load while the other is disabled or switched out for maintenance. The oscillator panels are equipped with transfer circuits, controls and jacks for maintenance adjustment.

Jacks are provided for headsets used in talking over N-carrier order circuits or idle channels to the distant terminal.

5.2 *Patching and Monitoring*

Patching and monitoring jacks which provide voice-frequency access to the various channels are furnished to permit circuits assigned to individual channels of one system to be routed over channels of another system during carrier line failures. These jacks may also be used for monitoring or for terminated measurements both toward and away from the carrier system, although all essential maintenance may be done without them, as indicated in Section 5.1. When centralized transmission and noise measuring equipment is available, it may be connected to these jacks and controlled by circuits and equipment associated with the patching jacks. This affords somewhat faster and more accurate circuit line-up than is possible with the portable equipment.

The monitoring jacks associated with the patching jacks may be connected to a high-impedance four-wire monitoring set which not only affords two directional monitoring without service impairment but also provides amplification for monitoring at a comfortable level and for the detection of low-energy interference.

This monitoring option also includes a telephone set and intraoffice communication circuit terminations for maintenance purposes.

VI. ENGINEERING AND INSTALLATION FEATURES

Many features can be provided to simplify engineering and expedite installation. They may increase or decrease manufacturing and merchandising costs. Accordingly, a prime objective of equipment design is an economic balance between manufacturing, engineering, and installation costs in light of the probable percentages of installations requiring various options. In general, shop wiring is much less expensive, more uniform and more readily tested than installer wiring.

Certain options, such as the use of E1F signaling units for revertive pulsing, are seldom required and involve considerable equipment and wiring which must be coordinated with the wiring for other options. In the N2 packaged frame, wiring terminals for administering this option are always provided, but the equipment and wiring is furnished only when specified. Preferably it is installed in the shop, but it may be added in the field.

As other options, such as monitoring and talking circuits, are required in an appreciable number of N2 terminals, the wiring is always furnished but the equipment may be added in the shop or field when required.

The broadband data option is seldom required when a terminal is initially installed, but is expected to be required in increasing numbers during the life of the equipment. The conversion to broadband data transmission involves simple but critical wiring and special terminal equipment. The wideband data terminal equipment consists of plug-in units which may be provided as needed, but the terminal wiring is always provided and terminated on the frame.

6.1 *Basic Plan*

Each packaged terminal frame includes plug-in unit mountings and common equipment suitable for any circuit option for a number of terminals. The complete frame is shop wired to terminal strips so that the frame wiring may be continually checked in the shop on a machine routined basis. Installers' connections are made to terminal strips rather than apparatus terminals. This not only minimizes installer wiring and testing costs but also affords close control of critical wiring. The range of telephone office ceiling heights results in frame heights of 11 feet, 6 inches, 9 feet and 7 feet, with corresponding numbers of terminals per frame of 6, 4 and 3, respectively.

The N2 packaged terminal meets the A.T.&T. Co. objective of office engineering and installation of a sufficient number of circuits to permit economical anticipated growth over a reasonable period of time. Major equipment expenditure may be deferred until service needs require specific plug-in units. The initial installation suffices until growth exceeds the anticipated number of terminals. Initial cabling to the distributing frame is suitable for all circuit options. Distributing frame space requirements and the size of installer cables are minimized by the use of the same leads for various options. This is made feasible by provision of terminal strips and wiring options at the packaged terminal and optional cross connections to trunk circuits at the distributing frame. Both types of optional wiring are normally made by operating company personnel.

An interesting variation occurs in 7-foot packaged terminal frames for 3 terminals because the common equipment for the first frame is adequate for a second frame. Accordingly, alternate frames do not contain common equipment but are furnished with factory-connected cable for installer connection to an adjacent frame. Connections to the distributing frame are the same as those for other terminals.

Additional cabling to and from the packaged terminals is required when wideband data channels are desired but additional frame wiring is not required. The additional external cabling is engineered and installed as a part of the wideband data project.

In some of the larger offices where centralized patching jacks are furnished for other systems, the telephone company may elect to use jacks in the centralized location rather than in the packaged terminals. An 11-foot, 6-inch frame for six terminals with terminal strips instead of jacks is available for this choice. It obviously requires greater engineering and installation effort as well as more expense. These terminals include all the other features of packaged terminals.

A single-terminal 7-foot frame is available for installation where more than one terminal will not be required in the foreseeable future. Engineering and installation are exceedingly simple, but per-terminal costs are high because there are no terminals to share the expense of common equipment.

6.2 *Power and Alarm*

The packaged terminals include fuses and alarm circuits suitable for individual or multiple connection to the power distribution boards and office alarms of all types of offices, including No. 1 ESS. Busy hour power requirements and permissible feeder voltages are specified so that the engineering of power plants and power feeder cables to the frames is simplified. Optional connections permit operating company choice of alarm division between major and minor alarms, if the normal arrangement is not desired. Special engineering or additional apparatus is not required for the alarm circuits of different types of offices.

6.3 *Optional Features*

Most optional features may be included in the original specifications and furnished in the shop without the need for additional installation. Others, such as protector blocks for distributing interoffice cable pairs, may be mounted in the packaged terminal frame and connected by the installer. Any of the options may be engineered and installed at a later date if unforeseen need arises.

Options requiring engineering and installation consideration include:

(a) E1F revertive signaling,
(b) E1LA or E1SA auxiliary signaling,
(c) 20-cycle supply for E1S signaling,
(d) 2000- or 2400-cycle oscillator for testing certain signaling units,
(e) interbay transmission trunks,
(f) 4-wire monitoring and intraoffice talking trunks, and
(g) centralized transmission and noise measuring equipment.

In each case, engineering and installation are simplified by the provision of equipment codes and space assignments on packaged terminal frames. However, some auxiliary signaling units will require space outside the packaged terminals. Shelves for this purpose include connector-terminated cables, the free ends of which are installer-connected to terminal strips in the packaged terminals. No other connections are required.

6.4 *Telephone Office Considerations*

Telephone offices often differ from one another in many important aspects, including ceiling heights, power facilities, alarm circuits, cabling plans, grounding practices and noise environs. N2 carrier terminals are intended for installation in many types of offices—frequently in some, and rarely in others. Accordingly, packaged N2 terminals are designed with the built-in capability of being used in any office without special engineering or equipment except for conditions that are rarely encountered.

The packaged N2 terminals are capable of satisfactory operation from near freezing to the maximum normal telephone office temperatures. Extremely low temperatures are sometimes encountered in community dial or other offices, and under these conditions some transmission impairment is permissible.

VII. CONCLUSIONS

Recent technological advances were used to advantage in the design of the packaged N2 carrier terminal. Solid-state devices, improved circuitry and modern packaging techniques were combined to produce a terminal which provides many advantages heretofore unavailable. It is felt that the features described in this paper are of considerable importance to the Bell System, and will earn for the packaged N2 carrier system a large share of the short-haul carrier market.

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