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JANUARY 1962

VOLUME 16
NUMBER 1

Engineering *for the* Future

C. M. Brown
Vice President
Research and Engineering

The increasing complexities of modern business are placing new demands on communication systems. Western Union recognizes the need for new systems with greater capacity, more reliability and faster, more accurate operation.

Our engineers are developing new areas of information transfer and high-speed data handling which will accommodate the increased volume of communications. It is imperative that our program for expansion be stimulated by more provocative thinking, development of new ideas and the manufacture of new products. The Western Union Technical Review provides a medium for publicizing the engineering milestones in our technical development. The authors who share their ideas and technical know-how are to be commended for their efforts and contributions to such provocative thinking. I trust the New Year will uncover new, exciting and more practical developments heretofore unknown in the telecommunications industry.

My congratulations to the staff and advisory committee of the Technical Review for their publications guidance and systematic documentation of our technical achievements and scientific advances.

A Happy and Successful New Year to all our readers.

C. M. Brown

January 1, 1962

PHILIP R. EASTERLIN, Planning Engineer, Plant & Systems

Telex in the U. S. A.

Direct subscriber-to-subscriber teleprinter connections to cities throughout the U. S. A., Canada, Mexico and other parts of the world are made in a few seconds by newly installed automatic Telex exchanges. After dialing the subscriber number, an automatic answer-back sequence is received from the distant teleprinter which identifies the called subscriber, even at unattended stations. This paper describes the service, exchange systems and overall operation of Western Union's U. S. Telex Network.

TELEX, the automatic dial subscriber-to-subscriber teleprinter exchange service, which the Western Union Telegraph Company first introduced between New York City and various Canadian points in May, 1958, will cover 45 U. S. cities after the 1961 expansion.[1] This is part of a five-year program which will extend the service in 1962-63 to a total of 180 U. S. cities with an anticipated capacity of 20,000 subscribers. In addition to domestic service between U. S. cities, subscribers can dial automatic teleprinter connections to Canada and Mexico and also obtain direct Telex connections to other parts of the world through the overseas facilities of RCAC (RCA Communications), AC&R (American Cables and Radio), and WUI (Western Union International).

In the present stage of expansion, the U. S. Telex Network consists of five key junction exchanges located at New York City, Chicago, San Francisco, Kansas City, and Atlanta. These exchanges are fully intermeshed with direct trunk groups and have the capability of alternately routing calls through a third junction exchange when trunks are overloaded or faulted. Each of the junction exchanges will serve as a parent exchange for ten secondary locations designated as district exchanges. Each district exchange will ultimately radiate to eight smaller locations having subdistrict exchange equipment.

For the fully automatic dial service between subscribers in the U. S., Canadian and Mexican Telex Networks, the New York, Chicago and San Francisco junction exchanges also function as gateway exchanges to the Canadian Telex Network, operated jointly by the Canadian Pacific and Canadian National Telegraph Companies.[2] The Kansas City junction exchange serves a similar gateway function for interconnection to the Mexican Telex Network, operated by Mexican National Telegraphs.

Calls between subscribers in the U. S. and Canadian or Mexican systems are made by dialing a designated one or two digit prefix, followed by the subscriber number in the respective network. The U. S. Telex network also functions as a transit path for automatic telex connections between subscribers in the Canadian and Mexican systems. Normally such calls are handled on a tandem basis through the two respective U. S. gateway exchanges, except where an alternate routing involves a third U. S. junction exchange.

The U. S. Telex system also provides automatic transit trunking for Mexican-overseas calls routed via RCAC, AC&R and WUI at New York City.

For overseas connections, the U. S. Telex Network is interconnected at New York City with the exchange facilities of the three principal U. S. international telegraph carriers. Subscribers in the network have the choice of placing international Telex calls through the international switchboards of either WUI, RCAC or AC&R by dialing 0101, 0102 and 0103, respectively. A similar interconnection will be made soon at San Francisco to the facilities of RCAC and AC&R to permit domestic subscribers to route calls more directly to Far East points by dialing 0302 and 0303, respectively.

A paper presented at the Winter General Meeting of the American Institute of Electrical Engineers in New York, January 1962.

The interconnection between the domestic system and the international carriers is on a direct switching basis without transmission storage of any kind. Outbound U. S. calls are presently handled on a semi-automatic basis. Semi-automatic operation provides for placing the call through an operator in the international exchange, who in turn dials the subscriber directly or to a switchboard in the overseas country. Inbound calls from some countries are now switched directly from the overseas switchboard to subscribers in the U. S. Telex Network. Plans are underway to provide fully automatic subscriber-to-subscriber dialing on overseas Telex calls.

The operating speed (50 bauds, 66 words-per-minute) and teleprinter keyboard in the U. S. Telex Network conforms to CCITT (Consultative Committee International Telegraph Telephone) international standards. This provides complete operating compatibility with other Telex systems throughout the world without the need for speed and keyboard translators.

After briefly describing how Telex operates, this paper will then discuss in greater detail the general layout and operation of the U. S. Telex Network. This will include the trunk circuit layout, directory scheme, subscriber and trunk circuit signalling, the several types of exchange equipments and the junction exchange switching functions.

HOW TELEX OPERATES

Subscriber Equipment

Subscribers have a choice of two basic types of Telex subscriber sets, each of which involves the use of a page teleprinter equipped with an automatic answer-back device which is coded with the abbreviation of the subscriber's name and city, i.e., "CONTLCOFFE CGO." Associated with the teleprinter is a remote control "dial" unit with two pushbuttons designated "Start" and "Stop" which are used in automatically setting up connections and for disconnecting.

The Telex KSR (keyboard-send-receive) Set, shown in Fig. 1, is equipped with a Model 32 Page Teleprinter and a remote control (dial) unit on the right. This set provides for send-receive operation where transmission is on a direct keyboard basis and where automatic (reperforator) tape facilities are not required.

Figure 1. Telex KSR (keyboard-send-receive) Set.

A second and more versatile operating arrangement is the Telex ASR (automatic-send-receive) Set, shown in Fig. 2, which provides the additional facilities for transmitting and receiving messages in perforated tape form. This set is equipped with a Siemens Model T 100 Page Teleprinter having a built-in reperforator attachment on the left side of the machine and a corresponding transmitter-distributor attachment on the right side for transmitting tape which has been prepared in advance. The remote control unit used in this set has additional controls which permit the page teleprinter and associated tape attachments to be used in an off-line mode for the preparation of tape simultaneously with a page monitor copy. For on-line operation, transmission may be either from the keyboard or the transmitter-distributor. On either outbound or inbound transmission, the reperforator attachment can be used to produce a tape along with the printed page copy.

Figure 2. Telex ASR (automatic-send-receive) Set.

Establishing a Connection

When idle, the printer of the subscriber set is turned off and the dial on the remote control unit is locked. A call is initiated by depressing the "start" pushbutton which corresponds to picking up a telephone hand-set. This signals the Telex exchange which immediately recognizes the calling line and transmits a "proceed-to-dial" signal corresponding to the dial tone. This signal unlocks the dial at the subscriber station.

The subscriber now proceeds to dial the number of a distant subscriber obtained from the Telex directory, usually a six- or seven-digit number. While the dialing process takes place, the circuit is simultaneously set up through one or more Telex exchanges to the called subscriber. Within a second or so after the last digit has been dialed, the direct connection is established. This is indicated by turning on the teleprinter motor and "Operate" lamp of both the calling and called subscriber.

Exchange of Answer-backs

The operating procedure now calls for the calling subscriber to initiate an exchange of answer-backs to identify the two subscriber stations. These two functions occur in turn as the calling subscriber first transmits the "who-are-you" (upper case D) signal which triggers the answer-back of the called subscriber. After having received the identification on the page copy, the calling subscriber now depresses an auxiliary "here is" key which triggers his own answer-back device and identifies himself to the called subscriber. A typical exchange of answer-backs as it would appear on the page copy of both subscribers is shown below:

CONTLCOFFE NYK (call*ed* subscriber)
CONTLCOFFE CGO (call*ing* subscriber)

Transmitting and Disconnecting

Just prior to terminating the connection, or at any time during transmission, either subscriber may trigger the answer-back on the distant printer and this will verify circuit continuity and reception of the transmitted signals. Either the calling or called subscriber can terminate the connection by depressing the "Stop" pushbutton on the remote control unit. When this occurs the connection is released sequentially through the one or more Telex exchanges beginning at the calling subscriber end.

Service Signals

If the called subscriber is engaged, or if the call cannot be completed due to a shortage of trunk circuits in a particular section, a busy signal will be returned which will momentarily turn on and off the teleprinter motor and the "Operate" lamp of the calling subscriber and relock the dial. If a call is made to a subscriber whose line or equipment is faulty or the paper supply is too low and needs replacing, the calling subscriber teleprinter receives no turn-on whatsoever. In such cases the subscriber is requested to depress the "Stop" pushbutton which cancels the call and enables him to re-dial and report the condition to a local supervisory position.

Western Union Local Positions

Subscribers may connect directly to the Telegraph Company's local positions in their own city for the purpose of sending and receiving public message traffic or for obtaining supervisory assistance in the Telex Service. By dialing 11 the subscriber is connected to one of a group of page receiving-only positions in the tie-line message section. Dialing 19 connects the subscriber to an Information Center which is equipped to furnish current changes in the Telex directory or to handle any subscriber opearting difficulties.

Telex Charges

There is no minimum time charge for individual Telex calls. Instead there is a flat connection charge of 50 cents for each completed call, plus a particular pulse rate—based on airline mileage—which is applied for the actual time the connection is held intact. The pulse rate, having no relation to the telegraph transmission speed, is expressed in ppm (pulses per minute) and the charge for each pulse is 2-1/2 cents. In addition there is a nominal monthly charge for the subscriber equipment. There is no charge for calls to Western Union other than the regular rate for telegrams or cablegrams. In placing overseas Telex calls, domestic subscribers may dial the U. S. international carriers at the New York and San Francisco gateway points on a free-call basis. The charges for International Telex calls follow a different rate pattern and subscribers are billed separately by the international carrier.

U. S. TELEX NETWORK

The U. S. Telex Network, by its expansion in 1961, has exchanges located in 45 of the larger cities as shown in Fig. 3. Five key switching centers, designated as junction exchanges, are located in New York City, Chicago, San Francisco, Kansas City and Atlanta. Radiating from each of these main points are a number of somewhat smaller district exchanges such as Denver, Milwaukee, Buffalo, etc. The next lower level in the switching configuration are sub-district exchanges and these are located in such cities as Ft. Worth, Phoenix, Dayton, etc. Additional expansion in 1962-63, along with anticipated future growth, ultimately comprehends 9 junction exchanges, each of which will serve as a parent exchange for 10 district exchanges and each district exchange will in turn serve up to 8 smaller locations having subdistrict exchange equipment.

Trunk Circuit Layout

The five junction exchanges have fully intermeshed trunk groups. Each district exchange operates to its respective junction exchange over a direct trunk group. The sub-district exchange may operate over a trunk group to either a district or junction exchange depending upon its geographical location. The New York gateway exchange also has separate interconnecting trunk groups to the three U. S. international carriers, WUI, RCAC and AC&R.

The junction exchanges provide for alternate trunk routing on all calls passed on to a second junction exchange as illustrated in Fig. 4. This also applies to calls between the U. S. and Canada/Mexico or Canadian-Mexican connections which transit the U. S. system. For example, a call originating in the Kansas City area, or incoming from Mexico, destined to the Chicago area, would be alternately routed Kansas City-New York-Chicago, etc. To avoid back-tracking, alternate routing takes place only when the call is handled through the first junction exchange.

Directory Code

Subscribers in the U. S. Network are assigned six- and seven-digit numbers. The first four digits follow a precise pattern to indicate the respective junction, district or sub-district exchange which serves the subscriber. For example, typical numbers are 02-52XX and 023-4XX for subscribers in Chicago and Detroit, respectively.

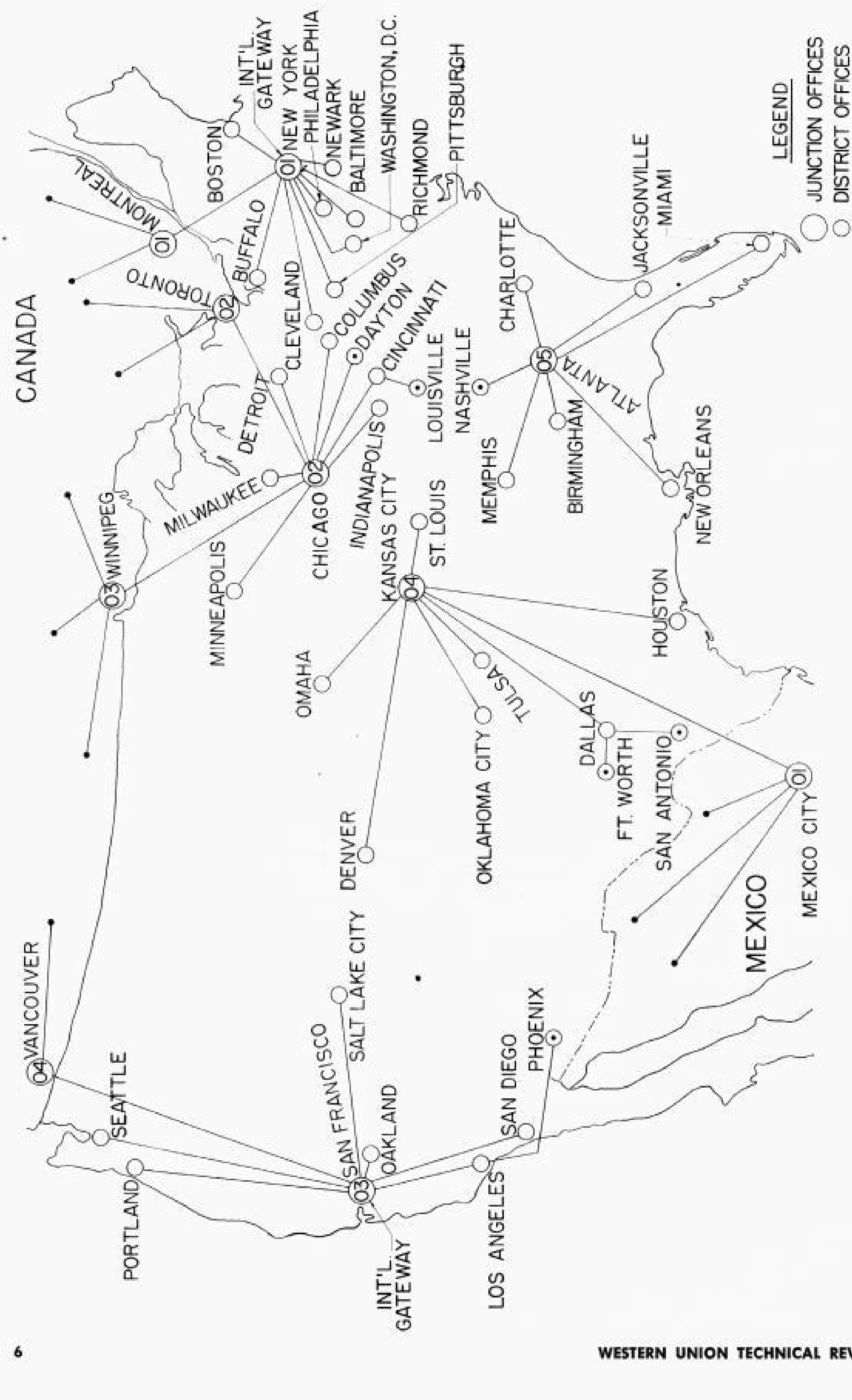

Figure 3. U. S. Telex Network, 1961 expansion to 45 cities.

The digits on the right side of the dash denote the local number which is dialed to reach a subscriber who is terminated in the same junction or district exchange as the calling subscriber. For long-distance connections to subscribers terminated in other junction or district exchanges, the complete number of digits must be dialed. "0" is used in the first position as a traffic discriminating digit to recognize long-distance calls.

CCITT recognizes either of two forms of signalling criteria for interconnecting Telex trunk circuits. These are known as Type A, usually associated with the teleprinter keyboard method of selection and Type B which, as a general rule, is used with number plate or dial switch selection. A technical evaluation of the two types will not be given here but it will suffice to say that they relate to the polarity and timing intervals of control signals

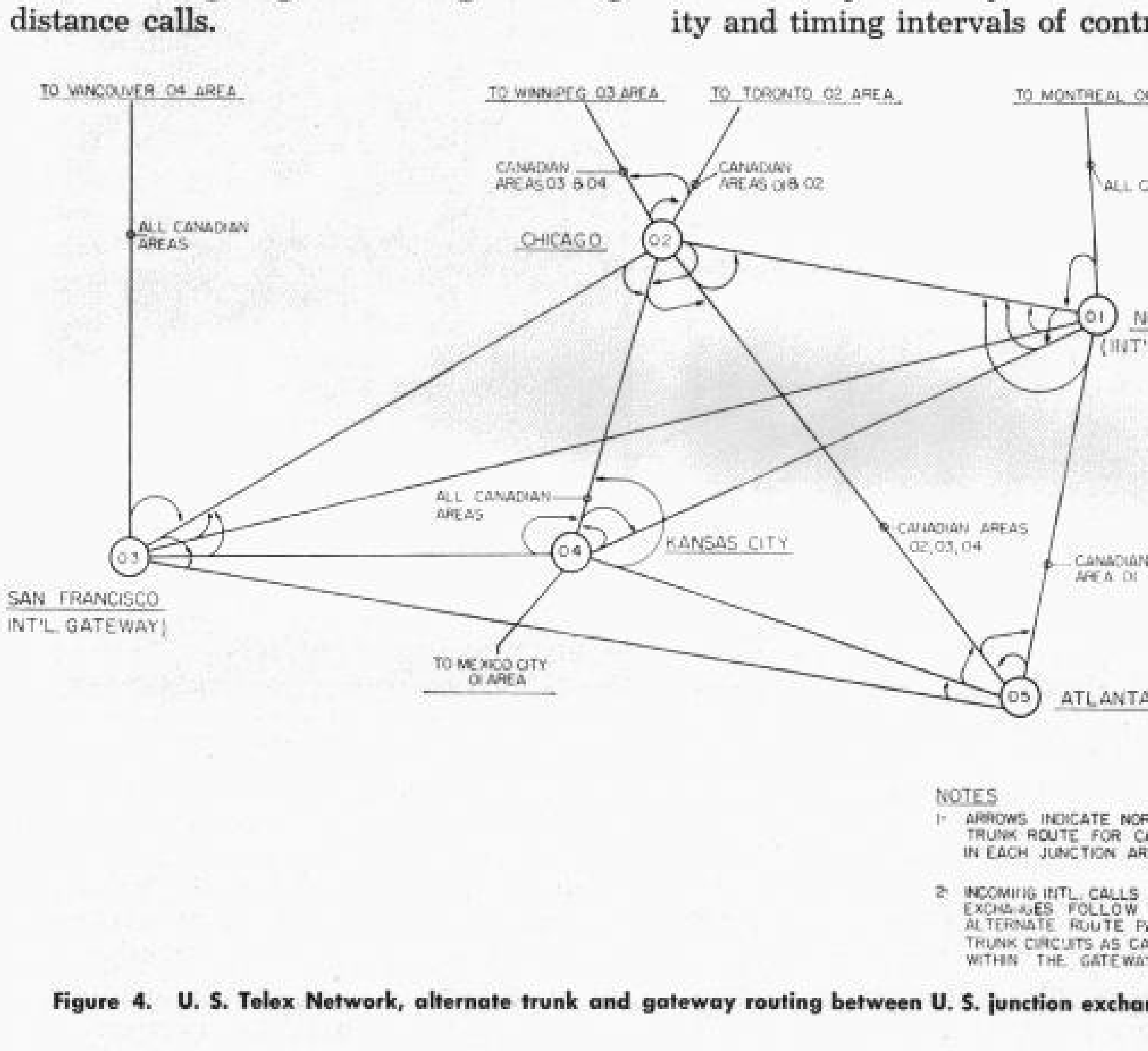

Figure 4. U. S. Telex Network, alternate trunk and gateway routing between U. S. junction exchange areas.

It will be noted from Fig. 3 that each of the five junction areas is given a two-digit assignment such as 02 for Chicago, etc. By using a different third digit for each of the junction exchange areas it then follows that this digit can be used to denote 10 district exchanges in each junction area. In a similar manner the fourth digit is used to denote the sub-exchanges operating out of each district exchange.

Signalling

For international Telex operation between countries throughout the world, the sent over the forward and backward telegraph transmission paths as an automatic Telex connection is set up or released.

The U. S. Telex Network, as the Canadian and Mexican systems, has standardized on Type B signalling and number plate selection. Fig. 5-A and 5-B illustrates the signalling criteria which takes place on the subscriber loop and the trunk circuit, respectively.

Exchange Equipments

Three distinct types of Telex exchange systems are used for the junction, district and sub-district exchange locations in the U. S. Network. These are the TWM-2 system for junction and gateway points;[3] the TW-39 system for district and sub-district locations and TW-56 concentrator units, also operated on the sub-district level. The latter has the required exchange components for 20 subscribers condensed on two racks and is used for opening up new service areas prior to the installation of regular exchange equipment. All three types of exchange systems are manufactured by Siemens and Halske of Munich, Germany, and have been specially adapted to meet the operating requirements of the U. S. domestic system. A brief general description of each exchange system follows:

trunk routing where necessary. Further concentration of exchange functions is made by having a large group of dial code translators obtain the required routing and zoning (charge) information for each call from a centrally controlled electronic coder rack, shown in Fig. 7.

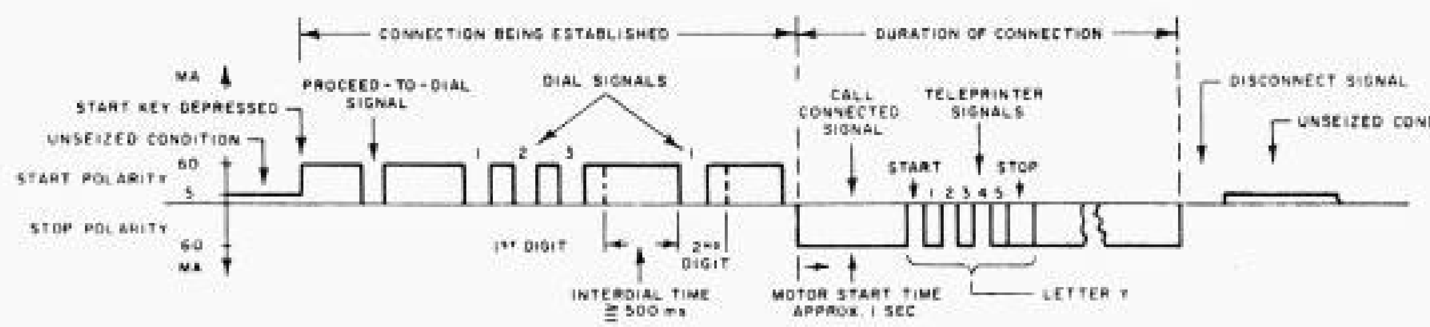

Figure 5-A. Signalling on a Telex subscriber loop.

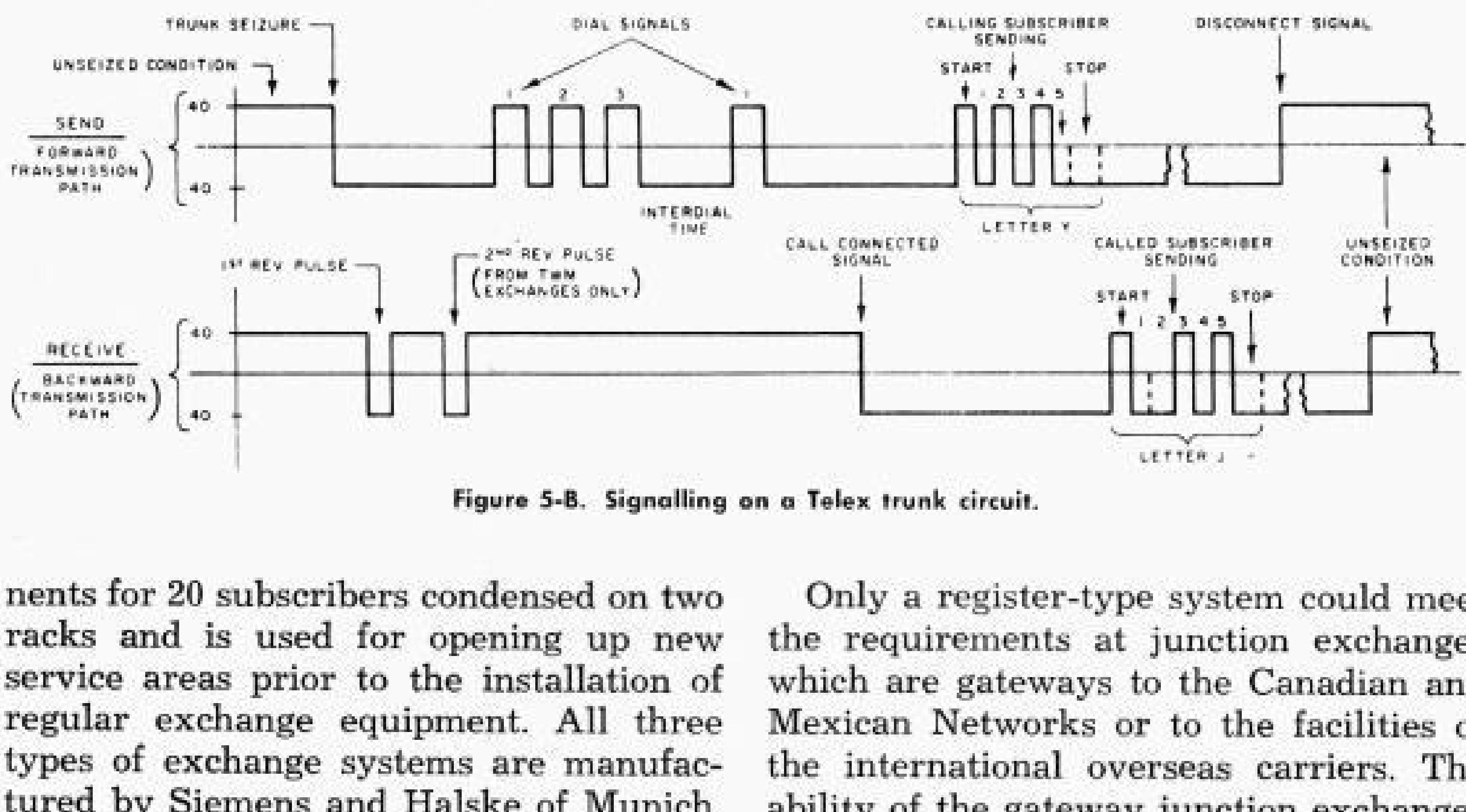

Figure 5-B. Signalling on a Telex trunk circuit.

The TWM-2 system, incorporating fundamental design principles for large exchanges, provides the required operating versatility for the key switching points in the network. The subscriber terminations are connected by line-finders to centrally controlled dial code translators or registers, Fig. 6, which can store, evaluate and interpolate the dial pulses for alternate

Only a register-type system could meet the requirements at junction exchanges which are gateways to the Canadian and Mexican Networks or to the facilities of the international overseas carriers. The ability of the gateway junction exchanges to insert additional digits for routing inter-system calls provides compatible operation to the Canadian and Mexican step-by-step systems and obviates any conflict in the directory code assignments of the three independent networks. For example, the U. S. network complements either the Canadian or Mexican systems by operating the interconnecting trunk circuits as though the U. S. gateway exchange was a district exchange in their respective systems. The versatility of the junction exchanges also makes it possible to provide fully automatic service between Canadian and Mexican subscribers as such calls transit the U. S. network on a tandem basis.

All routing and group selector stages in the TWM-2 system are equipped with the Type EMD noble-metal uniselector

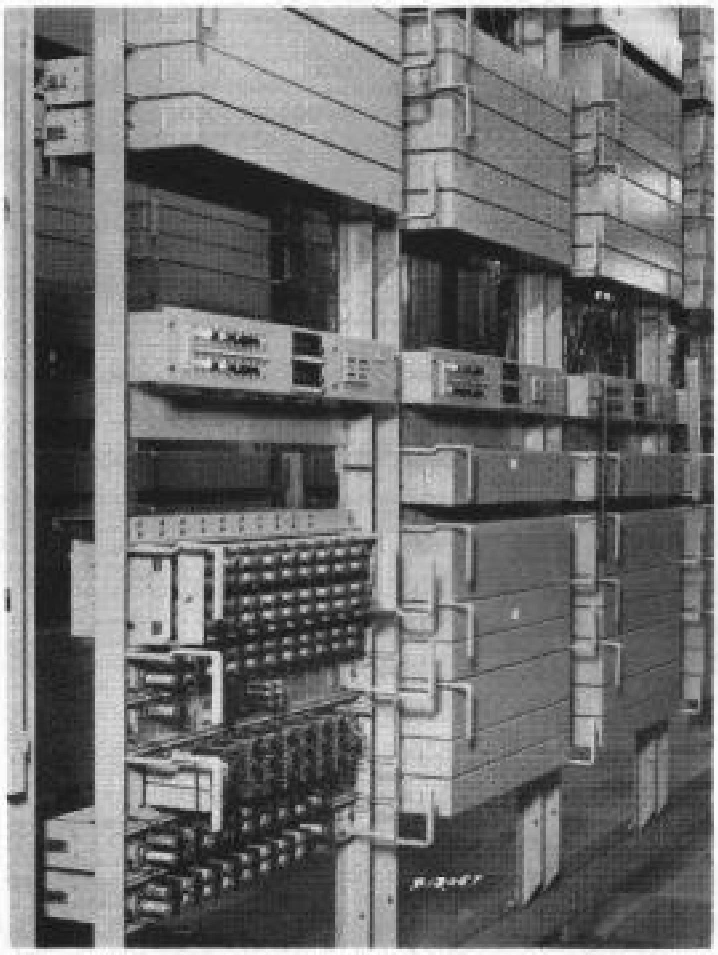

Figure 6. Dial Code Translators, two per rack.

switches, each having its individual motor drive. Fig. 8 shows two switch racks, each containing 16 Routing or Group Selector Switches, and the associated rack of 32 Group Selector/Relay Sets. In this application, the switches have four wipers, or circuit paths, and 192 outlet points which can be distributed as required over 14 decade or marker points. This feature provides for greater switching availability and more efficient use of long-distance trunk circuits between exchanges. Each of the respective 192 outlet points for a rack of 16 switches are connected by an internal card-type solderless multiple. Some EMD switches in the TWM-2 system are used for line-finder and final selector functions and for this purpose the switches are arranged to provide 8 wipers/100 points and 4 wipers/100 points, respectively. The setting speed is approximately 175 outlet points per second.

The TW-39 system is used at district and sub-district exchange locations. This system employs the well-known and simpler step-by-step principle, where the selectors are under the direct control of the subscriber's dial. The switching stages in these exchanges are equipped with two-motion selectors having 10 decades, 10 points per decade, or 100 outlet points. In general, the district exchange locations are not important trunk routing points and operate from relatively short distances over one trunk bundle to the parent junction exchange. Therefore, exchange versatility is not a prime requirement in the district level of the network.

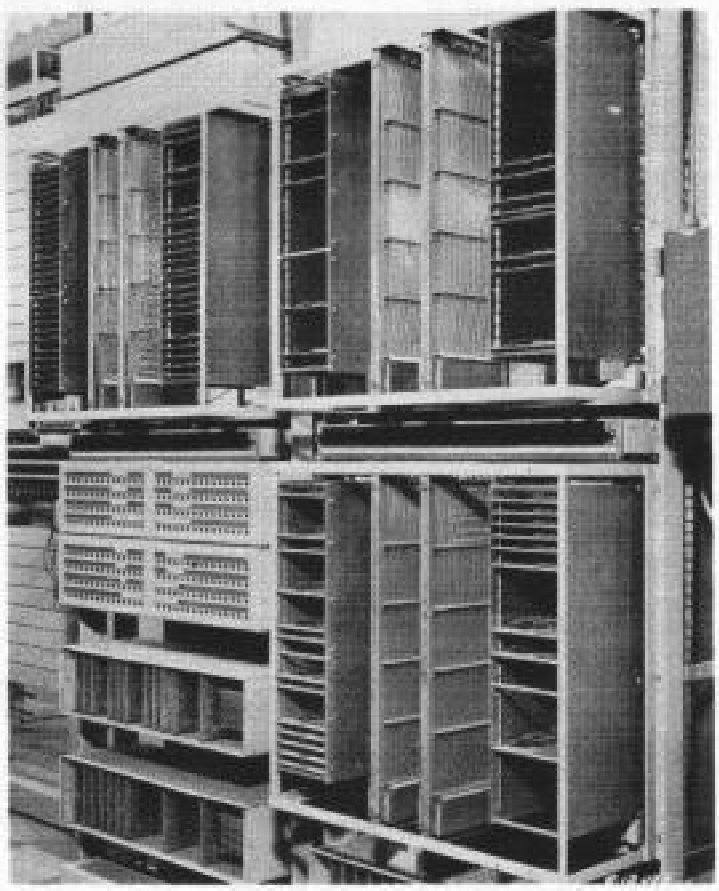

Figure 7. Electronic Coder, routing (left) and zoning (right) sections.

The TW-56 concentrator, operating on the sub-district level, serves 20 subscribers over five trunks to a parent district or junction exchange. The concentrator does not have a local dial stage because a very high percentage of Telex calls are long distance. Therefore, calls between subscribers terminated in the same concentrator are double-trunked through the parent exchange.

The operation of the TW-39 System, used at district exchange locations, has been described in a previous article.[1] Therefore, this paper will explain only the switching functions in the TWM-2 System used at all junction exchange points. Before doing so, however, it would be advisable to first briefly describe the control functions which take place in the subscriber set for initiating and receiving a call.

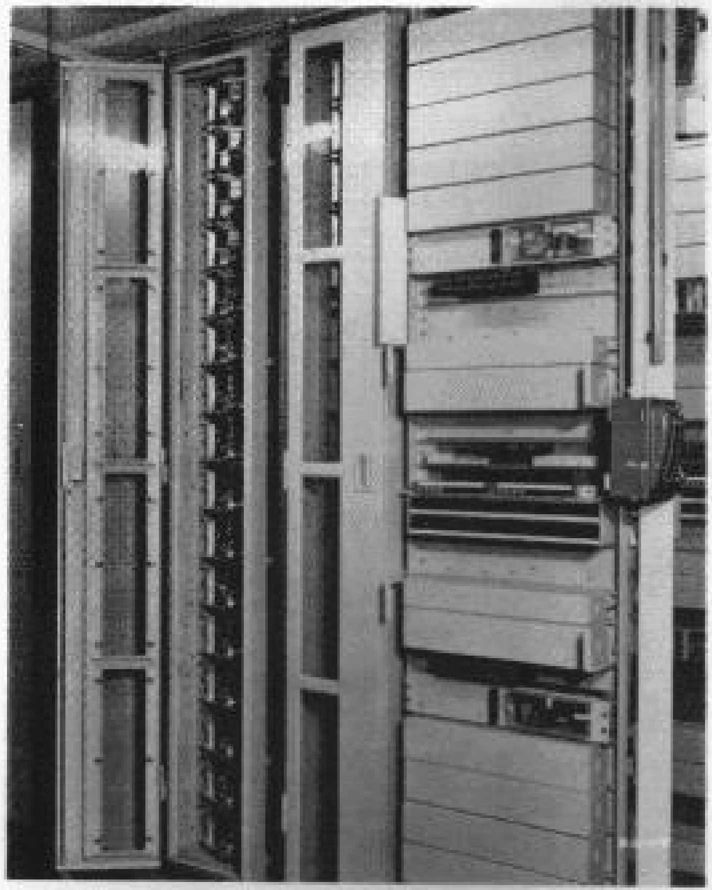

Figure 8. Two racks of Routing or Group Selector Switches (left) and the associated rack of Group Selector/Relay Sets (right).

Subscriber Set Controls

The connection between local subscriber sets and the exchange equipment is on a two-wire loop basis. In the idle or unseized condition, a current of approximately 5 ma (milliamperes) flows over the loop. This acts to keep the subscriber's teleprinter motor turned off and the RCU (Remote Control Dial Unit) locked.

As the subscriber initiates a call by depressing the start pushbutton on the RCU, the loop current is raised to the working level of 60 ma but in a polarity direction to keep the teleprinter turned off. In response to the higher loop current the exchange equipment proceeds to connect centrally-controlled answering equipment to the subscriber line. After this is done, the exchange transmits a "proceed to dial" signal to the calling subscriber, consisting of a 25 ms (millisecond) open or interruption in the loop current.

The "proceed to dial" signal is recognized in the subscriber's RCU, which unlocks the dial and permits the dial selection procedure to take place. For each of the dial pulses, operating at 10 cps (cycles per second), the 60 ma loop is opened for 60 ms and closed for 40 ms.

After the subscriber number has been dialed, the equipment in one or more Telex exchanges sets up the connection to the called subscriber and one of three possible signalling criteria is returned to the calling subscriber as follows: 1) a call connected signal, 2) a busy signal or 3) no response after the dial sequence. The call connected signal causes the 60 ma loop current to be reversed to a polarity direction which will turn on the teleprinter motor and "Operate" lamp, signifying completion of the connection. In the case of a busy signal, the teleprinter motor and "Operate" lamp are momentarily turned ON and then OFF, and the loop current is restored to the idle 5 ma condition and the dial is re-locked. No response, following the dial sequence, is indicative of either an open loop at the called subscriber station, an invalid number or a general trouble condition. Whenever this occurs, the calling subscriber cancels the call by depressing the disconnect pushbutton. He may then dial the "Information" position in the telegraph office to report the condition to supervisory personnel.

For an incoming call to the subscriber set, the exchange equipment reverses the current (5 ma) flowing in the subscriber's loop to the working direction. This causes the RCU to raise the loop current to the 60 ma level, automatically turning on the teleprinter motor and "Operate" lamp at the called subscriber station. Following this, a "call connected" signal turns on the teleprinter at the calling subscriber station.

Switching Functions in TWM-2 Exchanges

A simplified layout of a TWM-2 junction exchange is shown in Fig. 9. Local subscribers—those which operate directly to the exchange on a two-wire loop, or long-distance subscribers brought in over VFCT (Voice Frequency Carrier Telegraph) channels, are terminated on TS (Terminating Set) racks shown on the left side of the drawing. Each of these racks accommodates 100 subscribers. On the right side of the drawing are repeaters which terminate the trunk circuits to distant junction, district and sub-district exchanges. These repeaters, in addition to repeating the DC (Direct Current) telegraph signals, also contain switching controls which co-operate via the trunk circuit with similar repeaters in distant exchanges in establishing or releasing Telex connections. With respect to the seizure of trunk circuits for setting up Telex calls between two exchanges, the repeaters can be strapped to operate either on an outgoing, incoming or two-way basis.

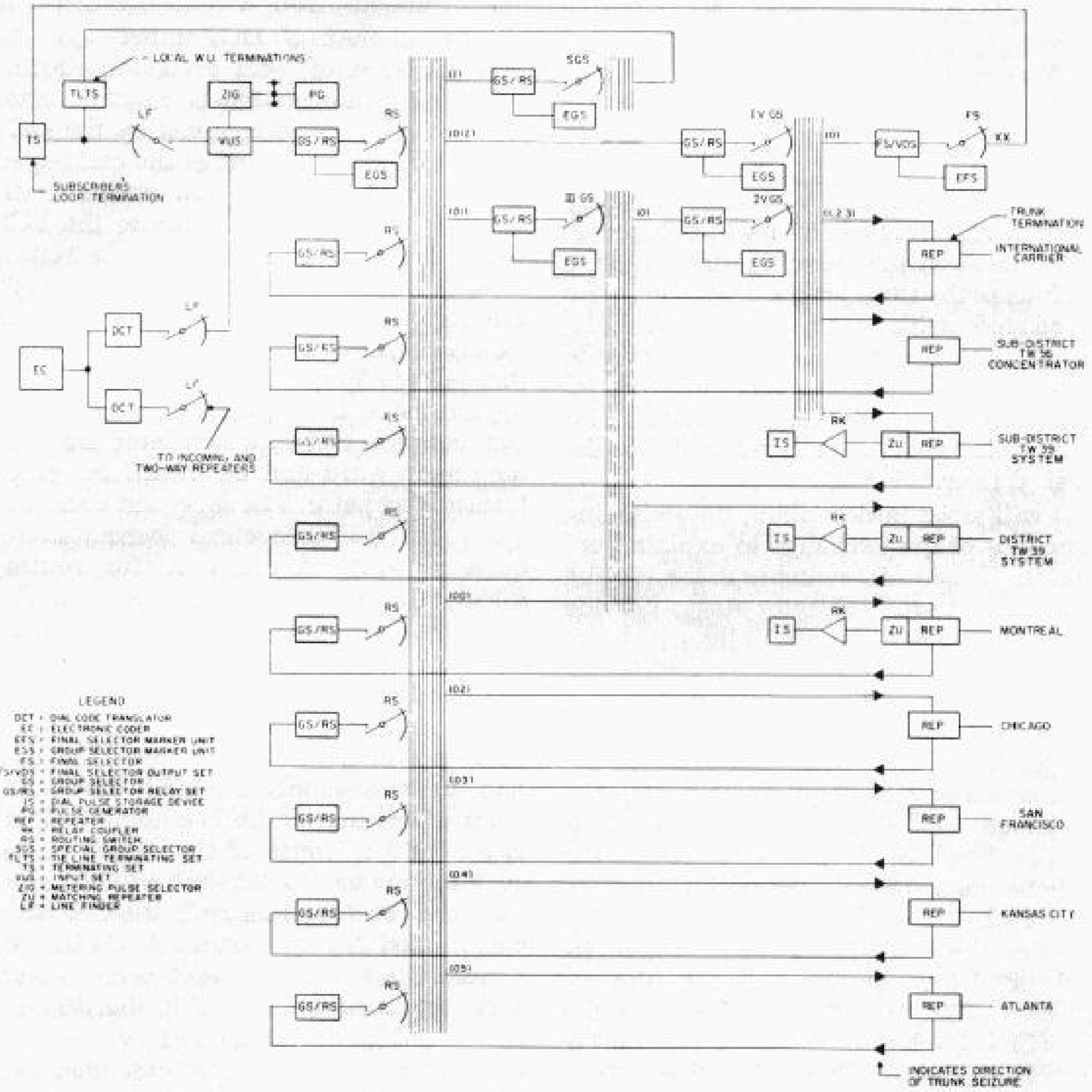

Figure 9. Simplified layout of New York TWM-2 junction exchange.

TWM-2 Local Calls

Local calls between two subscribers terminated in the same TWM-2 exchange can be made by dialing the digits on the right side of the dash in a typical subscriber number, such as 01-20XX.

As the subscriber depresses the "start" pushbutton preparatory to the dialing sequence, the respective subscriber line-controls in the TS rack recognize the increased loop current and request simultaneously a connection through an allotter to an idle VUS (Input Set) and an idle DCT (Dial Code Translator). As many as 24 VUS may be provided for answering calls from each group of 100 subscriber lines. Also each VUS is associated with one GS/RS (Group Selector/Relay Set) and RS (Routing Switch) which together form the switching array to direct calls to various paths through the exchange. Also associated with each VUS is a ZIG (metering pulse selector) which serves to time each call and apply the proper charges to the equipment associated with each subscriber line. This will be described later.

It will assist in describing the switching functions of the exchange to explain here that the Type EMD switches in the routing selector and group selector stages provide for four wipers or circuit paths which are designated *a*, *b*, *c* and *n*. The *a* and *b* conductors are used for the forward and backward telegraph transmission paths; *c* is for test control purposes in extending the connection to other equipment within the exchange and *n* is used for marking a specific level, or decade, after which the switch looks for an idle outlet point in this level.

After the DCT has tested through its associated 8-wiper line finder to the requested VUS, it will in turn control the LF (Line Finder) of the VUS to hunt for the TS of the calling subscriber. Upon completion of this line finder setting both operations requiring less than a second, the 25 ms "proceed to dial" signal will be transmitted over the subscriber's loop. As the subscriber dials the four-digit number, in this case 20XX, the digits are received by the DCT and as each digit arrives, it is presented to the EC (Electronic Coder) for an evaluation of the routing and zoning (charge) information. The EC is a two-section rack, for routing and zoning functions respectively. Each section is equipped with "AND gate" diode cards and associated transistor amplifiers which can evaluate the various digit combinations in a subscriber number. Since the connect and evaluation time of the EC requires only a few milliseconds, it is arranged through central controls to serve as many as 50 DCT units.

In the case of local calls, the routing and zoning information is on hand after the first digit "2" is received by the DCT and therefore processing of the call begins immediately. The DCT now transmits the required routing information to the EGS (marker unit) which controls the setting of all routing selectors within one rack. This information, to mark level 2 in this example, is conveyed from the DCT, through the VUS and GS/RS, to the EGS by means of a four-unit code sent over conductors *a* and *b*, which later are used for the forward and backward telegraph transmision paths. The four-unit code provides for 16 theoretical permutations, however only 14 are used for routing selectors and 10 for group selectors. The marking information is conveyed from the DCT to the EGS in approximately 50 ms.

The routing selector switch, having no home position, now moves over the contact back assembly seeking the outlet point which marks the beginning of level 2. As the "n" wiper of the switch passes over the marked point, but without stopping, the control circuitry in the GS/RS is conditioned to stop the switch via the "c" wiper on the first idle outlet point in level 2. As this occurs, the EGS in the RS rack is released for marking other switches and this particular call is now extended to a GS/RS in the IV GS (Group Selector) stage.

The DCT now transmits the second digit "0," also in four-unit code form over conductors *a* and *b*, to the marker unit (EGS) in the IV GS stage. The marking of this switch to level "0" and the seizure of an idle output point to a FS/VDS

(Final Selector Output Set) is identical to that previously described for the routing selector stage.

Each FS/VDS is connected to an associated FS (Final Selector) switch, having 4 wipers, 100 outlet points and 24 of these switches can be located in one rack to serve a group of 100 subscribers. Each FS rack is also equipped with one marker unit, EFS, similar in principle to the EGS unit for routing and group selectors. However, the EFS unit is arranged to receive two successive digits in four-unit code form from the DCT in order to mark a designated outlet point on the FS corresponding to a particular subscriber line.

After the DCT transmits the last two digits "XX" to the EFS, the FS switch is set to the TS of the called subscriber line and the EFS is released. If the called line is idle, the loop current is reversed and this causes the controls in the RCU at the called subscriber station to turn on the teleprinter motor and "Operate" lamp. The TS associated with the called line now returns the "call connected" signal—a reversal of polarity on the backward transmission path. This is recognized by the DCT which in turn causes the VUS to reverse the loop current of the calling subscriber. This results in a "turn on" of the equipment at the calling station and signifies completion of the connection. The DCT, now having completed its function, is disengaged from the VUS.

While the DCT was setting up this call, and as soon as adequate digits were on hand for the EC to establish the zoning, the DCT also transmitted the charge rate information in special code form through the VUS to its associated ZIG unit. The charge is based on time and distance, and is measured by applying the proper pulse rate, such as 4-, 6-, 12-, etc. ppm for each call. The ZIG obtains the various pulse rates from a PG (Pulse Generator) and applies the specified rate to a 5-digit counter individual to each subscriber line. For each completed call, (excluding busies and free-of-charge service calls), the ZIG also operates a connection counter associated with the subscriber's line.

TWM-2 Long Distance Calls

A call to a subscriber in another exchange requires the use of the long distance prefix. For example, a New York subscriber would dial 03 42XX to connect to a subscriber in San Francisco. With reference to Fig. 9 and the preceding description for local calls, the DCT will mark the RS switch to level 03 immediately after the first two digits are received from the subscriber. The call is then extended to either an outgoing or two-way repeater terminating a trunk circuit to San Francisco.

Inasmuch as the selection sequence must be made to conform to the requirements of the distant exchange, the repeater accordingly programs the DCT over the "*a*" lead for one of three possible criteria, as follows: 1) a TWM-2 exchange requiring selection signals in number plate or dial pulse form; 2) a TWM-2 exchange arranged for keyboard selection signals. Although the latter is not used, both 1) and 2) require the connection of a DCT at the distant exchange before the selection signals can be sent forward. Criteria 3) denotes a TW-39 (step-by-step) exchange which accepts number plate selection signals only and transmission of these signals to the distant exchange can take place immediately.

In seizing the trunk for an outbound call, the repeater reverses the polarity on the forward (outbound) transmission path and now two 25-ms revertive pulses will be forthcoming over the backward (inbound) transmission path from San Francisco. The first signifies continuity of the trunk circuit to the distant exchange and the second — the "proceed-to-select" signal — denotes that a DCT has been connected at San Francisco and is in readiness to receive the dial information.

Upon receiving the "proceed-to-select" signal, the DCT at New York transmits in dial pulse form the digits 342XX over the trunk circuit and then disengages itself from the VUS. In some instances, the DCT at the exchange of the calling subscriber —New York in this example—may prematurely disconnect itself before the subscriber has completed the dial sequence, provided it has obtained the required routing and zoning information. In such cases, the dial pulses from the subscriber are allowed to pass through the VUS, directly to the trunk circuit.

Since the switching functions for handling an incoming call at the San Francisco junction exchange are the same as those at New York, Fig. 9 will also be used to complete the description by changing the example to cover an inbound call to subscriber 01-20XX at New York. In response to an incoming seizure, the repeater at New York will return the first revertive pulse to San Francisco over the backward transmission path and it will also request connection to a DCT programmed to serve incoming and two-way repeaters. After the DCT is connected, it will transmit a "proceed-to-select" signal to San Francisco to report its readiness for receiving dial signals.

Upon connecting to the repeater, the DCT will be given a control criteria, by the repeater, which will identify the exchange category of the incoming circuit. This enables the DCT to select a specific routing program for switching calls from the junction, district and sub-district exchanges in the U. S. network as well as for calls from Canada, Mexico and the U. S. international carriers. This information is necessary to properly evaluate the dial selection sequence, apply alternate trunk routing possibilities and to provide, where required, a "proceed-to-select" signal to the DCT in a distant TWM-2 exchange.

Following the transmission of the "proceed-to-select" signal to San Francisco, the DCT at New York now begins to receive the incoming selection digits 120XX. While the digits are arriving, the DCT presents them in successive order to the EC for a routing evaluation. As soon as adequate information is on hand, the DCT proceeds to route the call through the RS, IV GS and FS switching stages in an identical manner to that previously described for local calls.

Alternate Routing Between Junction Exchanges

If all trunk outlets between two junction exchanges are either busy or faulty, calls are then alternately routed through a third junction and the typical New York to San Francisco call would have been directed New York-Chicago-San Francisco. This is recognized on a call to San Francisco by the failure of the RS to find an available repeater outlet in Level 03 and this results in a busy signal being returned to the DCT but not to the subscriber. The DCT then re-connects to the EC for the alternate route on digits 03, marks Level 02 in the RS, connects to a repeater outlet and then transmits the digits 342XX over the trunk to Chicago. The first or junction digit "3" on an incoming call at the Chicago exchange causes the DCT and EC to route this call through to San Francisco. The routing section of the EC also contains simple patching facilities for quickly rearranging the alternate route program at each junction exchange to meet emergency traffic requirements in the overall system.

Operation to District and Sub-district Exchanges

The junction exchange operates to the ten district exchanges in its respective junction area over direct trunks. Each of the district exchanges may also have separate trunk groups to 8 sub-district exchanges in its respective district area. Some sub-district exchanges, because of close proximity, are terminated directly into a junction exchange. Fig. 9 also shows how the trunks to these exchange points are terminated in the junction exchange.

Although the DCT receives a different program criteria from the repeater for operating with each exchange category, calls are passed to and from the district and sub-district exchanges in a manner similar to that previously described for trunk operation to other junction points. However, an additional operating function is required at the junction exchange for terminating the circuits from district and sub-district exchanges equipped with the Type TW-39 (step-by-step) System. It is required because these exchanges are not equipped to store dial information and the selection sequence from the subscriber's dial goes directly over the trunk circuit to the junction exchange. Therefore provision is made at the junction exchange for receiving the dial selection information without delay while a DCT is being connected to the incoming repeater circuit. This is also a requirement for terminating the inbound circuits from the Canadian and Mexican step-by-step systems.

The means of temporarily storing the dial digits from step-by-step exchange systems and then re-transmitting the information after the DCT has been connected is provided by a matching repeater (ZU) associated with the incoming and two-way trunks. A group of matching repeaters are connected through a Relay Coupler (RK) to a smaller number of Dial Pulse Storage Devices, (IS). The latter is a small mechanical unit having two wipers on a circular contact assembly which can store about 10 average-length digit combinations. It is also capable of sending out the information at any time after the receiving sequence has begun.

Matching repeaters are not required in the junction exchanges for terminating the trunk circuits from sub-district exchanges equipped with TW-56 Concentrators. This is not required because the "proceed-to-dial" signal is not transmitted to the subscriber until the DCT in the junction exchange has been connected to the incoming repeater circuit.

Calls to Western Union Local Positions

Loops to the tieline, information, test and other service positions in the telegraph office are terminated in a special TLTS (Tieline Terminating Set) and local subscribers may call these positions with a two-digit number on a free-call basis. Such calls are handled through the RS and SGS (Special Group Selector) stage and do not pass through a final selector. These positions also have access to all supervisory positions in the domestic and interconnecting systems.

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2. "Telex — A New Telegraph Service for Canada," C. J. COLOMBO, Canadian Pacific Railway Company CP 57-830 presented at the Summer General Meeting of the AIEE in Montreal, June 1957.
3. "A New Automatic Teleprinter Switching System Employing Uniselector Motor Switches (TWM System)", E. ROSSBERG, CP 58-399 presented at the Winter General Meeting of the AIEE in New York City, February, 1958.

As Planning Engineer, in the Plant and Systems Division, Mr. Philip R. Easterlin has been responsible for the overall technical planning of Western Union's U. S. TELEX Network and has represented the Company on a number of overseas assignments, including the CCITT Telecommunications Conference in New Delhi, India, in 1960.

Mr. Easterlin began with Postal Telegraph in 1920, progressing from Morse and automatic operator to multiplex, repeater and wire chief regulating work. Entering the Engineering Department in 1939, he helped design and test Postal's Semiautomatic Reperforator System, later supervising its application in many Army Signal Centers during the war. Following the merger with Western Union Telegraph Company, he designed a number of widely used telegraph repeaters, including a Switching System for Dispatcher Test Wires, described in the January 1953 issue of Technical Review. He was active in the development of Plan 21 Reperforator Switching Equipment and was responsible for its testing at the Minneapolis and Detroit offices. He also directed the development of the Control System for Integrated Data Processing described in the Technical Review for July 1956.

He is a member of AIEE.

ROBERT STEENECK IS 1961 D'HUMY MEDALIST

ROBERT STEENECK was presented with the 1961 F. E. d'Humy Award by Western Union President Walter P. Marshall at formal ceremonies on September 26, at New York. Mr. Steeneck is acting Data Systems Engineer, Research and Engineering Department, at company headquarters.

S. M. Barr, Vice President, Planning, speaker at the ceremonies was introduced by William H. Francis, Vice President, Plant. In his talk entitled "Engineering and Services," Mr. Barr commended the engineering group for its contribution to the advancement of Western Union and to the progress made on major projects.

Mr. Steeneck is the seventh recipient of this honor which has been awarded annually since 1956 to a Western Union engineering, research or technical worker who has made a most significant contribution to the telegraph art. The Award includes a bronze medallion, an engrossed citation certificate, a gold lapel emblem and a $500 honorarium. The Western Union Telegraph Company established the award in commemoration of the leadership in telegraph research and engineering by Fernand E. d'Humy, who died December 22, 1955.

The citation to Mr. Steeneck, which reads "For creative skill in adaptation of the electronic and mechanic arts to assure telegraphic reliability and to evolve new concepts in telegraph mechanization," takes cognizance of his outstanding contributions to telegraph communications. Some of these contributions include collaboration on various projects such as assistance in the development of the Varioplex system, work at the Water Mill Laboratories in designing components for the Navy Radar Contact Trainer Project during World War II, and his direction of the Signal Normalizer Project known as "Dingbat" which was awarded one of the five highest citations by the Department of Defense in 1955. Mr. Steeneck has recently been working on methods for automatic error detection and correction in data transmission systems. Last year he developed the Telecard System, which provides for conversion of telegraphic transmission into punched card data and vice versa.

A graduate of Stevens Institute of Technology, Mr. Steeneck joined the Engineering Department of Western Union in 1926. One of his early assignments was with the Ticker Group in the development of the newly established Teleregister service. He was later responsible for the development of the Company's line of Sports Timers widely used in athletic events today. In 1951 he invented an ingenious foot-operated teleprinter, a personal communication system for a paraplegic war veteran who could not talk and could only move his right foot. In 1954 he developed an electronic one-wire cross-office control for the Plan 55 Air Force switching system. Together with all of these activities, Mr. Steeneck has found the time to write many technical papers.

H. F. KRANTZ, Senior Project Engineer

U.S.A.F Technical Control — Part I

A Completely Modern Traffic Control Center

Regardless of the higher speed innovations of many new data systems and the infinite complexities yet to be developed, routing and control of telegraph channels for straight printer message handling will be a problem for years to come. The Channel and Technical Control Facilities recently installed by Western Union at Fuchu, Japan and Croughton, England are the first of the United States Air Force's modernized centers to be operational. This article describes, in two parts,* the techniques and simplification of circuit handling designed into these new USAF Technical Control Centers.

When Western Union was first introduced to the requirements for the Air Force's modernized technical control facilities, in connection with providing these equipments coincident with the installation of Plan 55 switching centers at Fuchu and Croughton, some innovations seemed to be slightly extravagant from the accustomed commercial viewpoint. However, as the planning behind these new ideas became apparent during the development of the final apparatus, it was increasingly easy to understand why such measures were not only desirable, but in most cases, absolutely necessary to meet the circumstances encountered in a world-wide, national-security-minded communications system. Military security imposes strict requirements which complicate the standard commercial viewpoint. Added to this, is the existence of apparatus from various equipment manufacturers which must all work in conjunction with any newly installed facility. Perhaps, the most important consideration in the planning of this complex system was the average experience of the operating forces. This experience level is considerably less than that enjoyed by most commercial carriers and contributed to equipment complexity but resulted in speedier overall circuit handling ability. The main purposes of the Technical Control Center are to give quick, accurate appraisals of a circuit's condition and to initiate immediate steps to correct or replace a circuit which has deteriorated, beyond acceptable limits, before the "customer" realizes his apparatus is about to fail.

Human Factors Engineering

The overall program, for modernizing the facilities used in signal analysis and patching, took these factors into account and included engineering to fit the human factors involved. The normal day's work is an eight-hour shift which can be extremely tiring if trouble prevails. Under the old methods, equipment failures were recognized by the "customer" who used the base phone exchange to inform the control center of his difficulty. This method of trouble shooting is additionally trying, since it requires a certain amount of diplomacy over the phone to get away. When a multiplicity of trouble occurs, the jangling of the phone itself becomes another irritant, requiring extra steps and interrupting the train of thoughts necessary for locating the source of trouble. With the new facilities, some automatic monitoring is provided and the ability to "see" any circuit is reduced to a minimum. On certain key circuits, a full-time electronic monitor is set to actuate a visual and audible alarm when distortion exceeds a certain prescribed limit. This eliminates any guess work as to whether or not these circuits are marginal. This alarm may be significant of a group failure prompting a routine check of all associated channels. The controllers are provided with a means of quality checking all circuits in the station by a dial system and high impedance probes. When these are properly selected a meter indicates the distortion

* Part II to be published in the April 1962 issue of Technical Review.

present at various stages throughout the signal path. Also associated with this probe, is an oscillograph display of the items, switchboards, monitoring positions and supporting facility terminals, all have simple identifications and easily manipu-

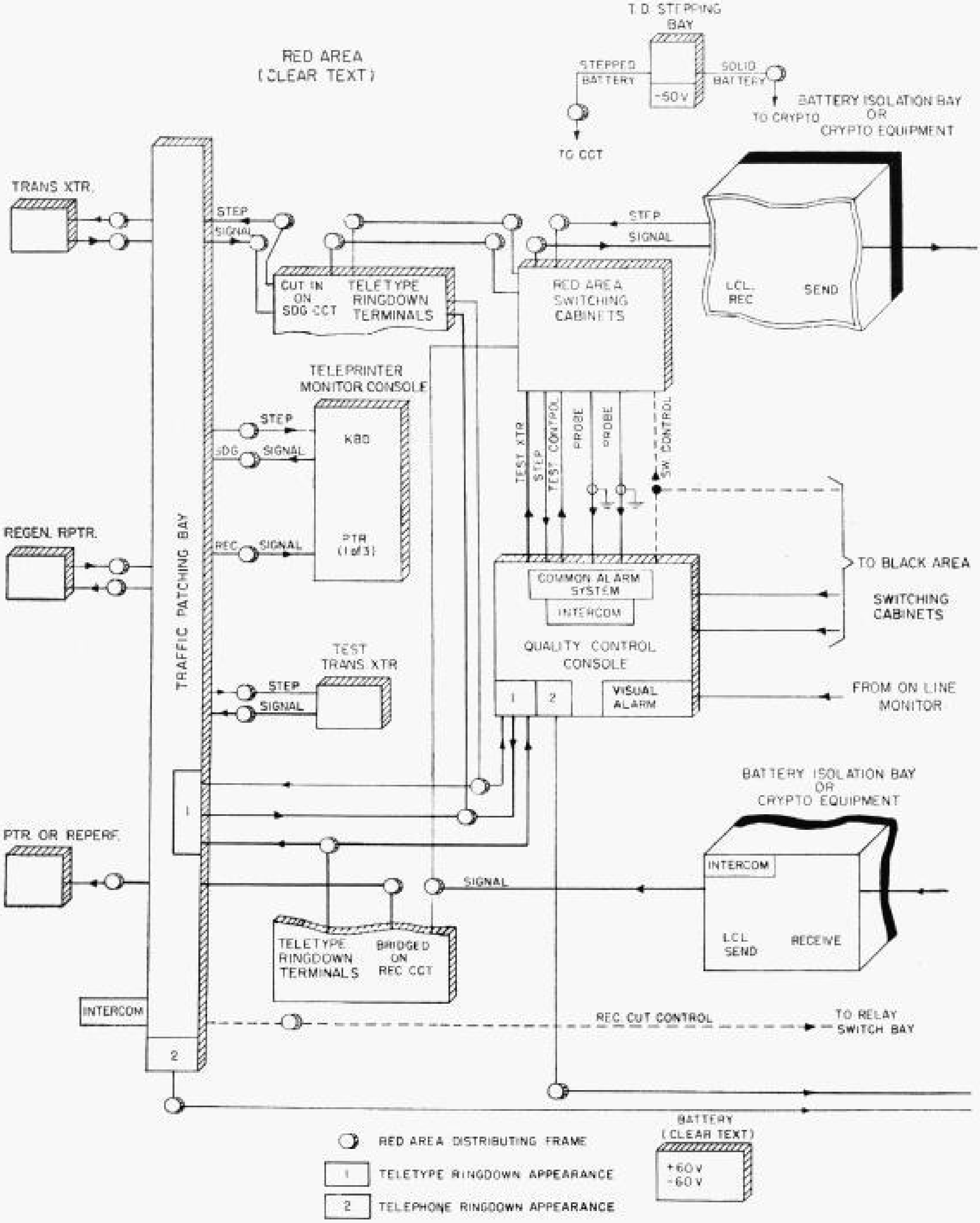


Figure 1. Block Diagram—Clear Text (Red) Area

signal wave being observed. These test and alarm features are located on a console designed for the maximum comfort of the seated operator. Various auxiliary lated controls which further enhance the ease of operation.

As would be expected, commensurate with the present "state-of-the-art," all equipments supplied for these centers are designed with transistor circuitry, when applicable, to save space and conserve power. Plug-in module construction is employed whenever practical for ease of maintenance and accessibility to parts.

Two Area Division for Security

The principle of security divides the Technical Control Center into two parts: a clear text (Red) area and encrypted text (Black) area. Figure 1 shows the equipments located in the clear text side. It should be noted that the "STATION BATTERY" shown here is duplicated on the encrypted text area so that there is no common impedance bridging the line between Red and Black. Even a separate ground return bus is provided for each area's equipment. All signal leads leaving or entering the Red area are isolated by either an encryption device or a simple battery isolation relay with its coils and contacts in the appropriate areas. Unavoidably, a few control circuit leads cross the Red-Black division; however, no traffic can be handled on these wires which are separately cabled. Examination of the block diagram of this Red equipment, reveals the normally expected patching facility, monitoring device, test transmitters, repeaters and terminating equipment. Several items not normally encountered in commercial practices are also represented. These are the Transmitter Distributor Stepping Facility, a Teletype Ringdown Facility and a Quality Control Console with switching apparatus.

Station Battery

The most generally used unit of the new equipments is the station battery which supplies the polar sixty-volt source for all traffic circuits. The current requirements for the entire station is approximately forty-five amperes of both poles; with slightly more than half of this current used in the Red area to accommodate such non-repeating apparatus as the pattern generators, order wire circuits, etc. Rectifiers for this supply are provided in sufficient quantity so that the maximum five-ampere capacity of each rectifier will not be exceeded. Individual marking and spacing legs are supplied through a current-limiting protective ballast lamp. The characteristic of this lamp presents a nominal five to ten ohm impedance at the operating current of twenty milliamperes. At fifty milliamperes the lamp will glow slightly but on direct short circuit it will limit the current drain to one hundred-sixty milliamperes and will light quite brilliantly. With this means of protection, trouble from outages caused by a blown fuse are not possible. By casually scanning the bank of ballast lamps during the normal routine of daily work, maintenance personnel can quickly tell where trouble is likely to occur because of excessive current. Each lamp is identified by a number in its lamp cap, giving immediate circuit reference from records of the cross-connections. These numbers only become obvious after the lamp glows brightly. It is possible to estimate roughly the amount of current being drawn and hence the urgency of the repair, by the brilliance of these lamps. This accelerates finding the trouble and repairing the damage.

The working rectifiers are equipped with a feature to provide a holdover of the output sixty volts for a period of approximately one hundred milliseconds to allow switching of primary power supplies without accidental loss of traffic due to a slight break when swapping loads.

Spare equipment is provided on an adjacent assembly. These rectifiers have a ten-ampere capacity, and can, therefore, take only two equipment failures simultaneously. It is expected that a condition of this sort will not continue without repairs being made; however, a complete spare five-ampere rectifier is kept to replace one which has failed. All connections to these rectifiers are contained in three plugs. The spare supply is set lower than the working groups and isolated therefrom with a diode. When a working rectifier loses control and its output is lowered below that of the spare, the spare assumes the full load. If the output should increase, the rectifier input circuit-breaker is equipped with a trip coil, which is operated by the increased voltage. This shuts off the rectifier and transfers the load to the spare unit. Alarm control leads are carried to the station alarm system.

Patching Facility

The patching bay provides the patch cords for rearranging, on a scheduled or emergency basis, the termination of cross-office-in-station lines and station transmitting and receiving devices, or "customers" apparatus. The circuits for the receiving and sending jacks are shown by Figures 2 and 3 respectively. These figures illustrate the physical arrangement

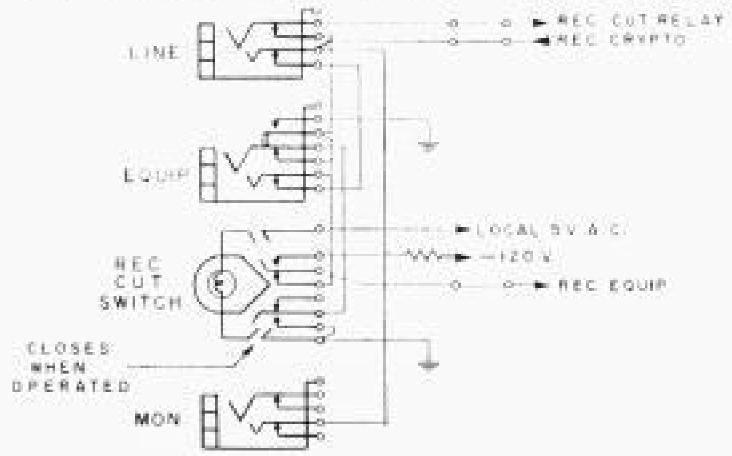


Figure 2. Wiring Diagram—Receiving Jack Circuit

of the jacks and keys, with the receiving set located directly above the sending set. One hundred such duplex circuits are included on each bay assembly.

Prominent features of these circuits are the sending circuit STEP PULSE SWITCH and the REC CUT SWITCH. These two switches provide controls not usually encountered in d-c telegraph patching facilities, but serve to assist the Air Force Controller in the rapid handling of certain circuit problems. Since it is expected that all distributors will be equipped with step pulse releasing devices, when the controller wishes to stop traffic from a particular position to its line facility, it is only necessary for him to push the switch. This action opens the step circuit, preventing release of the distributor which in turn closes a circuit for the "step readback" lamp giving a visual indication of the interruption. This visual indication is dependent, not upon the switch position, but upon the continued operation of the step-actuated distributor release. Thus, it can be seen that if the step pulse is interrupted for any reason, a light lights up on the switchboard, in the center of the push switch, informing the controller of an unnatural condition. This indication allows immediate investigation without an attendant at the distributor noticing the stoppage or the distant end complaining of lost text before Tech Control is aware of trouble. The REC CUT SWITCH is employed to hold receiving equipment in a steady marking condition when a receiving channel has failed. An operating ground is applied to a "cut relay" which, through its contacts, provides terminations for the receiving terminal equipment and holding battery for the receiving crypto or battery isolation relay. This "cut relay" is located in the Black area and the controlling ground is one of those few connections which must cross the Red-Black division. The CUT SWITCH also applies a holding battery to the receiving terminal equipment.

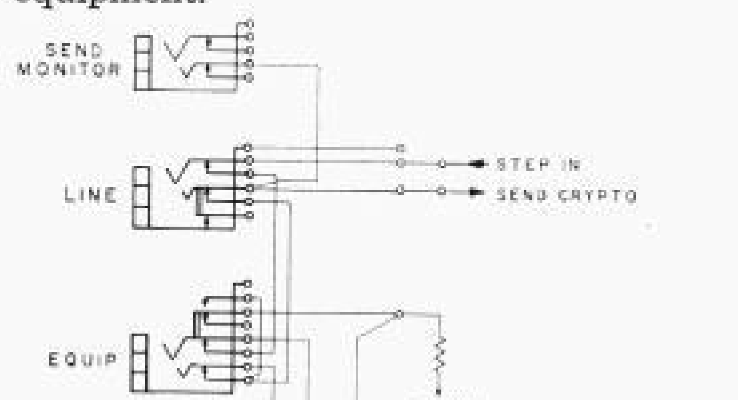


Figure 3. Wiring Diagram—Sending Jack Circuit

Additional miscellaneous circuits are provided on the patching facility for termination and readily available patching of the other facilities shown in the block diagram, Figure 1.

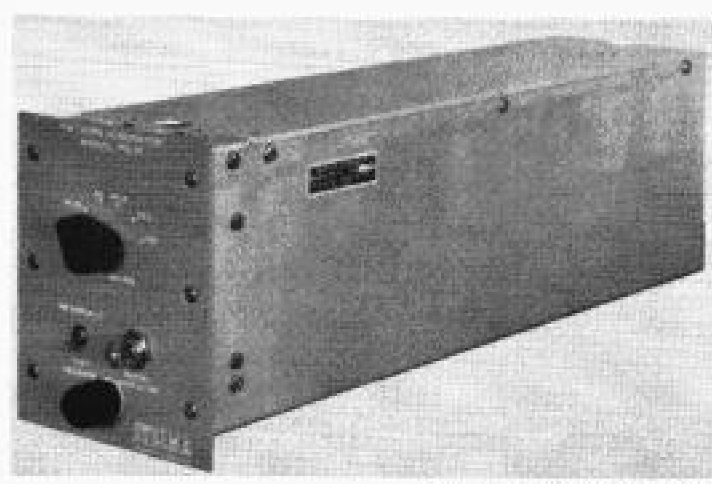
Six monitor printers are available for every one hundred traffic circuits and are arranged in consoles as illustrated in Figure 4. These are standard Model 28 printers modified slightly to allow the compact vertical arrangement of three printers and one keyboard. The printers are geared in the most desirable ratio for sixty (45.45 baud) or one hundred (74.2

baud) word operation with the top printer usually set for 74.2 baud. This gearing allows that printer to be operated over circuits of any baud-rate through a Character Storage and Release (Storel) device.

Figure 4. TTY Monitor Consoles

When properly patched at the switchboard to circuits equipped with a baud-rate determined step pulse, the Storel Unit provides the means to convert any baud-rate signal into one at a higher rate. As a receiving device, characters are released to the printer magnets at the higher rate giving the printer an exaggerated rest pulse until the time difference between the slow input and fast output character rate is absorbed. The keyboard and lower printer mounted on the same base are usually geared for the baud-rate of the orderwire circuit. The operating rate of all printers is identified at their switchboard jack appearance, and their use with the correct baud-rate circuit becomes a reflex action as the controller learns the relation between jack position and monitor. Printer monitoring, like all monitoring functions of the new tech control, is accomplished on a shunt basis through a nominal 50,000 ohms without discernible deterioration of the through traffic circuit. The shunt monitors manufactured by Western Union are mounted within the Teletype Monitor Console and are actually in the circuit at all times, so that the jack appearance does not require any additional patching to supply the shunt device. Switches are provided to turn off individual printers and copy display lights, and for home record copy from the local keyboard as desired.

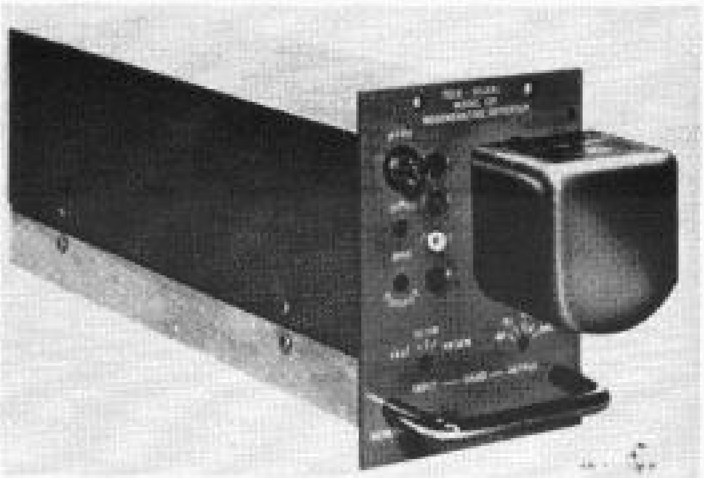
The Test Transmitter Distributor appears in groups of jacks at each switchboard assembly, and provides the well-known "Quick Brown Fox . . ." test message with the station's call letters inserted at the end of the line. These messages are electronically generated in the Pattern Generator assembly shown in Figure 5. The units may be operated at any of the commonly encountered baud-rates as determined by their switch settings and the step pulse of the circuits to which they are patched. The pattern generators may be set by a switch to transmit reversals at the selected baud rate. This capability is employed in instances where it is desired to have tests conducted from the Black area equipment patching bay over a circuit usually equipped with an encryption device. The signals from the pattern generators assigned to these positions are crossconnected to a battery isolation relay to permit access to the black distributing frame for connection to the equipment patch bay test jacks. They may, of course, be set to transmit the test message, if this is desired.



(Courtesy of Stelma, Inc.)

Figure 5. Pattern Generator Assembly

Repeaters designed for the new Tech Control centers are shown in Figure 6. These units provide, in addition to the ability to regenerate signals distorted up to forty-eight percent, the capability of speed conversions between 45.45 and 50 baud. This capability makes the regenerative repeaters particularly useful in areas where the 50 baud signal is predominate and only the normal 45.45 baud gearing is available.



(Courtesy GPL, Div. of Gen. Precision, Inc.)

Figure 6. Regenerative Repeater

Distributor Stepping Facility

The function of the Transmitter Distributor Stepping Facility is to provide precisely spaced pulses which will release transmitting devices at an eight-bit interval. When line facilities are connected to such a wide variety of transmitting devices and equipped with encryption devices, it becomes necessary to have control of the character interval to prevent garbling when test or order-wire circuits are patched in. Since the transmitters or distributors normally encountered over Air Force start-stop circuits are mechanically geared to rest intervals between one bit length and two bit lengths, these character step pulses are timed to release all transmitting devices with a two-unit rest pulse. This results in a total character interval of eight bits consisting of start pulse, five intelligence pulses and two rest pulses.

It can now be seen that a transmitter of the highest baud-rate can be released by step pulses of a slower baud-rate. Using a 74.2 baud step-pulse controlled keyboard as an example and referring to Figure 7, it can be seen how the high rate keyboard can be cadenced to the lower rate circuit, thus allowing a conversion within a Storel unit to the line baud speed. Obviously, there must be delay of at least one character between the input and output to allow for storage and release of the intelligence at the different rate. Conversely, of course, the release at a higher rate (with exaggerated rest pulse) of intelligence stored at the slower rate is simply accomplised by internally driving the output circuits at the faster baud-rate after the character has been received and stored.

The Transmitter Distributor Stepping Facility manufactured by Western Union is a self-contained unit supplying the sixty-volt rectifier for step battery, in addition to the step pulse timing circuitry. This rectifier and its fallback are identical to the station battery rectifiers. The assembly provides the ability for two means of operation by strapping: (1.) Stepped pulses at the various rate intervals ; (2) Solid battery for cross-connection to the encryption device to be interrupted by that equipment at its prescribed rate and then connected through the jack field to the desired terminal apparatus.

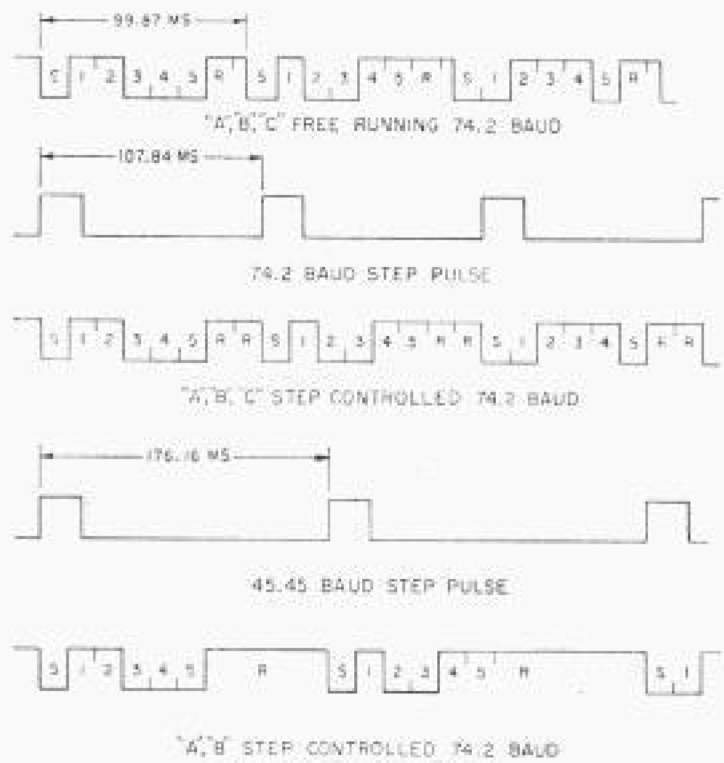
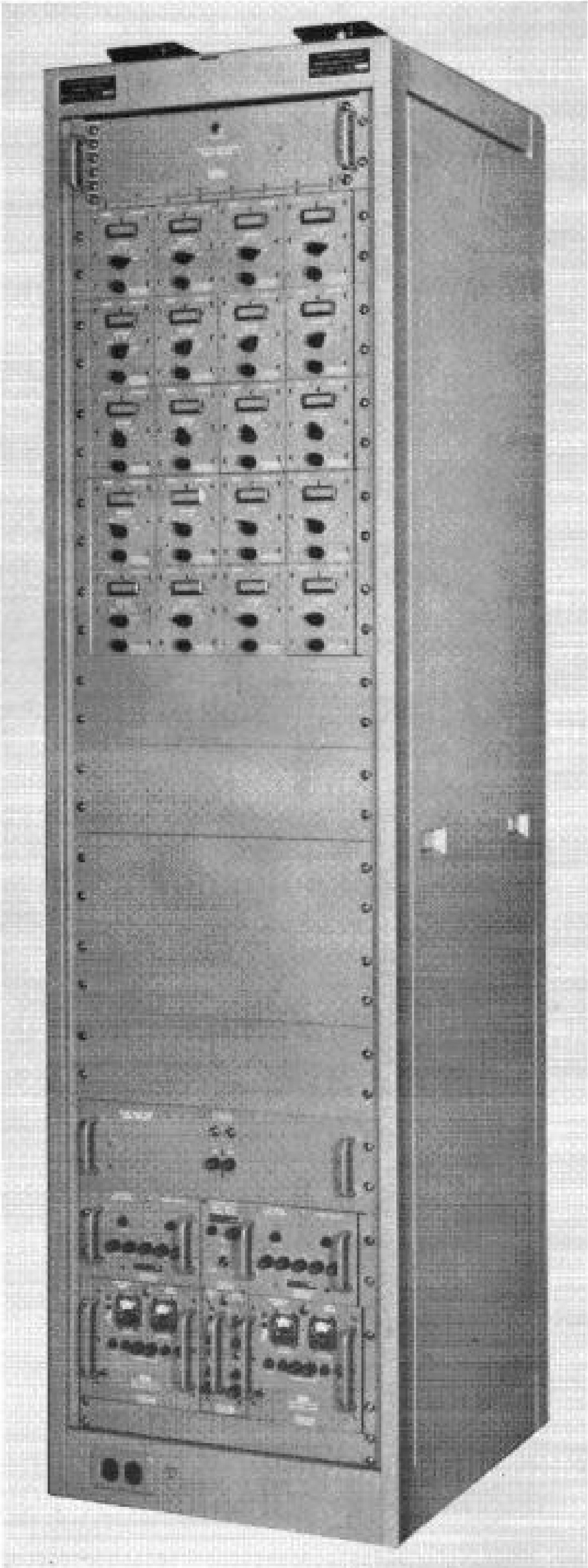


Figure 7. Step CCT Timing

Order-Wire Operation

Coordination of traffic patching and routing is accomplished in the Air Force by means of order-wire circuits much the same as that in commercial practice. Two order-wire facilities are available, and both appear on the block diagram in two positions — Traffic Patching Facility and Quality Control Console. One of these order-wires for voice coordination is terminated in the Black area where all audio circuit terminations are made, its operation and use will be discussed in the second part of this article.* The second order-wire for teleprinter use has its terminating equipment in the Red area, as shown in Figure 1, so that a recognizable coding for each of the positions can be used, and also an encryption of order-wire traffic is possible, when it is found necessary. The circuits assigned for this purpose may be set aside for order-wire use only or may be shared with a low priority, lightly loaded traffic position, which permits preemption by the order-wire at any given time. Stelma, Incorporated supplied the Teletypewriter Ringdown Facility shown in Figure 8.

Figure 9 shows the general configuration of the unit as it is connected in the through circuit. Various details have been omitted for clarity, but it should be noted that the normal traffic circuit elements, such as probe points for quality analysis and receiving cut relay contacts, are actually included. The order-wire printer position at the Quality Control Console has precedence over that at the patching bays. It can be seen, since the receiving circuit is only a bridge on the line, that a printer, patched at the switchboard, will record the text. However, since the keyboard circuits are in series, the console has the preference and will "take the line" at any time. Operation of the unit, however, is the same except for code designation when either position is activated. At the switchboard this is accomplished by patch cord insertion of an available monitor printer and keyboard combination jack to the order-wire appearance; at the console where all operation is by pushbutton, the order-wire appearance is so equipped. Referring to Figure 9, it can be seen that either position's calling action causes the other position to receive a "busy" or solid light signal. The line is seized when a coincidence of step and appearance call are gated to the Duocal's circuitry. This action terminates the incoming line where a shunt load is used to key the receiving order-wire printer and places holding battery on the receiving equipment. Marking battery, supplied through the keyboard of the inserted order-wire appear-



(Courtesy of Stelma, Inc.)

Figure 8. Teletype Ringdown Assembly

ance is interrupted by the Duocal's keying relay to send the position's four-digit code designation. Since a step-pulse activates the Duocal's keying, it is obvious that the shared circuit must have the same rate and the transmitter of the operating positions must be stepper-controlled if it is tion, traffic patch bay or quality control console, receives a flashing signal light. The other position receives a busy steady light. Simultaneously, the unit cuts into

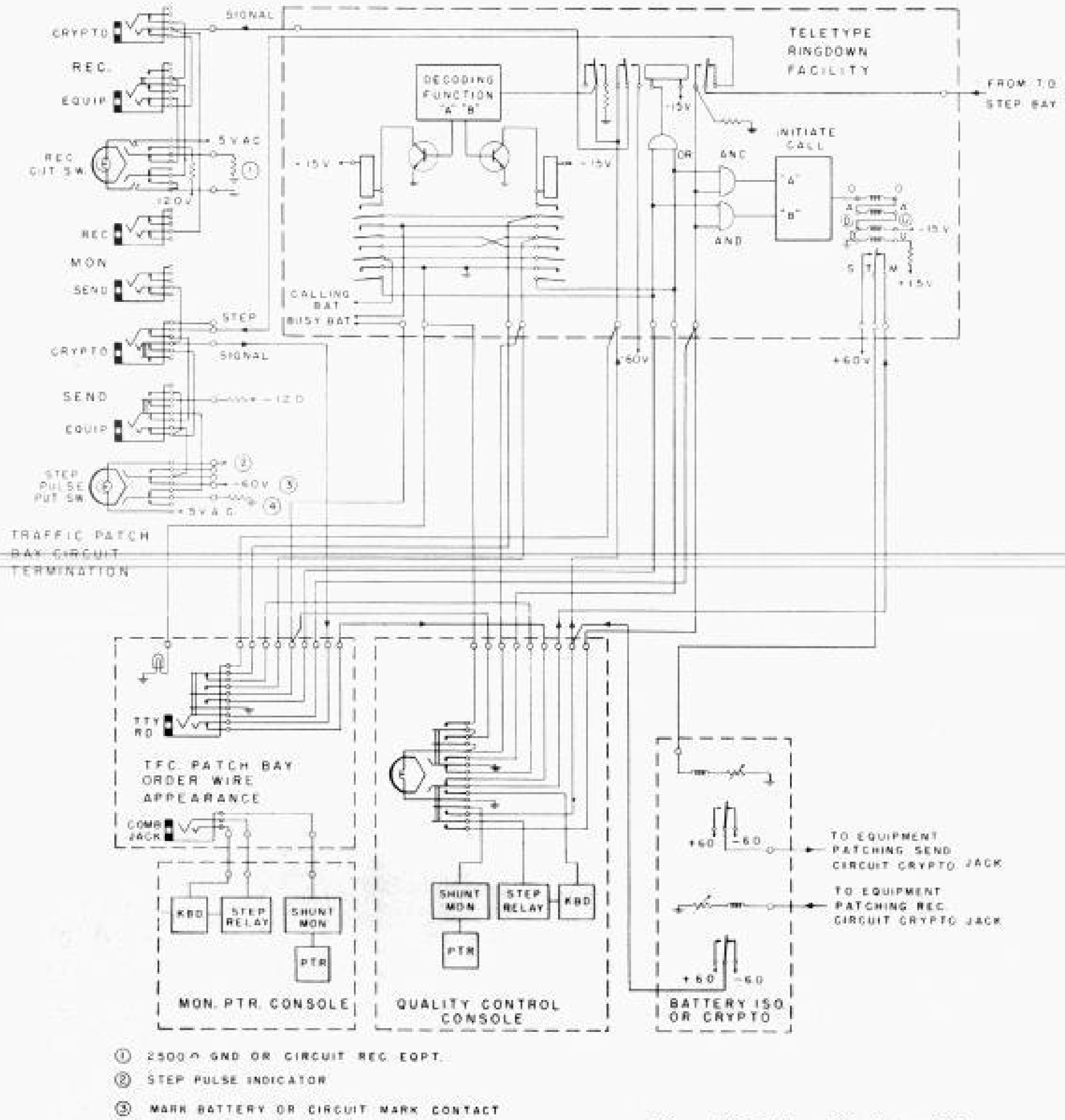


Figure 9. Teletype Ringdown CCT

to be stopped when the order-wire is employed.

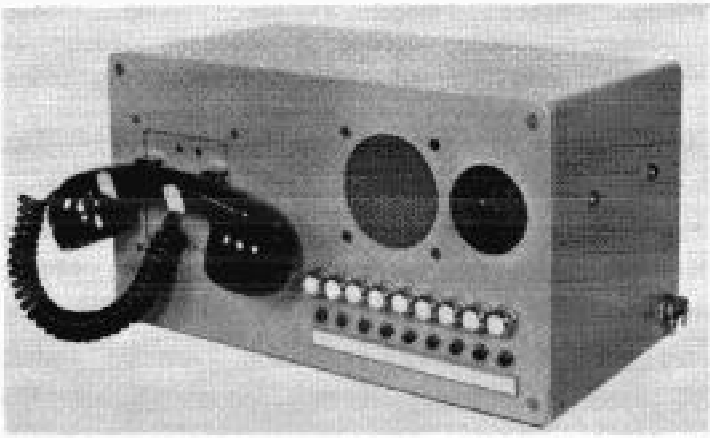
At the receiving teletype order-wire, the Duocal unit is continually monitoring the clear text traffic on the assigned circuit and when the four digits used for either call appear the unit responds. (The coded digits are obviously selected to be least likely to appear in sequence under normal traffic conditions.) The called posi-

and terminates the receiving and sending line, the same as if a call were initiated. However, under these circumstances, the sending position marking battery is interrupted to return the call of the opposite position. This seemingly peculiar return of the opposite call digits is purposely provided to prevent an erroneous answer back by reflection when the order-wire is assigned to a physical duplex circuit and an open condition is encountered on the line. These four digits are printed on the page of the initiating station's printer and that operator is automatically informed that his call has been received and recognized at the distant end. Of course, the received call must be answered by inserting the printer-keyboard patch to the order-wire jack, or depressing the console appearance button and signalling with the keyboard to the initiating operator. The normal order-wire business can now be terminated and the circuit returned to its normal condition by removing the patch or releasing the button. When this is done, the stepper circuit is again returned to its assigned operating position, where receipt of the first step pulse releases the transmitter for the next character in the tape without garbling or an attendant.

It is apparent from this discussion that conversation is only possible between patching positions or console appearances (if normal routine is followed). This is so designed, since it is expected that a traffic patching operator will have to coordinate his work with his counterpart at the distant end to prevent routing circuits to undesirable terminations. Likewise, the controller assigned to the quality control console during the normal performance of his duties will have requests of, and questions for, the console operator at the distant end. The latter has the same type test equipment available to him for the proper determination of circuit condition and acceptability for traffic. It is normally expected that the console operator will be first to use the order-wire, turning the circuit over to traffic patch for remedial patching if necessary, or continuous monitoring when the circumstances require that type of action.

Station Intercommunications

In connection with communicating to correct circuit or apparatus conditions, an intercom system is provided shown on the block diagram at the traffic patch bay and quality control console. For complete usefulness, this intercom system obviously must be carried to other locations as well. In fact the system actually has ten stations. Each station is as shown on Figure 10 except for the quality control console where it is integrated into the design of the console. Additional positions may be connected in parallel (as in the case of the quality control consoles) for the most convenient arrangement.



(Courtesy of North Electric Co.)

Figure 10. Intercom Master Station

The second part of this article* will discuss the equipments located in the Black area, and also the quality control console.

* To be published in April 1962 issue of TECHNICAL REVIEW.

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He was assigned to the Manager of the U.S.A.F. Technical Control project to assist in the design, development and final acceptance of various equipments involved in that program.

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Microwave No-Break Power Units for the New Radio Beam System

PHASE I of the Western Union Transcontinental Radio Beam System has been (and still is) the proving ground for the operation of radio beam equipment to be used on the main beam trunk between Los Angeles and Boston, and some tributaries branching from the main trunk. Phase I is comprised of stations located on seven mountain tops in the Pacific Coastal Range, linking together the two terminal stations, one located at Vandenberg Air Force Base and the other at Sunnyvale, California. While the average air distance between any two adjacent stations in the system is approximately 30 miles, because of intervening terrain, the length of time it takes radio beam supervisors, engineers, and maintainers to travel between two adjacent sites can exceed three hours (a factor of importance in planning maintenance). Since late September 1960, radio beam personnel have been travelling these roads to insure proper operation of the equipment. See Figure 1.

Figure 1. Typical Terrain between Phase I stations

Proper operation of the equipment can be insured only when the voltage to the power supplies of the transmitting equipment is held at a constant value. Commercial power is available at all nine stations but, because of the effects of adverse weather conditions, commercial power at the seven linking mountain stations cannot always be relied upon as can the power at the two terminal stations. Therefore, some emergency source of power must be available at the linking stations.

Should commercial power fail at Vandenberg Air Force Base, emergency power is provided by a source other than Western Union. In the event of a commercial power failure at Sunnyvale, a U. S. Motors Instant Start Emergency Power Unit supplies the needed power to the microwave equipment. At each of the remaining seven stations, however, where commercial power failures are more frequent and of longer duration, two Nordberg No-Break Power Units utilize commercial power to regenerate a continuous and non-varying source of voltage for the critical microwave transmitting equipment as explained below. These power units are called "No-Break" Power Units because the generator output voltage does not change significantly in value. They are of a new design that has never been used before; and are of interest because they will be used on the main radio beam trunk after trial during Phase I.

This article includes the operation and maintenance of these Nordberg No-Break Power Units.

As developed by the Nordberg Manufacturing Company, each unit consists of a Diesel engine coupled to a Kato motor-generator set, by means of an Eaton heavy-duty electromagnetic clutch. The control system of each unit is designed by Automatic Power, Incorporated. The units are designed to furnish power to any critical electric load, such as that used in the transmitting equipment of the radio beam system. Fluctuating voltage, or loss of voltage to the power supplies of the system's transmitting equipment, results in malfunctions in the radio equipment.

The design criteria of the power units must fulfill the following requirements in order to comply with microwave system needs:

1. 117 volts (rms) 60-cycle, single phase output,
2. Power factor corrected to 80 percent,
3. Voltage regulation:
   (Normal) plus or minus 1 percent.
   (During tranfer) in 3 seconds or less—plus or minus 2 percent.
   (During transfer) in 5 seconds or less—plus or minus 1 percent,
4. Minimum instantaneous voltage during transfer—105 volts (rms),
5. Frequency regulation:
   (Normal) plus or minus 2 percent.
   (During transfer) frequency drop not to exceed 6 cycles/sec,
6. Permissable total integrated harmonic content—3 percent-average, 5 percent-maximum,
7. Fifth harmonic rms content shall not exceed 1 percent.

By fulfilling the above requirements the power units serve as a key element in system reliability.

During normal operation of the power units, commercial power, either 3-phase or single phase, drives the motor. On the same shaft is the generator that produces the 117 volts (rms), 60-cycle, single phase, for the transmitting equipment. A 400-pound flywheel is connected to the motor generator set through a flexible coupling. In the event of a failure or a severe drop in commercial line voltage, the motor is disconnected from the line and the magnetic clutch is energized by the controls and connects the flywheel to the engine crankshaft. The kinetic energy stored in the rotating flywheel continues to drive the generator and starts rotation of the engine crankshaft. The engine's fuel rack solenoid is also energized and "full open" throttling takes place. This permits the engine to start and accelerate rapidly to operating speed with a drop in generator frequency of about 6 cycles. The generator is then driven by the engine until commercial power is restored.

Upon restoration of commercial power, the clutch and fuel rack solenoid disengage, thus stopping the engine and reconnecting the motor to the commercial line. The generator output voltage does not change by more than plus or minus 2 percent during these automatic transfers. Theoretically, units can operate unattended on engine drive for periods exceeding 30 days. As two of the stations are manned 24 hours a day, they are never unattended during engine drive. At the other five unmanned sites it has been proven practical to spot check any unit operating on engine drive at intervals, which never exceed 48 hours. Spot checking is considered an important method of detecting trouble in the early stages, trouble that could lead to major engine failures if not noted. For example, recently at Little Coyote Peak, there was a long commercial power failure. The maintainer responsible noted that the unit had developed an abnormal noise and he shut it down. Later inspection proved that the crankshaft nut had worked loose. Had the unit been left unattended and the noise

Figure 2. Torque Wrench used to tighten crankshaft nut

been undetected, a broken crankshaft (with possible damage to the engine block and components) probably would have resulted. Corrective measures as applied to a crankshaft nut are shown in Figure 2.

As an additional safeguard, the No-Break Power Units are installed in pairs; as each normally supplies its own radio beam load. Although the load is thus normally divided equally between the two units, either unit is capable of carrying the total load should the other one fail.

The component parts of the power units are described in detail in the following paragraphs:

I. THE DIESEL ENGINE

(a) The Diesel Engine is a Nordberg Power Chief of one of two sizes, depending upon the rated capacity of the unit. The 15-kw size uses a 3-cylinder Diesel and the 10-kw uses a 2-cylinder Diesel. Both the 15-kw and the 10-kw engines are 4-cycle vertical inline types with a cylinder bore of 4½ inches and a stroke of 5¼ inches. The compression ratio for both is 14.6 to 1. When operating at 1200 rpm, the piston speed is 1050 feet per minute. The total piston displacement is 167 cubic inches for the 10-kw and 250.5 cubic inches for the 15-kw engine. The continuous brake horsepower at 1200 rpm is 20 and 30, for the 10-kw and the 15-kw, respectively. The direction of rotation is counterclockwise when facing the flywheel end. See Figure 3.

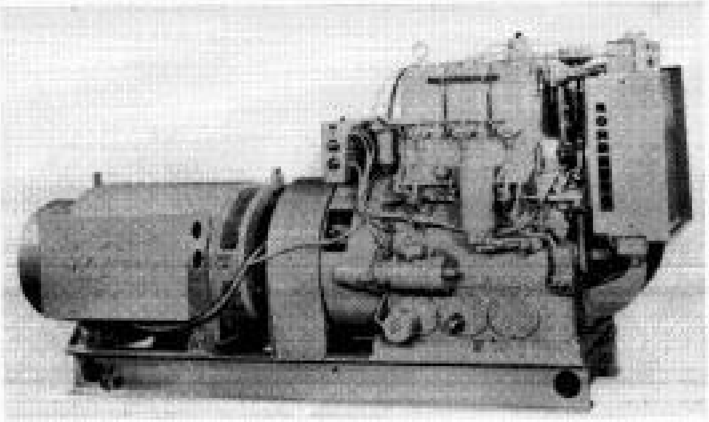


Figure 3. Micro Power Plant, 15 KW, 3 cylinders

(b) The Fuel System of the engine consists of a plunger-type, hand priming pump, a positive displacement gear-fuel transfer pump with a built-in pressure valve, American Bosch APF fuel injection pumps and American Bosch pintle-type fuel injectors, primary and secondary replaceable element fuel filters, of which the filter covers are equipped with a bleeder screw for venting air bubbles from the fuel lines. A variable speed gear-driven mechanical flyball-type governor is used to regulate the engine speed. The engines use No. 2 Diesel fuel oil, which is contained in tanks outside the buildings. These tanks are of two sizes—550 gallons and 1000 gallons. The size of the tank is dependent upon whether the station is a repeater station with a 10-kw unit or a junction station with a 15-kw unit. Junction stations necessarily require the larger size tank.

Repeaters located on the more remote mountain tops are also furnished with the 1000-gallon tanks because of the inconvenience of refueling. Eventually, when repeater stations carry their maximum loads, they will consume 30 gallons per day, the contents of a 550-gallon tank in 18 days, or the contents of a 1000-gallon tank in 33 days. Junction station power units will ultimately consume more than twice as much as repeater units; specifically, they will consume from 60 to 86 gallons per day, or the contents of a 1000-gallon tank in 11 to 16 days.

Fuel flows from these supply tanks into inside 30-gallon "day" tanks as shown in Fig. 4. One of the two day tanks at each station has a gravity-type sight gauge which gives a visual indication of the fuel level in the outside supply tank. From the day tank, the fuel flows to the primary fuel oil filter and then to the fuel transfer pump, the secondary filter, the injector pump, and the injector. Finely atomized fuel oil is injected across the combustion chamber into the energy cell during the compression stroke. The fuel oil is ignited by the heat of the compressed air in the chamber where combustion takes place, thus providing the energy to run the Diesel. Excessive fuel oil, not injected, is returned either to the supply tank or to the injection pump.

(c) The Exhaust System of the engine provides a means of conducting, to the outside atmosphere, the gases left in the piston cylinders after combustion of the fuel oil. During the exhaust stroke, these gases are forced out of the cylinder into the exhaust manifold through the exhaust

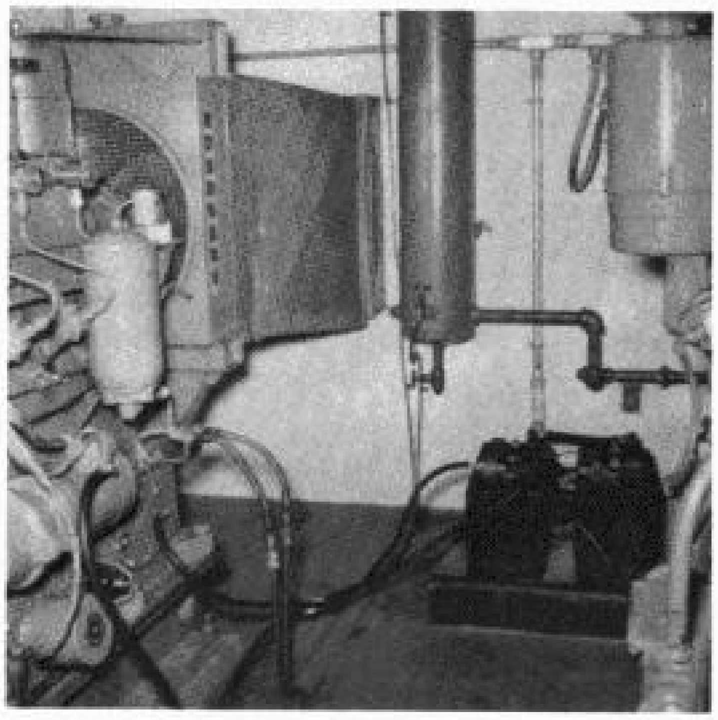


Figure 4. Fuel Oil "Day" Tank and starting batteries

valve. From this point, the gases pass through a vertically mounted 2-1/2-inch flexible pipe for a 10-kw or 3-inch flexible pipe for a 15-kw unit approximately 30 inches in length. Two 45-degree elbows with a 12-inch pipe between them connect the flexible pipe to a 3-inch horizontal pipe. The horizontal pipe goes through the power room wall to the outside of the building, as shown in Figure 5 where it is connected to the exhaust muffler. A vertical pipe, connected to the other end of the muffler and extending above the roof, exhausts the gas fumes into the atmosphere. An umbrella-type hood, fastened to the top of this pipe, helps to prevent rain and snow from entering the exhaust system.

(d) The Oil Lubricating System of the engine has a capacity of 14 quarts for the 2-cylinder Diesel and 20 quarts for the 3-cylinder Diesel. The grade of oil used is SAE 30, type DG, which is well fortified with a rust inhibitor. The oil pressure is maintained at 35 psi by an adjustable relief valve in the filter base and is derived from a gear-type oil pump that is chain driven from the crankshaft. Attached to the oil pump is a floating suction strainer located near the top of the oil level in the base of the Diesel. The oil system has a bypass-type replaceable filter element.

The oil is pumped in two directions, either to the oil filter, which returns it to the oil sump, or through the components, i.e., the camshaft, rocker arms for the valves, main bearings of the crankshaft, the connecting rod bearings, and the piston pins. The oil eventually returns to the oil sump in the base of the engine.

An oil pressure gauge is mounted on the engine box so that the oil pressure may be read and, if necessary, adjusted to the normal operating pressure of 35 psi by the pressure relief valve.

To insure instant starting of the engine in any kind of weather, a 600-watt, 230-volt a-c immersion oil heater is used. It is connected to the base of the engine and keeps the oil at 70 degrees F. The temperature is adjusted to the desired value by a thermostat located on the oil heater.

(e) The Water Cooling System of the engine has a capacity of 20 quarts for the 2-cylinder Diesel and 26 quarts for the 3-cylinder Diesel. An impeller pump pro-

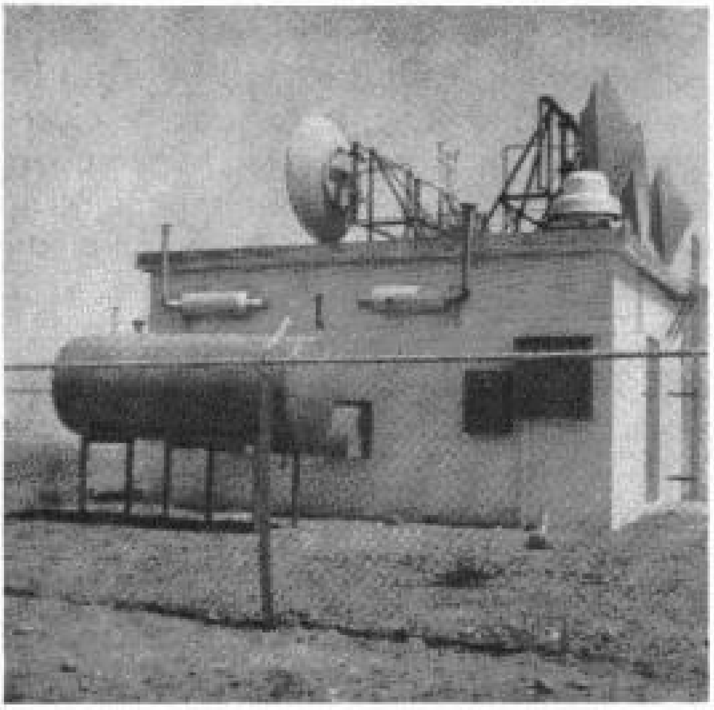


Figure 5. Typical station—Exhauset Pipes and Fuel Tank

vides the circulation and pressurizes the system at 4 psi. A bypass thermostat starts to open at 177-180 degrees F. and fully opens at 202 degrees F. The rate of flow is 15.4 gpm at an engine speed of 1200 rpm. The normal operating temperature of the water, measured at the water manifold, is 180 degrees F. A temperature gauge, mounted on the engine box, indicates the engine temperature. The water is cooled in a fin-and-tube fabricated steel shell radiator. A 4-blade, pusher fan with a capacity of 1735 cfm for the 2-cylinder Diesel and a 6-blade pusher fan with a capacity of 2530 cfm for the 3-cylinder Diesel force air through the radiator, through an air duct, and out of the building. The water pump and fan are connected to a V-belt that is turned by the crankshaft. All cooling systems have antifreeze added to provide the necessary protection against high-altitude cold weather. A 1500-watt, 230-volt a-c, water jacket heater is used to keep the water at about 70 degrees F, while the engine is not running. The thermostat control for the water heater is located on the water manifold.

(f) The Electrical System for the engine uses 12 volts direct current with a negative ground. It is powered by the starting battery or from the generator's d-c power supply. Two 6-volt heavy duty C & D batteries, 189 ampere-hours at a 20-hour rate, are wired in series to provide the necessary power for starting the units. The life expectancy of the batteries is predicted to be from 10 to 20 years, thus making the batteries as reliable as any component used in the power units. This long life expectancy is due to the utilization of calcium hardened lead grids and to the fact that a C & D, Auto Reg silicon battery charger, keeps them fully charged at all times without overcharging.

Initial starting of the unit is accomplished by using a heavy-duty, Bendix-drive, 12-volt starting motor. The starting motor, connected to the flywheel by gears, rotates the crankshaft.

The fuel rack solenoid operates on 12 volts direct current to allow "full open" throttle on initial start until the engine reaches operating speed. At this time, the engine's governor controls the flow of fuel.

II. MOTOR-GENERATOR SET

(a) The basic function of the motor-generator set, manufactured by Kato Engineering Company, is to provide closely regulated continuous power to the microwave radio equipment. The set consists of a generator and motor mounted on a common shaft, a static exciter voltage regulator unit, and a d-c power supply.

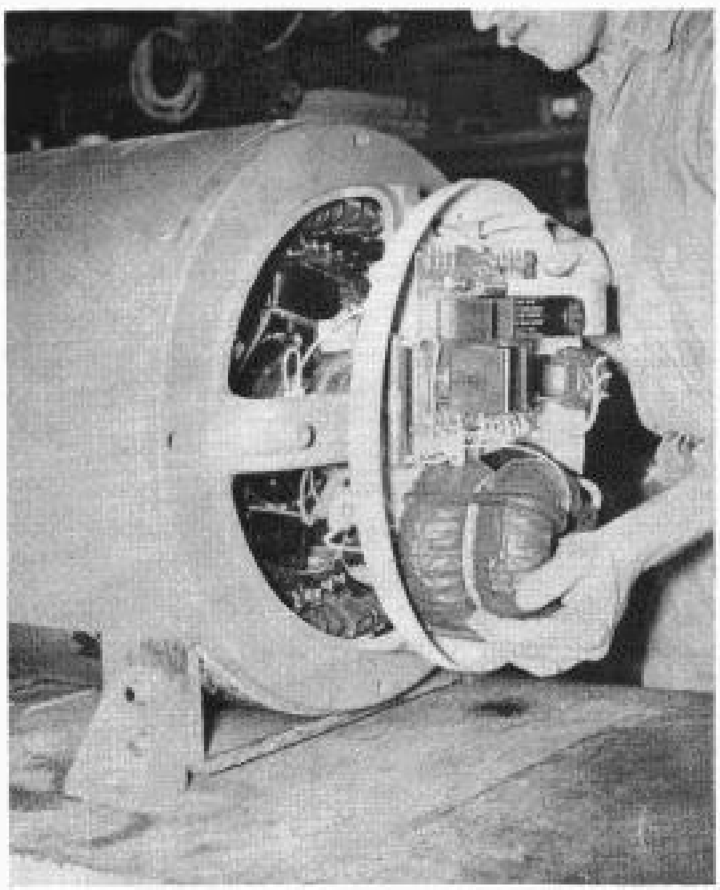
(b) The Motor used in the set is either a single phase or a 3-phase squirrel cage motor. Single-phase motors operate on line voltages between 220 and 240 volts, and 3-phase motors operate on line voltages between 208 and 230 volts. The operating speed of these low-slip, 60-cycle a-c induction motors is always less than synchronous speed; therefore, the generator frequency is always slightly below 60 cycles.

(c) The Generator, either 10-kw or 15-kw, is a 6-polt, alternating current generator that produces 117-volt, 60-cycle alternating current when operating at 1200 rpm. The controlled, rectified current for the generator's rotating field is taken from its stator and applied to the static exciter rectifier. The field current is then conducted to the field through collector rings located at the end of the motor-generator set.

(d) The Static Exciter Voltage Regulator is sometimes called the Magnetic Amplifier because the components in the regulator unit are designed to be used in conjunction with a magnetic amplifier as shown in Figure 6. The magnetic amplifier controls the amount of rectified current in the rotating field of the generator, thereby regulating the output voltage of the generator. The regulator is unique in design in that it has a minimum of components and no moving parts in the regulating portion of the circuit. The static exciter voltage regulator consists of a flashing circuit, a sensing circuit, and a single-stage amplifier circuit.

1. **Flashing Circuit** The field of the generator consists of a laminated core that will not hold residual magnetism when the power unit stops. When starting a power unit from stand-

still by engine drive only, some means must be provided to energize the rotating field of the generator to produce a voltage. This is accomplished by connecting the 12-volt d-c starting battery in series with a single-pole pushbutton switch, a 12-volt current-limiting light bulb, and a blocking rectifier across the generator field. When the engine has reached operating speed, the pushbutton is pressed and direct current energizes the field. Voltage build-up is made more rapid by using the full rectified output voltage of the alternator and applying it directly to the field. When a generator output voltage of approximately 50 percent of full voltage is attained, the K-1 relay energizes and regulation of the output voltage begins.



Courtesy of Kato Engineering Co.

Figure 6. Magnetic Amplifier Assembly

2. **Sensing Circuit** The components of the sensing circuit consist of sensing transformer T-1, a rectifier bridge, Zener diode CR-5, temperature compensating diode CR-6, voltage adjusting potentiometer R-2, current limiting resistors R-3 and R-1, and a filter capacitor C-1 as shown in Figure 7. The function of the sensing circuit is to sense the output voltages and supply current to the control windings of the magnetic amplifier, thereby affecting the field current of the alternator.

The current flow through the control windings is dependent upon the output voltage of the sensing transformer. The sensing transformer is an auto-transformer with hook-up taps on the primary. The secondary voltage may be varied over a considerable range by adjusting the taps on the primary and then it drops off in steps as the primary lead is moved to the higher number.

The secondary voltage fed to the sensing rectifier is varied by potentiometer, R-2, which is connected between X-2 and X-3. The slider of the potentiometer and X-1 are connected to the rectifier bridges. By adjusting the slider, the voltage impressed on the rectifier bridge can be varied from approximately 15- to 25-volts. This d-c voltage is fed to the control windings of the magnetic amplifier through the current limiting resistors, Zener diode, and temperature compensating diode.

Current will not flow in the control windings of the magnetic amplifier until a voltage of 13.4 volts, plus or minus five percent, is impressed across the Zener diode. The voltage of the Zener diode is used as a reference voltage when necessary. Any slight variation in the Zener breakdown voltage, due to temperature, is offset by the temperature compensating diode and the diodes in the sensing bridge.

The temperature characteristic of the sensing circuit causes the voltage to rise slightly as the ambient temperature rises. It is designed specifically to offset the generator voltage sensing relay and the regulator characteristics that cause shut down at high ambient temperatures.

3. **Single-Stage Amplifier Circuit** The amplifying circuit consists of a single-phase magnetic amplifier MA-1 and MA-2, rectifying bridge CR-11, control windings, shunt wire S-1, and resistor R-4. The function of this circuit is to supply controlled, rectified direct current to the alternator field with the aid of the sensing circuit and to regulate the generator's output voltage during automatic transfer from either motor to engine drive or from engine drive to motor and during load changes.

The direct current for the rotating field is rectified from the alternating current of the alternator by the rectifiers of the bridge CR-11. Pulsating direct current is fed to the gate winding and feed-back windings of the magnetic amplifier to the field. The magnetism of the cores of the magnetic amplifier determines the amount of current that can flow in the field. The amount of current flow in the field is controlled in the following manner:

If the cores of the magnetic amplifier MA-1 and MA-2 are not saturated with magnetism, any increase of current in the gate windings will increase the magnetism in the cores. The changing magnetism in the cores generates a counter electromotive force (counter emf) in the windings and this (counter emf) resists any change in current flow. As current continues to flow in the windings, magnetism increases to the point at which the cores become saturated. At saturation, no more magnetism will be induced in the cores, no

Maximum current flow in the field is not desired because regulation of the generator output voltage could not be attained if a continuous and constant current existed in the field. The current in the control winding opposes the magnetizing effect of the current in the gate winding. During the half cycle in which the gate windings do not conduct, the control winding resets the magnetism of the core to a point below saturation.

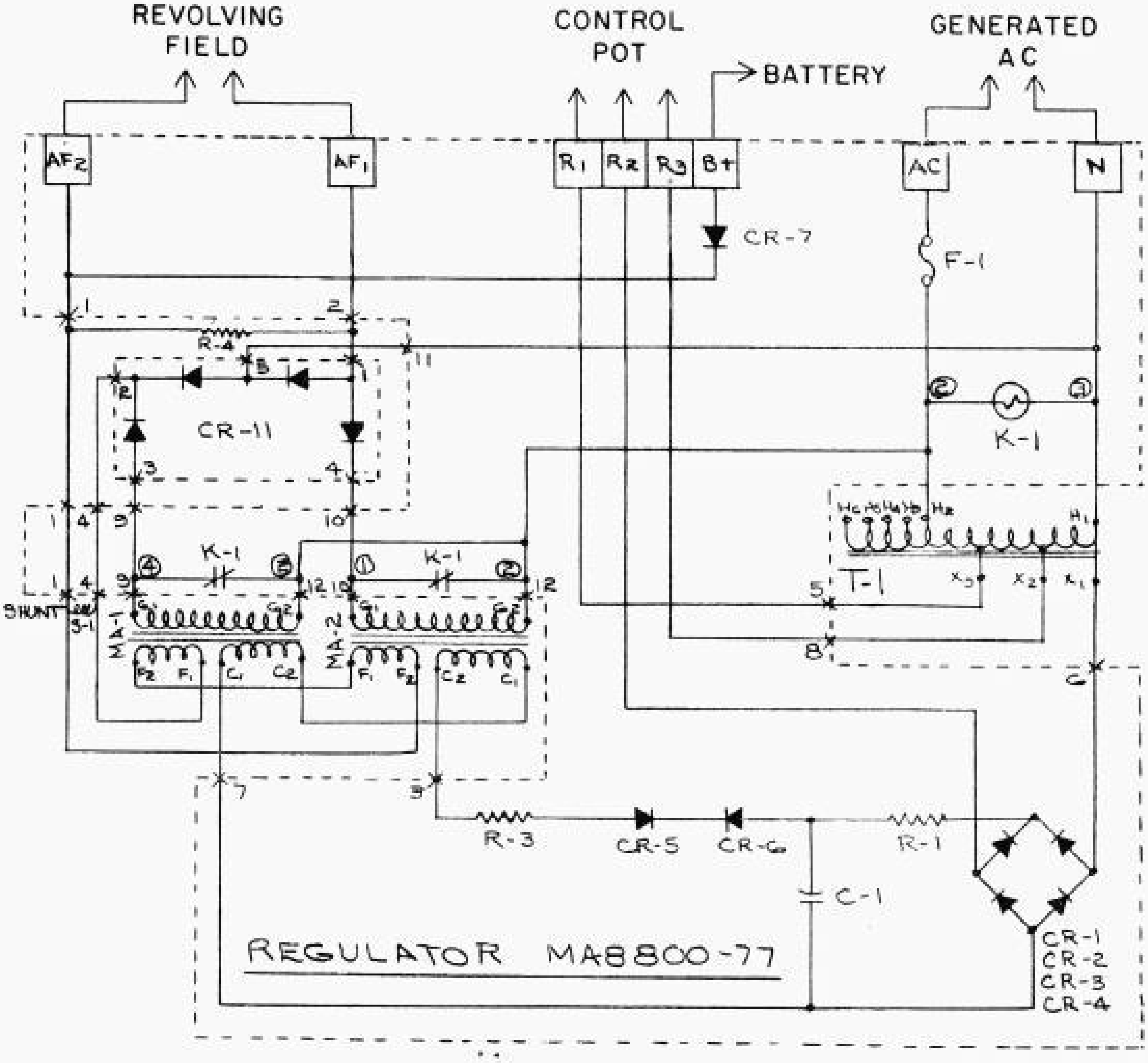


Figure 7. Wiring Diagram of static exciter and Magnetic Amplifier Regulator

counter emf is generated, and maximum current flow takes place. The inductive reactance of the cores becomes zero with the only impeding force to the current flow being in the wire and in the impedance of the field.

When the magnetic amplifier cores are saturated, each core conducts on opposite half cycles. During the half cycle in which the cores are not conducting, they are held at saturation by the blocking effect of the CR-11 rectifiers.

The gate winding current cannot conduct maximum current until the core is saturated again. The time it takes to saturate the core again depends on the point at which the magnetism of the core was reset and the voltage impressed or the voltage times time to reach saturation. The length of time the gate windings conduct depends upon the amount of current flowing in the control windings to reset the magnetism in the cores. Therefore, the more current that flows in the control windings, the less the current that will flow in the gate winding.

The feed-back windings and field are in series and connected across the output of the gate windings. The feed-back windings are positive feed back and use part of the output of the magnetic amplifier to help the gate windings saturate the cores. Since the feed-back windings are in series on each core, they oppose the demagnetizing effect of the control windings at all times and, therefore, aid in the control of the field current.

Shunt wire, S-1, is connected in parallel with the feed-back winding and shunts part of the current in the field around the feed-back winding and lessens its effectiveness; the length of the shunt determines its effectiveness as a means of control. A long shunt, having more resistance, tends to overcompound the generator, that is, it gains voltage as the load is increased. Shortening the shunt will undercompound the generator, that is, it loses voltage as the load is increased. A "flat compounded" generator holds the voltages constant as the load is increased, by changing the length of the shunt. A properly compounded generator gains about 2 to 3 volts as the power unit is shut down.

Resistor, R-4, is a pure resistor and is connected across the field. It serves to bypass any spikes that might appear in the field current. A spike, a sharp increase in d-c voltage for momentary periods, reacts as alternating current to the inductive reactance of the d-c field windings and is choked back by the field impedance.

To review again briefly, the control the static exciter regulator has on the alternator voltage, assume that the field has been flashed. This builds up the magnetism in the field that causes the alternator to generate a-c voltage. The a-c voltage is rectified by CR-11 and is fed directly to the field, bypassing the gate windings by the closed contacts of K-1.

Relay K-1 energizes when about 50 percent of the full output voltage of the alternator is reached. Then current flowing in the gate windings saturates the cores. When the cores are magnetized, maximum current can flow in the field. The alternator voltage will build up rapidly since there is no current in the control windings at this time.

The sensing transformer, T-1, and the voltage-adjust potentiometer control the terminal voltage and feed it to the sensing rectifiers. An open circuit exists in the sensing circuit until the Zener diode break-down voltage is reached. Then current flows in the control windings of the magnetic amplifier. This current, controlled by the voltage-adjust potentiometer and limiting resistors, R-3 and R-1, and filtered by capacitor, C-1, resets the magnetism of the cores.

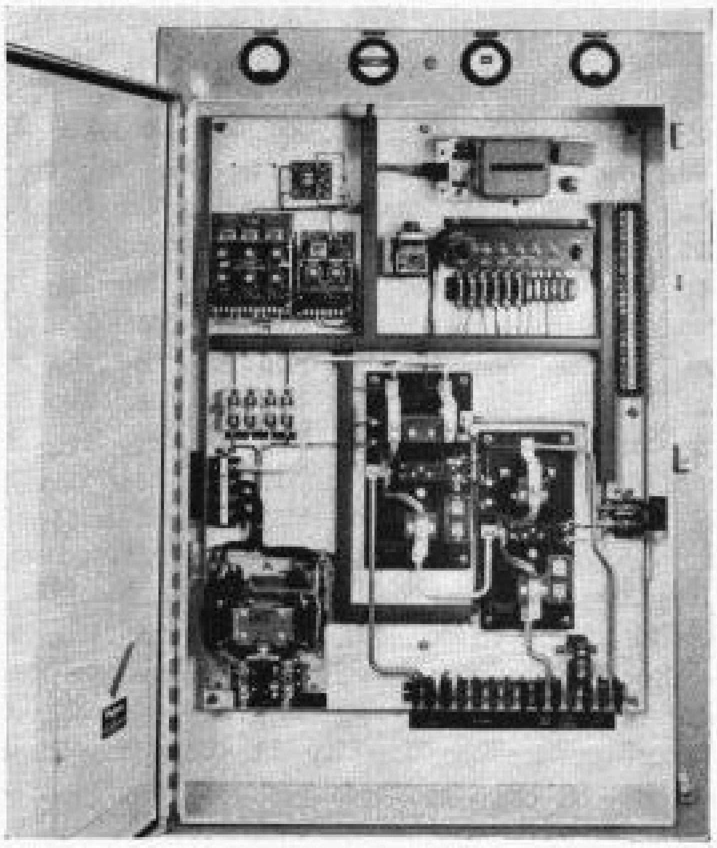
Resetting of the magnetism in the cores reduces the flow of current from the magnetic amplifier through the feed-back winding and shunt to the rotating field, thus reducing the alternator voltage to a point where a balance is reached. The voltage ratio of transformer, T-1, is determined by the setting of the potentiometer; this setting plus the resistance value of the shunt determine the output voltage of the generator.

III. THE CONTROL SYSTEM

The operation of the power unit is controlled by the control system designed by Automatic Power, Incorporated. The main control switches are located in wall-mounted NEMA 12 dust-type control cabinet directly behind the motor-generator set as shown in Figure 8. A full-size hinge door swings out to provide ease of maintenance of all components. These components are bolt-threaded into the 12-gauge steel panel and each is readily removable from the front. Stud-type terminals with locknuts are used to make the power connections. To insure excellent electrical contact, the current-carrying portion of the terminal is a silver-plated copper strip. The wiring is color-coded, and all connections are clearly marked or numbered for ease in servicing. A wireway is provided along each side and above the bottom of the panel for ease in wiring. The components and their associated circuitry, shown in Figure 9, serve the power units in the following manner:

1. Enable initial starting of Diesel by an operator,
2. Enable the operator to flash the generator field, which produces an output voltage,
3. Enable the operator to meter the generator and available commercial line voltage,
4. Provide for either manual or automatic transfer of the unit to motor drive if commercial power is available, and automatic transfer back to Diesel if line voltage is not within the proper operating range of the motor,

5. Provide for either manual or automatic transfer of the load from one unit to the other in case one unit should fail,



Courtesy of Automatic Power, Inc.

Figure 8. Wall-Mounted Control Cabinet

6. Provide for manual and automatic transfer of the load to available commercial single-phase power in the event both units should fail,
7. Provide for automatic shut-down of the unit when on engine because of low oil pressure, high cooling-water temperature, or overspeed,
8. Provide for automatic shut-down of the unit when on either engine or motor drive if the generator output voltage is not within proper operating range for the load,
9. Provide automatic visual indication by annunciator flag should the unit be shut down for any of the four reasons listed in 7 and 8 above,
10. Provide visual indication, by frequency meter, of generator and commercial frequency,
11. Provide for automatic metering of the number of hours the engine has run,
12. Provide for automatic metering of amperes fed by unit to load.

A brief description of the components in the control system is a necessary aid to understanding their functions in the total operation of the power units.

(a) THE MAGNETIC MOTOR CONTACTOR, MC, with its associated contacts, time-delay relay, and commercial line voltage sensing relays serves to connect and disconnect the commercial power, and the motor. If commercial power fails, the contactor opens and its auxiliary engine starting contacts, ESC, close to engage the clutch relay and fuel rack solenoid and start the engine instantaneously. The louver control, LC, auxiliary contact is open and the air intake and exhaust louvers open.

The other auxiliary contact is the hour control contact for the engine hour meter. This hour meter registers the total hours run while the unit is on engine drive. When commercial power is restored, the magnetic motor contactor closes after a suitable time delay and returns the unit to motor and stops the engine.

(b) THE PRIMARY TRANSFER SWITCH, PC, transfers the load of one generator to the opposite generator in the event a failure occurs in a unit. The coil of the transfer switch is energized through contact P-3 of the pilot relay. (Note: Contact P-3 is omitted in 10-kw units.) The coil of the

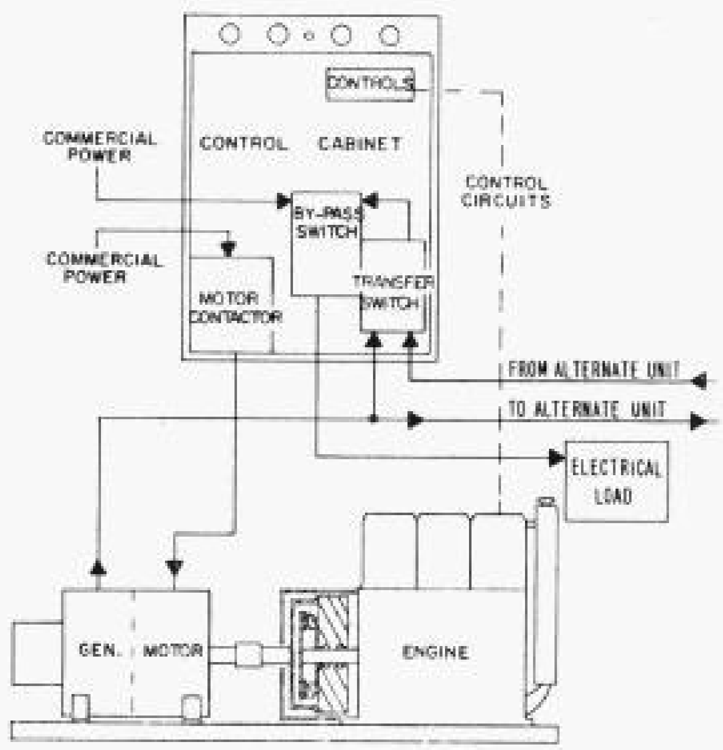


Figure 9. Description Diagram—Instant start Micro Power Units

pilot relay, P, is in series with the auxiliary contact, VG, of the generator voltage sensing relay, and opens whenever the generator voltage is above or below the range set by the generator voltage sensing relays. When the VG and the P relays are energized, the primary transfer switch is closed, and its auxiliary switch closes the circuit for the bypass relay, BR. Contacts, BR-1 and BR-2, control the operation of the bypass switch and will be open. Contact, BR-3, monitors the position of the transfer switch and indicates an alarm via the alarm system of the transmitting equipment to the control station. This reports an abnormal power unit condition at an unattended station.

(c) The Automatic Bypass Switch operates when both power units have failed. This connects the available single-phase commercial power to the radio load. The operating coil of the automatic by-pass switch is connected in series with the contacts of the by-pass relays of both units.

(d) Panel Switches. Five panel switches are located directly below the d-c control panel and are used to operate the unit manually. The normal position for the switches is DOWN and if one or more is left in the UP position a panel indicator lamp, located at the top of the control cabinet, will light. A check of this indicator lamp should be the last check made before leaving a station.

From left to right on the above panel switchboard, the first panel switch is the Manual START Switch. When the switch is in the START position, it removes the d-c voltage to the failure circuit of the d-c control panel. The switch should always be in the START position whenever starting the unit and should be returned to the DOWN position after the unit has been started and is generating normal voltage.

An Engine Safe Switch, located next to the manual start switch, opens the circuit to the clutch relay, CR, and the fuel rack solenoid when in the Safe, UP, position. This allows maintenance to be performed on the engine without the danger of its starting.

The Commercial Power Test Switch is in the magnetic contactor circuit and when it is in an UP position has the same effect as a commercial power failure, thereby engaging the magnetic clutch relay and the fuel rack solenoid and starting the Diesel. When in the normal, DOWN, position, the time-delay relay energizes and automatically transfers back to motor drive as soon as the set time delay expires.

The Primary Test Switch serves to remove the generator voltage to the coil of the primary transfer switch when in the test, UP, position. This de-energizes the primary transfer switch and switches the load to the other unit.

The extreme right-hand panel switch is the Bypass Test Switch and connects the coil of the bypass switch to commercial single-phase power when in the test, UP, position.

The Time Delay Relay, located to the left of the panel switches, serves to delay the return to commercial power for a period of 12 to 15 minutes. This delay time is provided to insure that the commercial line voltage is stable and, also, to enable the engine to reach normal operating temperature, which eliminates condensation in the engine. The time delay period is adjustable by turning the blue cap from zero to A, B, C, for increasing the delay. Since the markings are only approximate, actual timing must be done after the relay coil is energized. To accomplish this, commercial voltage must be available and the unit must be operating on Diesel drive. All panel switches must be in the NORMAL position except the commercial test switch. Timing of the relay starts when the commercial test switch is put in the DOWN position and ends when the unit goes to motor drive. The time delay relays of the power units at each station should be set 2 or 3 minutes apart to avoid having both units come on the line at the same time. The auxiliary contact, TD-2, of the time-delay relay is connected to the transmitting fault system and indicates a fault, which is detected by the control stations, whenever the TD relay is not energized.

(e) The DC Control Panel, located in the upper right corner of the control cabinet, contains the failure or FX relay, FX reset button, F relay, annunciator system, and oil failure timer relay. All electrical connections are made through a multiconductor quick connector, male plug on panel and female socket on the cable to the panel. The function of the d-c control panel is to monitor the four failure conditions of the power unit and to shut it down in case one or more unwanted conditions exist. The four failures monitored are:

1. Low or high generator voltage outside the range of 107-125 volts.
2. High engine water temperature above 205-210 degrees F.
3. Low engine oil pressure below 6-10 psig.
4. Engine overspeed above 1320-1380 rpm.

Power to the different failure circuits is supplied from either the 12-volt d-c power supplies or from the starting battery during initial start. When a failed condition exists, a ground is applied through the sensing element to the failure circuit. This energizes the FX and F relays, which are wired in parallel, and at the same time activates the appropriate annunciator, which drops its flag. Each annunciator has an isolating diode that prevents more than one drop from being energized when only one failed condition exists. If two failed conditions exist, such as low oil and low or high voltage, both annunciator flags will drop. The F relay has a paralleling capacitor that delays its action until after the FX relay has latched in the failed position. Contact, F, then removes the voltage to the failure circuit and limits the current drain of the d-c controls in the failed positions to less than 10 milliamperes. Thus, the FX coil is de-energized in the failed condition.

When the FX relay is latched in the failed condition, contact FX-1 is opened and this opens the circuit to the magnetic clutch relay, CR, fuel rack solenoid, and oil failure timer, OFT, which prevents the engine from starting. Contact FX-2 is also open and removes the ground of the generator voltage sensing unit causing its relays to de-energize. This, in turn, opens the circuit of the pilot relay, P, which removes the ground of the primary transfer switch, PC. When the primary transfer switch de-energizes, the load is transferred to the other unit and its auxiliary contact opens the circuit of the bypass relay, BR. When the pilot relay de-energizes, its auxiliary contact P-2 opens the circuit of the time-delay relay, TD; when the time-delay relay de-energizes, its auxiliary contact, TD-1, opens the circuit of the magnetic motor contactor, MC. The magnetic motor contactor de-energizes and removes the line voltage from the motor, thereby stopping the unit.

If both units fail, both bypass switches will be energized by the BR-1 and BR-2 contacts of both units. This will supply the load with whatever single phase commercial power is available.

To reset the d-c controls, the manual START switch must be in the START position and d-c voltage must be available from either the battery or other unit. By momentarily depressing the reset button, located on the face of the d-c control panel, the circuit to the 12-volt d-c reset coil of the FX relay is closed and latches the failure relay in the reset position. That is, the FX-1 and FX-2 contacts are closed and the FX is de-energized.

To clear the annunciator flags, the plunger on the bottom of the annunciator assembly is tapped.

(f) The Oil Failure Timer is a plug-in relay and has a time delay of approximately 10 seconds. This delay keeps the oil pressure failure from indicating a false failure during the first few seconds required to start the engine.

(g) The Meter Panel Assembly, located at the top of the control cabinet, consists of a voltmeter, ammeter, frequency meter, and engine running hour meter. A voltmeter tap switch, mounted on the panel switch assembly, is used to read generator and line voltages.

(h) The Generator Voltage Adjustment rheostat is located on the extreme right side of the panel switch assembly. This varies the generator voltage from approximately 100 to 130 volts.

(i) The Generator Voltage Sensing Relay Unit, as shown in Figure 10, is located to the left of the time-delay relay and directly below the pilot relay. The unit employs a transistor circuit to amplify the voltage error signal to trigger the undervoltage and overvoltage sensing relays. A Zener diode is used as an actual voltage reference and the circuits are temperature compensated. The contacts of the two plug-in sensing relays are in series. Should the voltage exceed 125, the overvoltage sensing relay will energize and its contacts will open. If the voltage should drop below 107, the undervoltage relay will de-energize and its contacts will open. The input connections to the generator voltage sensing unit should be connected to the zero to 115-volt connections. To adjust the generator voltage sensing relays, first, the primary transfer switch must be placed in the TEST position and the normal START switch in the START position; then, the commercial power TEST switch must be placed in the TEST position. A calibrated Weston voltmeter, model 433, accurate to 1 percent, is used to check the generator output voltage measured at the generator input to the control cabinet. This reading should correspond to the control panel voltmeter. If a discrepancy occurs, the panel voltmeter must be adjusted to the proper value by its adjusting screw, which is located at the bottom of the meter.

Figure 10. Checking Voltage sensing Relays

As a check for the voltage range, the generator voltage rheostat can be varied to insure that the voltage range is between 100 and 130. If the voltage falls outside this range, the taps on the autotransformer, T-1, in the voltage regulator circuit can be varied to obtain the desired range. Next, the voltage must be varied through the range and the pick-up and drop-out values of the undervoltage and overvoltage relays must be observed. These can be observed either by placing the fingers on the plastic covers of the plug-in relays and feeling the relays pick up and drop out, or by listening to the clicking noise of the relays as they pick up and drop out. The desired pick-up voltage on the undervoltage relay is 112 volts and the drop out should be set at 107 volts. The overvoltage relay pick-up voltage should be set at 125 volts. Its drop-out voltage should be set at 104. Should adjustment be necessary, the locknut on the pick-up and drop-out potentiometer for both relays can be loosened; then, the potentiometer can be adjusted to the desired values and the locknuts retightened.

A final recheck should be made of the entire operation of the generator sensing relays. To do this, the generator voltage is reduced to its lowest value, then, the voltage is slowly increased. Then, the voltage is decreased and the drop-out values of both relays are observed. Accurate adjustment of these relays is essential for continued operation of the power units. Incorrect setting of the sensing relays causes units to shut down when automatic transfer from motor to Diesel and back again occurs.

(j) THE COMMERCIAL LINE VOLTAGE SENSING RELAYS are located directly to the left of the generator sensing unit. The unit utilizes the same circuitry as the generator sensing unit, except that the units have either a single sensing circuit or three sensing circuits for either single-phase or three-phase commercial power. The 0 — 208-volt input terminal connections are used for three-phase power and the 0 — 240-volt input terminal connections for single-phase power. To adjust the commercial line voltage relay, first, the unit must be shut down completely. Then, commercial power to the unit is disconnected. Next, the oil base and water jacket heater units are isolated to prevent overloading the variable voltage source. A variable voltage source is then connected to the input lead from the auxiliary unit. The auxiliary furnishes voltage to the control cabinet of the unit that is shut down. This furnishes a constant voltage to the variable voltage source. The output leads are then connected to the appropriate input terminal connections of the individual sensing circuits. The values of the pick-up and drop-out settings should be 95 percent and 90 percent of the line voltage. The drop-out setting may be reduced, depending on commercial voltage fluctuation.

If commercial voltage is noted to fluctuate near the drop-out voltage setting, it may be reduced below 90 percent to eliminate unnecessary transfer from motor to Diesel and vice versa, due to momentary drops in commercial line voltage. By varying the rheostat on the variable voltage source, checking and adjusting of the relays is accomplished in the same manner as checking and adjusting of the generator sensing relays. However, for three-phase units the pick-up and drop-out values for the relays should be as nearly the same as possible. If difficulty is encountered in setting three-phase units at the same value, it is recommended that one relay be set at the desired values and the other two relays be set 2 or 3 volts lower for the pick-up and drop-out values. After the relays have been set and checked, the unit is returned to normal operation.

IV. THE COUPLING ASSEMBLY

The coupling assembly serves to connect the engine and motor-generator set together during engine drive and to disconnect them while the power unit is operating on motor drive. The main parts used in the coupling assembly consist of the following:

1. Flexible coupling hub connected to the common shaft of the M-G set at the motor end,
2. Coupling disk connected to the flexible coupling hub,
3. Flexible coupling adapter connected to the above and to a 400-pound flywheel,
4. Flywheel, which rotates on roller bearings,
5. Magnetic clutch field connected to the flywheel,
6. Magnetic clutch armature,
7. Armature adjusting plate connected to the above by means of four springs,
8. Browning bushing connected to the armature adjusting plate,
9. Waldron coupling connected to the magnetic clutch armature,
10. Stub shaft connected to the Waldron coupling by pressure fit; produced by Browning bushing. A step key is employed to keep Browning bushing, Waldron coupling, and stub shaft from slipping,
11. Adapter hub is connected to the stub shaft. The flywheel bearings are mounted on the adapter hub,
12. Crankshaft nut connects the adapter hub to the engine crankshaft. A key element is used to prevent slippage between the crankshaft and the adapter hub.

The two parts of prime importance in performing the connection and disconnection between the engine and motor-generator set are the magnetic clutch and the Waldron coupling. When direct current flows in the field of the magnetic clutch, its armature is pulled towards the field by magnetic force, and connection between the engine and M-G is accomplished. If current is removed from the field, the armature is pulled away from the field by the four springs located on the armature adapting plate.

Movement of the magnetic clutch armature is achieved by the Waldron coupling. The gears of the Waldron coupling allow only horizontal movement between its gear hub and male sleeve, as mounted in the coupling assembly. The male sleeve is connected to the armature and therefore must move freely. If the tension of the springs is not even, and if the four adjusting screws on the armature adjusting plate are not all set properly, binding between the Waldron coupling gear hub and male sleeve occurs. This prevents the armature from being pulled free from the field and, if not corrected, can cause damage.

To illustrate, assume that commercial

power fails, the magnetic clutch engages, and Diesel drive takes over. When commercial power returns and is applied again to the motor, the magnetic clutch will disengage. However, if the Waldron coupling should bind, the armature and the field might remain in contact. Since the field is rotating and the armature has stopped, a great deal of heat will be created by friction. Excessive wear at the contact point will develop and other parts might be damaged. To protect the units at unmanned stations so that this will not happen, the operation of the magnetic clutch must be checked. This can be accomplished by shifting from motor to engine several times, or by shutting the unit down and engaging the clutch by switching the battery switch ON and OFF several times.

OPERATION

From the start-up of the first unit to the present time, important facts have been noted concerning the NORMAL (on motor) and ABNORMAL (on engine drive) operation of the power units. During the testing period and early months of operation, not all sites were furnished with commercial power or with power units. Portable emergency power units had been used at San Benito and Cedar Canyon until the power units and the commercial power were installed and were available. The other stations, operating on Diesel, also had utilized the availability of the portable, emergency power units until commercial power was installed at the sites. The power units are installed and operating at the following seven sites:

1. Plowshare—Two 15-kw units, 3-phase commercial power.
2. Cedar Canyon—Two 10-kw units, single-phase commercial power.
3. Table Mountain—Two 10-kw units, 3-phase commercial power.
4. San Benito Mountain—Two 10-kw units, single-phase commercial power.
5. Call Mountain—Two 10-kw units, 3-phase commercial power.
6. Hollister—Two 15-kw units, single-phase commercial power.
7. Little Coyote Peak—Two 15-kw units, 3-phase commercial power.

It was during the period in which the units were operating on Diesel, that imperfections began to show up and corrections had to be made. Each time there was trouble, the tedious work of finding the cause and ultimately the solution, began.

Several of the first troubles proved to be the result of excessive vibration which were caused by improper leveling and grouting of the units during installation. As the power units use either 2- or 3-cylinder Diesel engines and cannot be spring mounted because of the uneven rhythm of power strokes of the engine, the units are bolted to a rigid subbase that is bolted to a solid foundation underneath the floor. In this way, any vibration caused by the units is distributed throughout the building. It was found that none of the first few units installed in this way were leveled and grouted properly.

MAINTENANCE

Although maintenance of the units is not excessive because of excellent design, some required maintenance must be performed. Maintenance of the control system consists of checking all switches to insure that the power units operate properly. This check should be conducted at least once a month.

Maintenance on the motor-generator set is limited, primarily, to checking the operation of the two sealed ball bearings, mounted on the common shaft of the motor generator. This check is made by listening to the noise while the unit is motoring. While the life expectancy of the bearings is approximately 10,000 hours, and while it is recommended that they be changed once a year. experience has indicated, thus far, that a life expectancy many times 10,000 hours may be expected.

The handling of the motor-generator set is facilitated by an overhead rolling beam and hand chain hoist shown in Figure 11.

Engine maintenance requires that the governor linkage and fuel rack solenoid shifter bearings be oiled every month. Once a month the fan belt deflection should be checked, and all external nuts and attachments should be checked and tightened. The oil and its filter should be changed at the end of 500 running hours, or once a year. Oil pressure and water temperature should be checked any time that a maintainer is present and the power unit is on engine drive.

The operation of the coupling assembly should be observed during maintenance checks of the control system. Any improper operation or any operation causing excessive noise should be noted and corrected immediately. The flywheel bearings should be greased every four months; the Waldron couplings should be greased once a year.

It is very basic and extremely important to good maintenance that a supply of clean rags be available to be used to keep the units clean.

Disassembly of the motor-generator set from the engine, and disassembly of the engine to check for trouble, is a two-man job. Precision measurements of crankshaft deflections during assembly of main components will determine the amount of maintenance that will be required later.

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The Nordberg No-Break Power Units have performed satisfactorily during many cases of commercial power failure. They have fulfilled the function of generating a continuous and non-varying voltage during operation. The motor-generator set and the engine are of excellent design, but the coupling assembly apparently is the weak point of the unit and may need some further modification in order to assure sufficiently reliable operation.

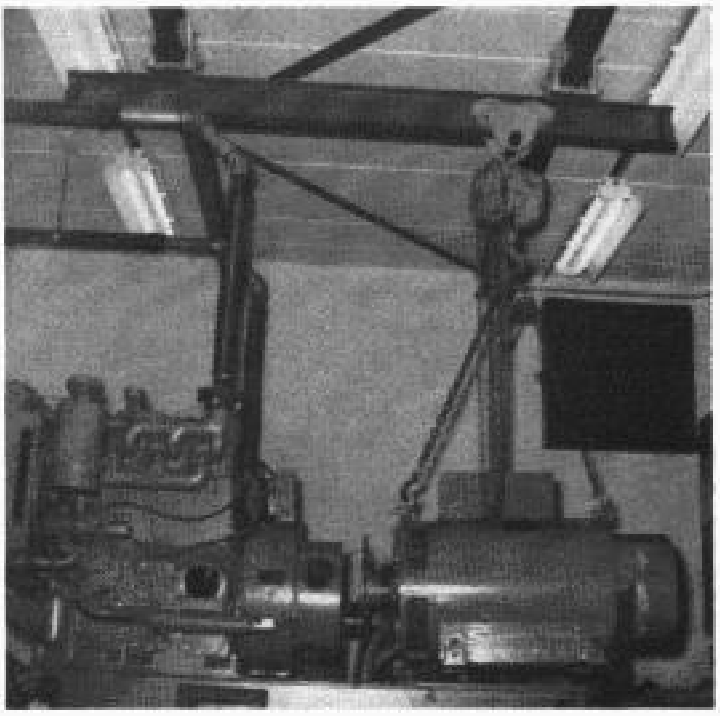

Figure 11. Removing the Motor-Generator for Repair

After working closely with Phase I, it is the author's opinion that the unit will continue to assure a satisfactory power supply as long as the required maintenance is performed.

Charles G. Ernst received his degree of Bachelor of Science in Electrical Engineering from the University of Missouri in January, 1960. Previously he served with the U. S. Air Force during the Korean Conflict. He joined Western Union as a field engineer in the Oakland area and was assigned to Phase I of the Radio Beam expansion program. It was during the first year of this project he was associated with the operation of the Nordberg Microwave No-Break Power Units. He is a member of I. R. E.

Telecommunication Literature

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Electric Contacts, by Ragnar Holm, Ph.D., published by Almquist & Wilksells, Stockholm 1946, (398 pages).

It is one of the standard works in the field of electric contacts.

This book is an English translation of a revised edition of the author's "Die technishe Physik der elektrischen Kontakte" (The physics of electrical contacts) first published in Germany in 1941. The scope of the book is indicated by its subdivisions; Part I — Stationary Contacts, Part II — Sliding Contacts, Part III — Electric Phenomena in Switching Contacts and Part IV—History.

One area which the author covers fully, is the topic of tarnish films on contacts. Starting with a general survey of tarnish films, the author proceeds to consider the theory of tarnishing, properties of films on contacts, and the conduction of electricity through films of varying thickness. The section on conduction by "coherer action through tarnish films in metal contacts," is especially informative. The theory of contact arcing and methods of suppression are covered in great detail.

The research worker in the field will find a good theoretical treatment of electric contact problems, as well as an abundant list of literature references. Although the practical designer may not readily find specific design information in this book, he will have a better understanding of the subject of electric contacts if he studies this volume.

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Electric Contacts Handbook, by Ragnar Holm, Ph.D. Third Edition, published by Springer-Verlag, Berlin, 1958, (522 Pages).

This book is the most recent revision of the earlier work reviewed above. The appendices have been increased and expanded as compared with the previous edition. Anyone concerned with the physics of contacts will find the physical theories of hardness, electronic conduction in solids, tunnel effect, structure of carbons, thick film lubrication, fundamental formulae concerning the electric discharge, general theory of relay arcs, etc., to be covered quite thoroughly in the enlarged appendices.

The author covers the topic of contacts in the modern technical electronic field of semiconductors and transistors. The case of contact between metal and semiconductor and the rectification property is dealt with in a detailed treatment.

— J. J.

McManus, Project Engineer, Switching Division, Research and Engineering Dept.

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These books are available in the Western Union Library, New York.

Patents Recently Issued to Western Union

Patron's Tie-Line Reperforation and Top-Line Signal Generating System

F. L. CURRIE, G. G. LIGHT, E. J. BOIVIN, F. T. TURNER, A. E. HILDRETH, JR.
2,998,478—AUGUST 29, 1961

A system for automatically generating and adding the necessary top-line information comprising origin, destination, sequence number, time, date, and other identification and accounting information to messages incoming from private line patrons through a manual printer concentrator. In accordance with regular concentrator practice, the patron calls, the central office operator inserts a cord circuit and the patron's printer motor starts. The patron then sends the area destination code and a SPACE and the cord circuit, after reading these characters, seizes equipment which generates the remainder of the top-line information and sends it both to the cord circuit printer-perforator and to the patron. Next the patron sends the message followed by an end of message code. The cord circuit then sends a series of line feeds, releases and, unless a new message starts promptly, disconnects the tie-line and lights a disconnect lamp at the turret. The signal generator embodies a matrix of cold cathode tubes.

Drive Pulse Generator for Providing Different Selectable Frequencies

W. D. CANNON
2,998,576—AUGUST 29, 1961

The method of stabilizing a vibrating fork-tuned amplifier combination wherein the feedback to the fork drive coil consists of short sharp pulses which then leave the coil circuit virtually open circuited so that for the remainder of the cycle the fork vibrates at its natural period independently of external influences. By adjustment of the amplifier tuning condenser the phase of the feedback pulse can be varied to provide a slight "pulling" of the fork frequency, when desired. The fork may operate into a frequency divider circuit to produce a base frequency from which a series of both odd and even harmonics may be derived. Selection of harmonics is by a three-gang switch which makes a selection among original, or odd or even harmonic frequencies in conjunction with tuning of an active null filter to suppress all but the desired frequency.

Telegraph System

F. L. CURRIE
3,001,008—SEPTEMBER 19, 1961

A method of recording telegrams as received from patrons by telephone and at the same time preparing them for transmission over an automatic switching network through automatic insertion of the essential "top line" characters employing a "Flexowriter," a device adapted to simultaneously type the message and perforate a tape in response either to operation of the keyboard or to signal permutations from a signal generator. A single switching system receiving position and a single numbering machine serve a group of, say, five Flexowriters. The message is first typed and the patron is released, and a message number is automatically typed and perforated at the request of the operator, then the operator adds the selection characters, place of origin, time and date. Since this last named information must be transmitted first, the tape passes through two transmitters so controlled by perforations in the tape as to transmit in proper order the top line, text and end of message characters while idling through the other parts, with appropriate tape feed out signals. The messages leave the position in the order of their respective message numbers rather than in the random order in which they are produced by the five Flexowriters.

Telegraph Way Station Selector

G. G. LIGHT, W. J. WICHTENDAHL
3,001,009—SEPTEMBER 19, 1961

A way-wire selection system shown as half duplex but applicable also to full duplex which employs separate selective control means at the way stations so that the regular printer and keyboard are not disturbed by the selection process. Selection of a way station by the central station is by means of a series of timed pulse sequences interspersed by dwells which together operate on a rotary switch, gating tubes and associated circuitry at each way station to close the transmitter clutch, or to lift a short circuit from the printer magnet, for transmission or for reception, respectively, as may be desired for the selected way station. Stations are invited in sequence by the central office to send, either upon the initiative of the central office or at the request of a way station. The central office may connect any way station for reception while cutting out all others.

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Telegraph Switching System

G. S. Vernam, M. D. Adams,
E. J. Chojnowski, W. B. Blanton,
H. A. Jansson
3,006,986—October 31, 1961

A double storage automatic switching system designed particularly for armed services use and adapted for convenient expansion by direct addition of units. Contributory to this feature is the single conductor, cross-office paths, electronically operated at a pulse rate of 600 per second to give a cross-office message speed of 200 words per minute. Another feature is the provision of directors and translators on a concentrator basis. Provisions for accuracy checks, simultaneous multiple address sending, multi-party lines, signal number indicators, message priority and alternative manual switching are included. A special message format designed for military type messages is illustrated.

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Submerged Repeater Switching System

E. L. Newell
3,007,000—October 31, 1961

A submarine cable submerged repeater system embracing two repeaters. Signals from the near terminal, controlled as to polarity and amplitude, operate a polar relay at the inner repeater to close a bypass circuit thereat and then operate a rotary switch at the outer repeater for the performance of various tests, or to bypass that repeater also. Since repair of the outer repeater is more difficult and costly, it is shown with a spare amplifier which may be switched into the circuit when desired but the bulky signal shaping apparatus is concentrated in the inner repeater.

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COMING EVENTS — in the April 1962 issue

The next issue of the Technical Review will include such articles as:

Character Recognition	by F. T. Turner
Use of the Computer in Routing Messages	by W. R. Francis
The New IMCO Installation at London	by Donald Edgar
Recording on Teledeltos Types L48 and L39	by J. H. Hackenberg and F. L. O'Brien
U.S.A.F. Technical Control — Part II	by H. F. Krantz
Material Control Computer	by F. A. Herman
Trends in Cable Ship Design	by C. S. Romanelli

LOOKING FORWARD at WESTERN UNION

Western Union has filed tariff amendments with the Federal Communications Commission covering voice communication services. As of January 1, 1962 Western Union will engage in voice communication in addition to record communication. An engineering group has been formed to handle all details in the new area. Readers of TECHNICAL REVIEW may expect to read technical papers pertinent to the voice and voice-data field in future issues of this magazine.