U. S. Army Southeastern Signal School
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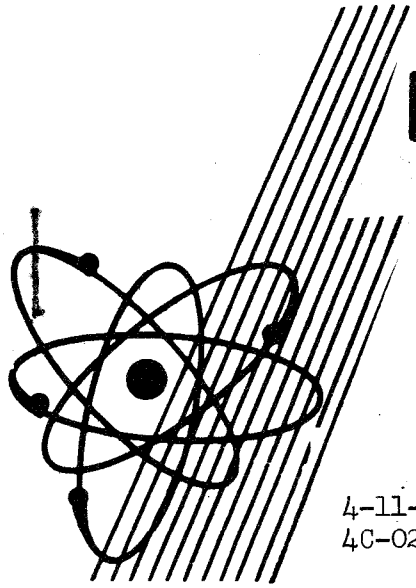
MANUAL NEW EQUIPMENT AND FUTURE TRENDS IN COMMUNICATIONS



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CHAPTER 1. FUTURE TRENDS IN COMMUNICATIONS

Section 1. General

EQUIPMENT

1. All signal equipment will be considerably reduced in size through miniaturization of the component parts in the very near future. There are many advantages to reductions in size. Among them are reduced cost, tactical portability, reduced shipping bulk, and ease of replacement. Simplicity of maintenance is being stressed in design and construction so that a minimum of second and third echelon repair is required. Radios will be of new design and provide increased range and frequency coverage. Radio relay systems will have a greater number of channels than are available today.

2. The trend away from wire began with radio relay to the brigade. Such systems will be further improved by the addition of radio centrals which will provide dial service over voice radio circuits to battalion and possibly company level. Miniaturization and advance in the technical development permit such central systems to be completely mounted on one vehicle enabling the unit to maintain continuous communications. Teletype switching will be accomplished by direct dialing.

3. Automatic data processing systems will be available at division. These will include data recording and storage devices and small capacity mobile computers which can be employed to compile essential administrative and logistical reports, projected reports, as well as to effect consolidation of requisitions. Such systems have also proved adaptable to collection and transmission of intelligence data between division, corps, field army, and to interrogation of other systems which may possess and have stored the information desired. An integral part of such systems is the communication link provided by the area communication system. Improved employment of Army aircraft will be achieved through advanced air navigation and traffic control communications system now being developed.

ORGANIZATION

In the field of organization, the ultimate desired is that any organization or activity be capable within itself of communicating immediately with any other organization with which coordination is required. At the present time the ability of one unit to communicate with others is partially dependent upon a third organization, the supporting signal unit(s) responible for portions of the area signal system. In the not-too-distant future, this area service requirement may be reduced in forward areas as tactical units become more self-sufficient in the communications field.

STAFF IMPLICATIONS

1. The development of the tactical operations center (TOC) and administrative support operations center (ADSOC) concepts emphasizes the requirement for highly integrated communication systems.

2. Improved efficiency of communications equipment will result in transmission of more information, more rapidly, for staff and command action. The increased capabilities of future communication equipment will assist the commander and his staff in the control and coordination of both tactical and administrative support operations on the widespread battlefield of the future.

Section 11. Satellite Communications

INTRODUCTORY INFORMATION

1. In the summer of 1958, the Signal Communications Department, U. S. Army Electronic Proving Ground, conducted a series of radio communication tests in the course of which the moon was used for the first time as a passive relay for ultrahigh frequency transmissions. A radio-teletypewriter message was transmitted from a station near Fort Huachuca, and was picked up clearly by a receiver at Encino, New Mexico, after traversing the nearly half-million miles from the earth to the moon and back again.

2. A frequency of 810 megacycles was used to increase the effectiveness of both antenna systems and to take advantage of lower signal losses in the transmission path. The result was to verify a point of far-reaching consequence. It was to prove the accuracy and dependability with which a complex transmission can be bounced off the moon.

3. The moon bounce itself was not new. Before the close of World War 11, for example, we had known that it was feasible to transmit radio signals through outer space; and as early as 1946 the large experimental DIANA radar at Fort Monmouth had received its own signal back after bouncing it off the moon.

4. But what was new in 1958 was the achievement of accuracy and dependability; and now, in the early February of 1960, the Navy-building upon the precedent established by the Signal Corps - has bounced a photograph off the moon.

RADIO COMMUNICATION WITH A RANGE OF FULLY 12,000 MILES

1. Radio communication of the type tested and proved at Fort Huachuca in 1958 has a range of fully 12,000 miles. This means that a station on one side of the earth can reach, by a single bounce, a station that is almost exactly on the opposite side of the earth. The only limitation is that the moon must be above the horizon for each of the two communicating stations.

2. That, measured by all its consequences, is a quite considerable limitation - and its very existence has been, to us, a loud toot on the horn of challenge. To meet the challenge, we have centered tremendous research efforts upon the use of artificial satellites - what we call communication satellites - for such devices can be made always available as the moon is not always available. All that is necessary is to have a sufficient number of them properly deployed in outer space.

3. In addition, satellites have the immense advantage of being closer to the earth; the transmission losses involved in a satellite bounce are but a fraction of the losses incurred in a moon bounce. Still another advantage is that communication satellites can be used, not only as passive relays, but also as fully equipped radio relay stations established - and well stabilized - in space.

4. Nor must we speak of communication satellites today as a matter of promise for the future. Through their use we have already mastered a new and vital technique of radio communication.

A PROGRAM OF EXPLORING AND EXPLCITING THE VAST POTENTIAL OF OUTER SPACE

1. Men have always tried to reach beyond the horizon - both figuratively and literally. They have always tried to get beyond the physical limits of the earth; and that, in a way, is what we are doing now in the field of radio. To tell the story somewhat differently, we are embarked upon a tremendous program of exploration, discovery, and exploitation of the vast potential of outer space, and parallel developments in the missile field have had the incidental effect - the additional effect - of equipping us to communicate by reflected or relayed radio signals between widely separated points on the earth.

2. There is today a desperate need for more adequate and more reliable global communications. That need presents to us one of the most challenging problems we have ever had to deal with. Also, it raises a curious question: What makes us look toward the day when we can have a regularly established system of communication satellites stationed in space around the earth? Are today's communications so woefully short of man's requirements?

3. The answer is neither a categorical yes not a categorical no. There is nothing fundamentally wrong with the commercial communication system within the United States, or within some of the west European countries. The same can be said of the military systems of the Armed Services. Indeed, there are some who feel that our domestic or interior communications have advanced faster than man's ability to make use of them.

4. The situation is not the same for transatlantic or transpacific communications. We have serious problems with cable and radio facilities when it comes to long-distance global communications - particularly in the polar regions.

5. Our existing systems are overburdened with traffic. They lack solid reliability, because of atmospheric conditions and other factors. They are not versatile, nor are they very flexible. For example, there is no commercially feasible trans-atlantic or transpacific television service.

6. For long-range voice and coded transmission, of course, we have excellent submarine cables; and in the field of radio we use both tropospheric and iono-spheric layers on the earth's atmosphere as reflectors, and we bend, or turn, our signals back to earth, receiving them at points far distant from the trans-mitters.

7. All these achievements are overshadowed by the tremendous possibilities of satellites - orbiting earth satellites - for the relay of both audio and video communications. In its simplest form, the satellite replaces the natural space layers of the troposphere and the ionosphere. There is one vital thing more to be said about it: We can put inside the satellite special communication equip-ment which will amplify the signal or store it before relaying it back to earth receiving stations or to another satellite. The satellites thus equipped will ultimately prove a reliable and efficient means of spanning the oceans and polar regions, and thus of providing truly global communications.

8. Many programs and projects have been set up within the Defense Department for communication satellites in outer space. They had their origin 4, 5, even as much as 10 years ago. But until recently they proceeded at a moderate pace.

CAME THE SPUTNIKS, AND THE REACTION WAS SHARP

1. In the years after Korea and before the sputniks, our national security was based mainly on a policy of massive retaliation - with a balanced budget. Economy and nuclear weapons were the watchwords of our military strategy.

2. The sudden and positive appearance of Soviet satellites brought sharp reactions. The potential of our space activities was recognized, and our scientific work in this field was pushed with greater vigor. The SAC dispersal program was expedited. The Atlas program was undertaken. The Navy stepped up work to provide an operational Polaris missile. The Army developed the Redstone and Jupiter missiles. And, in the field of communication satellites, we extended our plans and accelerated the de-velopment of our first hardware.

3. The first military experiment in space communications took shape in 1958. It was called Project SCORE - Signal Communications by Orbiting Relay Equipment. It was a development of the Army Signal Research and Development Laboratory and it was under the jurisdiction of the ARPA, the Advanced Research Projects Agency of the Defense Department. The Army-developed communication "package" was aboard a satellite placed in orbit by an Air Force Atlas missile on December 18, 1958.

4. Task Decree is a real-time relay station aboard a satellite in a 24-hour equatorial orbit. Operating at about 23,300 miles above the earth's surface, a Decree satellite will travel at a speed that exactly matches the rotation of the earth. In effect, then, the space vehicle will "hover" over a fixed position on the equator. At this great distance, a large portion of the earth will be visible to the microwave transmissions of the satellite, which will serve as a relay between points on the earth separated from each other by several thousands of miles. The Decree satellite's Army-developed communication package will provide a large number of voice channels plus a voice channel for aircraft communications.

5. The Advanced Decree satellite, a larger, heavier, and more sophisticated type of 24-hour equatorial communication satellite will provide a much greater traffic-handling capacity. Three or four of these, properly placed in space, would be sufficient to "cover the world", except for two small polar areas. Ultimately, the 24-hour equatorial Advanced Decree satellites, by themselves alone, will constitute a complete global communication system which will also include communication satellites in polar orbits.

6. All the communication satellites of Project Notus are active satellites - equipped with their own transmitters, receivers, control devices, solar power, and ancillary equipment. There is another type of communication satellite - the passive satellite - without communication equipment and moving at extremely high altitudes in outer space.

7. Simplest kind of passive satellite is a large aluminized balloon, about 100 feet in diameter, which can be launched from missiles. Sufficiently powerful microwave signals directed at such a balloon would be reflected back to earth - weakly, of course, but over a wide geographical area. Ground stations within that area could pick up the reflected signals - but to do so, the station would have to be equipped with sensitive tracking and receiving equipment with highly directional antennas. One passive balloon launched in a relatively low-altitude orbit would provide communication between two ground-based stations for only a portion of a day. But if enough balloons were launched, instantaneous relay communications could be provided almost continually.

8. An alternative to launching large balloons would be to place pbjects of other shapes in orbit in such a way that they would reflect microwave signals back to earth. While passive satellites are possibly of greatest immediate interest to broadcasters, active real-time communication satellites can also prove useful for low-power transfer of data and video information.

Section III. Four-Wire Electronic Switching Systems

FIELD ARMY COMMUNICATION SYSTEM SWITCHING CONCEPT

1. US Army Signal Engineering Laboratories is now deeply into a development program which will result in the production of 4-wire electronic automatic switchboards which can be integrated in a complete local and long distance communication network within which switching is performed automatically in a rapid and efficient manner. The development of this equipment represents the first major advance in communication switching equipment in 20 years. Four-wire switching equipment is being introduced into the Bell System long distance network and will replace 2-wire equipment generally as rapidly as economy will permit.

2. Electronic telephone switching equipment is being developed for commercial use and will most certainly replace electromechanical equipment in the commercial network, again, as soon as economy will permit. In the latter part of 1959, work went ahead on installation of the experimental, transistorized Electronic Central Office, first in the world, at Morris, Illinois. Bell Laboratories engineers are testing the equipment and the first connection with the lines of telephone users will be made in June 1960. The trial of Morris will provide experience and knowledge required for development and production of a system for wide-spread use. This system will make possible a wide variety of optional service features. A complete automatic electronic switched network is essential to military services as it is to civil communications.

3. The area communication system concept, which has been generally accepted as the only system which will permit the organization which it serves to move about at will and maintain intercommunication, in operation, will require the tandem connection of trunks through a number of switching centers in most user-to-user connections.

4. If 2-wire switching centers were to be used to implement the area communication system, each user-to-user connection involving a number of trunks connected in tandem through intervening switching centers would involve hybrid insertions at each switchboard. Elimination of hybrid losses and echo suppression problems would make the installation engineering and operation of the otherwise 4-wire system impossible to handle in the field. This is essentially true since signals other than voice signals must be transmitted through the switchboards. Hence, 4-wire switching equipment is a necessary adjunct to the area communication system.

5. Noting that data, telegraph and facsimile, will be transmitted through the area communication system, it is also noted that the terminal equipment receiving and transmitting these signals is 4-wire. Only the telephone and field cable are 2-wire. Hence, to provide a universal switching facility and avoid the use of hybrids on the loops, 4-conductor field wire and a 4-terminal

field telephone should be provided. This last statement is further supported by the fact that radio loops terminating on the switchboard together with wire loops will become a predominating condition and in order to provide a high signal-to-noise ratio on a wire-loop to radio loop connection, the loop circuit must be 4-wire.

6. Results of Project COMPASS studies emphasize the necessity of providing of a complete 4-wire communication system for military use. Bell Telephone Laboratories have recommended that the projected Air Force world-wide communication system be completely 4-wire.

7. The area coverage communication system has been mentioned above as being a system requiring 4-wire facilities throughout in order to make possible the maintenance of high quality transmission. It is also recognized that switched traffic through the system will be dense and will require the application of the most advanced traffic handling techniques if the equipment required to insure continuous flow is to be kept to a minimum. Since there can be no questioning the fact that automatic switching is the most efficient method of handling communication traffic, it should be used in the military system.

8. Automatic switching equipment designed around the use of new available electronic devices such as transistors, diodes, magnetic cores, etc, will:

a. Make it possible to mount the equipment for the entire area coverage communication system in vehicles no larger than 2 1/2 ton trucks.

b. Reduce the number of operators used throughout the system to an absolute minimum. A user-to-user connection, regardless of the number of switching centers involved, will require no more than two operators. User-to-user calls within a local network such as those serving division, Army, or corps can be made entirely automatic without the services of an operator. Through the use of code translators, now under study, it will be possible to eliminate the operators from the whole system except those needed to give out information.

c. Because of the rapidity with which switched traffic can be handled, the size of interconnecting trunk groups can be kept to a minimum thus effecting a saving in costly outside plant and also reducing installation effort.

9. A 4-wire area coverage communication system does not preclude interoperation with existing military systems, either our own or foreign, nor with civilian systems, either namual or automatic. Development of simple small converters to make such interoperation possible is now being undertaken.

10. It does not follow either that the use of automatic equipment will require longer training in operation and maintenance of methods. The basic equipment design is to be such that:

a. All terminal circuits, if not identical, will be similar. For example, personnel having learned the operation of a line circuit will also understand the operation of trunk circuits.

b. Circuits will be "plug in" assemblies and testing will be reduced to comparing a predetermined wave shape or meter reading with actual readings.

PROPOSED MILITARY CHARACTERISTICS FOR A 4-WIRE COMMUNICATION SYSTEM

1. Objective. To provide a 4-wire communication system which will include 4-wire automatic telephone switching equipment suitable for use at all Army echelons, a field telephone for terminating a 4-wire line circuit, 4-conductor field wire and a 4-wire field wire repeater.

2. Proposed service employment.

a. Installation location. The system will serve all echelons of a field army.

b. Inter- and intra-system relationships. Within the automatic system all signaling on loops and trunks will be at voice frequency in band. Connections to existing switched system (Telephone Central Office AN/TTC-7, Switchboard SB-86/P) will be accompliched by means of special converters which will be designed to receive and transmit the signals employed in the automatic system and will be designed to receive and transmit the signals generated in the existing switching system. Inter-and intra-area connections will be made by radio relay or cable using existing multiplex equipment or frequency division multiplex equipment now under development.

3. Equipment to be developed.

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a. Transistorized Automatic Central Office. This equipment will provide 200 local lines, 60 dial-to-dial trunks, and 16 trunks to the long distance switchboard. It will be possible to connect a number of these Central Offices together with dial-to-dial trunks to serve a larger number of telephones. Local loops may consist of physical circuits using 4-wire field wire, radio loops using radio equipment presently under development, or cable using a loop multiplexing system planned for development. Limited operation in motion using radio loops will be required.

b. Transistorized 4-wire Switching Center of Operator Long Distance Dialing. This equipment will provide the long distance switching center. These switching centers will provide 100 long distance trunks in 8 groups, the size of the groups being flexible. It will provide a total of 60 trunks in 10 groups to local central offices; each group will be capable of handling 0-60 trunks.

c. A small exchange, similar to the 100-line exchange described in a above, must be developed for use in regiments and battalions or similar units. This will be a 20-line unit expandable to 60 lines. The basic unit of 20 lines will contain 16 trunks in 4 groups to other local central officers. The attendants' equipment and ten trunks to the long distance switchboard will be supplied as optional equipment.

d. A special telephone for use on 4-wire circuits and making use of voice frequency signal throughout will be developed for use with the switchboards described in a and c above.

e. 4-wire field wire for use with the switchboards described above. This field wire should not be much heavier per mile than WD-1. It should have the pairs sufficiently well marked by tracers which can be felt, as well as seen, to permit splicing in the dark without crossing the two pairs.

f. A 4-wire, transistorized repeater must be developed for use on the 4-wire field wire described above. It must be unattended and battery operated with low drain on the batteries. It need pass only voice frequency signals.

g. Compatibility equipment to permit interoperation of the 4-wire automatic switching system with 2-wire manual or dial systems of either military or civilian types. This equipment will be in the form of hybrid-type ringing converters designed for nonattended use.

h. Division Area Tandem Switchboard. The Division Area Tandem Switchboard is a transportable automatic switching center for use within an infantry, airborne, or armored division. Two or more of these switchboards can be connected together to serve the local units within the division area. Each switchboard will serve 48 tie trunks, 72 trunks to local switchboards, and 18 trunks to a long distance switchboard. The entire office including and operator's position will be housed in Shelter S-141/G.

4. Functional requirements. To provide satisfactory switched telephone communication. Within a local area served by several local switchboards, the telephone user will dial the desired telephone number. On long distance calls, trunk routing will be performed by the originating long distance operator and connection to the desired telephone will be performed by an operator at the terminating local exchange.

5. Background and/or related information. Modern warfare requires an efficient, highly mobile communication system. Switchboard installations presently in the field are bulky, heavy, require many operators, and depend upon the in-efficient ringdown system of trunk signaling. Through the application of modern, electronic circuitry, an efficient, universal system of switching can be evolved making the minimum use of operators.

PHYSICAL CHARACTERISTICS

1. The 100 line local switchboard and the long distance switchboard, will be housed in Shelter similar to the S-141( )/G to be carried on 2 1/2-ton trucks.

2. The small switchboard, the division tandem switchboard, the field telephone, and the 4-wire field wire repeater will be designed as ruggedized, transportable equipment.

EQUIPMENT OPERATION AND MAINTENANCE CHARACTERISTICS

1. Operating time. Twenty-four hours per day.

2. Permissible scope of continuous and periodic adjustments, calibration, maintenance, etc. Maintenance and repair may be necessary during operating periods. In the automatic portions of the equipment, maintenance may be performed on any part in trouble without affecting the operation of the rest of the equipment. In the attendant's position, it may be desirable to delay maintenance until a period of light traffic occurs.

ADVANTAGES AND DISADVANTAGES 4-WIRE VERSUS 2-WIRE SYSTEMS

ADVANTAGES:

1. A 4-wire connection from calling telephone to called telephone is very stable and does not oscillate or "sing" as a 2-wire circuit without careful adjustment has a tendency to do. This stability makes it possible to maintain an almost zero loss transmission condition between two connected telephones regardless of the number of intervening switchboards on a multiswitched trunk connection.

2. In a 4-wire communication system which includes both wire and radio loops, the signal-to-noise ratio on a wire-loop-to-radio-loop connection through the network can be maintained at a relatively high value. A 4-wire system will permit extensive use of radio loops with a minimum attention being paid to system lineup.

3. Use of the 4-wire system eliminates cumulative losses occasioned by introduction of hybrids where 2-wire systems are connected to radio and/or multiplex equipment which provide 4-wire termination.

DISADVANTAGES:

1. Special measures must be taken when interoperation with existing military or commercial 2-wire systems is required.

2. Four-conductor field wire will be heavier and will introduce more attenuation than 2-conductor field wire. How much heavier and how much more attenuation will be introduced is not known at this time but the question is now under study. The design goal will be to keep the size and weight to within 1 1/2 time that of WD-1/TT. The expected increase in attenuation is not considered a serious problem since the 4-wire circuits lend themselves to more advantageous use of repeaters.

AUTOMATIC SWITCHING SYSTEMS VERSUS MANUAL SWITCHING SYSTEMS

ADVANTAGES:

1. In a system such as the Army Area Communication System, consisting of a network on interconnected switching centers, employment of automatic switching equipment reduces the number of operators necessary to route calls through the system. Ultimately it may be possible to dispense with operators altogether except for those needed as information dispensers.

2. The speed with which a connection may be routed through the area communications system will be greatly enchanced by using automatic switching equipment.

3. Better system control can be realized by using automatic alternate trunk routing.

DISADVANTAGES:

1. In order to fully realize the advantages of an automatic switching system, it will be necessary to maintain a more comprehensive directory system.

2. Automatic switching equipment and the associated telephone will be more complicated than manual equipment.

Summarizing the above items, it is apparent that considerable improvement in transmission can be realized and a significant improvement in efficiency in the switching system may be gained in going to a 4-wire automatically switched communication system. The price of these improvements is paid in more complicated equipment.

The manual switching equipment presently available (SB-86, AN/TTc-7) is inadequate to serve in an area coverage type system. It is necessary therefore to provide greatly improved manual switching equipment or automatic switching equipment. Since automatic equipment offers the possibilities of the greatest gain in efficiency, it is believed that the right course of action is to proceed directly to the development of the automatic system.

BACKGROUND INFORMATION FOR MATERIAL REQUIREMENTS

1. Reason for the requirement. The advent of atomic warfare, and the extensive Department of the Army program to develop new combat techniques and to reorganize for better combat effectiveness has required extensive reappraisal of the research and development program for communications. In examining the communication systems that are possible with equipment currently under development, it is obvious that telephone switchboards and the type of supervision they employ have become one of the most difficult of the communication problems. This has come about because of the wide dispersal of telephone users and the high degree of mobility they require. This has intensified the switching problems in the field army area to the extent that a drastic change in switching equipment and techniques is required.

2. Additional capabilities and/or characteristics desired of the equipment. This system will provide faster and more reliable communications throughout the areas of use with a high degree of mobility.

3. Probable maintenance and supply implications. Maintenance should be reduced by introduction of the system.

4. Other items affected by this material. Elements of this system will eventually replace all of the existing 2-wire manual switching equipment as well as existing 2-wire transmission or terminal equipment.

WHY FOUR-WIRE COMMUNICATIONS?

1. General.

a. Suppose we had to establish a modern telephone system where none had ever existed before - to the moon, for example. It would be a 4-wire system. Why? Because it would be so much easier that way. Many people believe we have a 2-wire telephone system in the United States.

b. That was true 40 years ago. Today much of our domestic telephone system is 4-wire. What is left of the 2-wire system consists largely of local loops - circuits that connect subscriber instruments to central offices.

c. Back of the steady growth on the 4-wire system in the United States are certain basic necessities. With a 2-wire connection, for example, a teletypewriter system operates on a one-way basis; but with a 4-wire connection, it works on a two-way basis. And the same is true of facsimile, data transmission, and many other systems that have been grafted upon the telephone network in the past 40 years. The final necessity arose with the introduction of radio relay transmissions into the telephone trunk system, for all two-way radio circuits are necessarily 4-wire circuits, and to set up 4-wire circuits within a 2-wire network is, from the economic point of view, a very costly business.

d. In any case, the broad fact is that the commercial communication systems of the United States are changing over to a 4-wire base as rapidly as prudence and good business sense allows; and a second broad fact is that the Signal Corps stands today at the verge of a total changeover that will cover, from first to last, a transistion period of only 3 or 4 years. According to plans now being implemented, 4-wire systems may be introduced as far forward as company headquarters by 1965.

e. All this implies a tremendous operation; and the preparatory work is already well advanced.

2. 4-Wire Work on a 2-Wire System and the Trouble It Involves.

a. What is to be changed is, of course, the area communication system; and both the purpose and the consequences of the change can best be illustrated by a quick look at that system and its working.

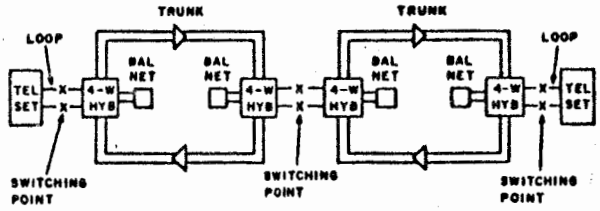
b. The present-day area system is a 2-wire setup. It is adaptable to the needs of radio relay, teletypewriter, data transmission, and all the other systems that operate through 4-wire connections. Just the same, however, it remains a 2-wire system.

c. A second point to observe is that the present-day area communication system is characterized by a multiplicity of switching points - and it goes without saying, perhaps, that every switched connection means a certain signal loss. These losses are cumulative. As they multiply, the signal becomes more and more attenuated, and in consequence of this, two needs arise: The first is to suppress the noise level to a point below that of the signal. The second is to maintain an unusually high order of circuit balance, so as to keep the circuit below the singing level.

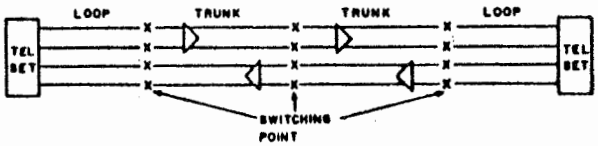
d. Nor is this the whole story: for it is also true that every switched connection means echo. Like signal losses, echo is cumulative too; and as echo multiplies, it gets through a 2-wire connection to the return path.

e. Loss and echo both are serious problems. Even with normal 2-wire traffic, they can cause operational difficulties; and these difficulties have a well-known way of accumulating. Then, as the traffic increases, communication becomes increasingly difficult.

f. Things become a great deal worse when radio relay transmissions must be cared for, or any other transmissions that require 4-wire connections. Let us look, for example, at one particular aspect of the present-day area communication system - the ordinary hook-up that makes possible the use of radio relay within a 2-wire system. This hook-up is shown schematically in the upper part of the illustration. Here we have two telephone loops interconnected by two trunk lines in tandem; and also involved in the hook-up are hybrid networks for every switching point and a balancing network for every hybrid. The hook-up, judged by any standard at all, is complicated.



2-WIRE SYSTEM



4-WIRE SYSTEM

Complication vs. Simplicity. In this contrast are exhibited the principle merits of the 4-wire system.

g. Also it causes many operational difficulties. For example, there is a constant need to balance the 2-wire side of the hybrid with the balancing network, and the attempt to achieve that balance is a source of never-ending trouble. The impedance of the 2-wire side of the hybrid can never be predicted accurately, because the characteristics of the wire lines vary with, for example, weather conditions. Therefore, a compromise balancing network must be used and this causes a loss from one 2-wire terminal to the other.

h. Thus each of the trunk circuits shown in the diagram must be adjusted and maintained to introduce a loss from every 2-wire switching point to the next. Otherwise the circuit would sing, and the result of that in turn would be to disrupt not only that circuit but all other circuits using the same multiplexing equipment.

i. It becomes obvious, perhaps, that the area wire system as it stands today can handle radio relay traffic, but only at the cost of greatly increasing the work burden imposed upon the operators and of greatly increasing the complexity of the system itself.

3. Simplicity of the 4-Wire System Makes for Ease of Operation.

a. How needlessly complex and complicated that hook-up is becomes apparent if we glance at the diagram in the lower part of the illustration. Here we have the same subscribers interconnected by 4-wire loops and two 4-wire trunks in tandem. The hybrids and the balancing networks have no place here, nor do any of the echo and singing problems that result from the use of a hybrid.

b. Here instead we have, as a general rule, zero-loss circuits. For that reason the number of switching points can be increased from the currently allowable 5 to something in excess of 10 to meet the forseeable requirements of an ever-expanding area communication system.

c. Here, too, we have a relatively easy job of circuit maintenance. The switchboard personnel must still be responsible for changes in the transmission path to accomodate the differences between radio relay and straight wire transmissions; but with a 4-wire setup this job of circuit maintenance is far less critical than it would be with a 2-wire system.

d. To carry this point a step further, let us look back for a moment at the present-day 2-wire system. Under average operating conditions in the field, variations in the transmission path are always likely to occur; and every such variation may cause the circuit to sing. Then it becomes the job of the maintenance men to overcome the singing through a series of readjustments that fall under the head of circuit maintenance. However, there is a quicker, easier way to meet the trouble, and that is to introduce a compensating signal loss. Many of the high-loss circuits in today's tactical systems result, as a matter of fact, from such intentional impairment of the quality of the circuits.

e. It is a further advantage of the new system that, with a 4-wire network, it would not be necessary to resort to this expedient.

f. A still further advantage is that the best possibilities of automatic switching are realized with a 4-wire system. This is not to say that automatic switching is impossible with a 2-wire system; it is to say, rather, that in a 2-wire system that use of automatic switching is subject to the same difficulties as the setting up of a 4-wire circuit. When used in a 4-wire system, however, automatic switching is freed of these limitations. It becomes, in fact, a major factor in the overall success of the area communication system. To establish a circuit through 10 switching points, for example, would take 3 minutes with manual switching, and that is a highly optimistic estimate. But with automatic switching the same call could be put through in 30 seconds.

g. In the end, perhaps, the question may again be asked: Why a 4-wire system? By now, though, the answer may be obvious: Because of its intrinsic merits. Also because a 2-wire system, or even a combined 2-wire-4-wire system, could never be expanded fast enough to meet the needs of a fast-moving modern Army in combat.

4. The Change to a 4-Wire Base Has Been Long in Preparation.

a. The changeover to a 4-wire area communication system, will be total and absolute; and it will be effected, barring the unforseeable, over a transition period of unprecedented brevity. Never in the past has a change of such magnitude been carried out so swiftly.

b. The explanation, and the great surprise of this program, is that the preparations have been going on for years, and that the bulk of all tactical communication facilities in service today are - with only three notable exceptions, 4-wire facilities. They were designed, with forethought, to work indifferently in either a 2-wire or a 4-wire system. As matters stand today, therefore, and as far as all these facilities are concerned, it is a question merely of hooking them into the proposed 4-wire network.

c. The three exceptions are: (1) switching equipments, (2) telephone sets, and (3) field cable. The work ahead, therefore, consists primarily of replacing these with (1) 4-wire electronic switching systems. (2) 4-wire field telephone sets, and (3) some thousands of miles of 4-wire field cable.

SIG 3 BACK - 2

d. Development work on all these items is far advanced, and we have on hand at least an engineering-test model of each. One by one, let us turn to each and see what manner of thing it is, and how near it seems to final procurement and distribution to the field.

e. Telephone Cable WF-16: This is a four-conductor field cable having a tensile strength and electronic characteristics similar to those of WD-1. It weighs 65 pounds to the mile (WD-1 weighs 48 pounds), and it can be easily wound on conventional reels or loaded in conventional wire dispensers. Each of the four conductors is composed of seven strands of .0085-inch cadmium-copper alloy 85; and to identify each pair of conductors, the insulation of one is black, the insulation of the other, gray or beige. In addition, the insulation of 1 pair has a sharp ridge, enabling the user to identify it in the dark. Quantities of this cable have been procured for field test.

f. Transistorized Telephone Set TA-341/PT: This is a 4-wire portable, local-battery-powered set, for use with 4-wire electronic switching systems. In addition to transistors, it uses printed circuits packaged as plug-in units. It also uses a magnetic transducer in place of the conventional carbon microphone; and because a keying device is not only

faster but is more adaptable to the tone signaling used in this system, it has a key-type selector in place of the conventional dial. Engineering test models of this item have been procured.

g. Electronic switching equipment: The operation of a 4-wire system is characterized by a multiplicity of multiswitched trunk connections. The requirement, then, is for high speed switching; and for tactical reasons, the equipment must be mobile. Thus we have the AN/TTC-12, -13, -14, and -15.

h. Each of these is a 4-wire electronic switching system; and each is contained, complete with power supply, in one shelter. In all cases but one, the shelter is mountable on a 2 1/2-ton truck; the exception, the AN/TTC-14, is even smaller. The main point is that each can be swiftly uncoupled from a wirehead, easily transported by truck or by air, and swiftly coupled up and placed in operation again.

i. On the other hand, each is installed and operated by relatively few men. For example, a present-day 200-line switching center is contained in 6 trucks, requires 36 tons of logistics support a month, and requires the services of 24 men for operating and maintenance purposes, whereas a 200-line electronic switchboard can be carried on 1 truck, requires 6 tons of logistic support a month, and requires the services of only 4 men for operating and maintenance purposes. It follows from all this that the 4-wire system offers, in addition to its other merits, the advantages of faster switching and greater mobility, while requiring the attention of substantially fewer men.

j. Of the newly developed 4-wire switching systems, all four are about to enter the service test stage. All four have operator positions, but the operator's principal function is to give information to local callers and to help direct incoming calls. Highlights of the system are:

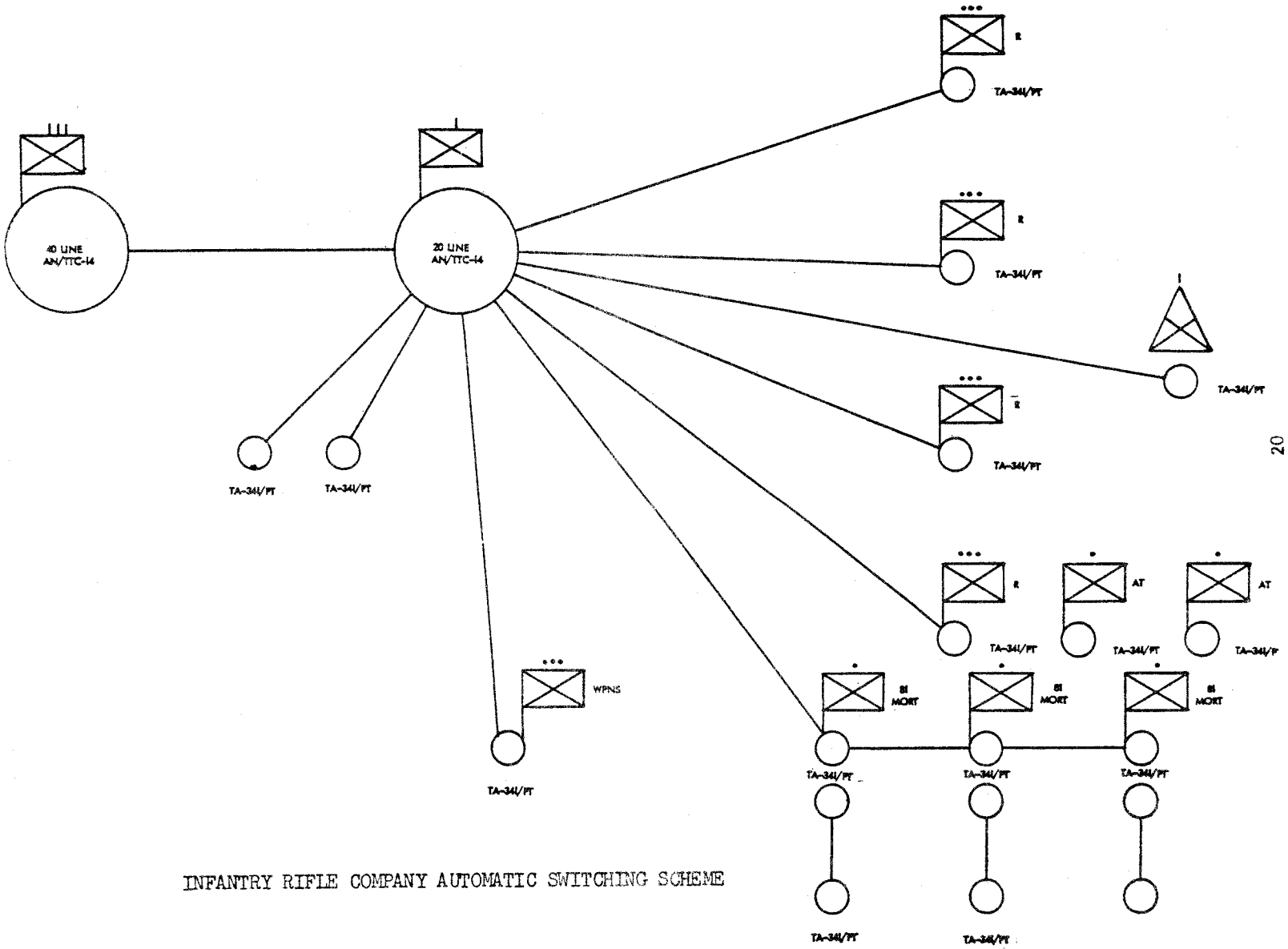
k. Local Switchboard AN/TTC-12: This is a 200-line, 80-trunk board for a large headquarters. It has a position for 1 operator, and its technical characteristics are such that 60 calls can be in progress simultaneously.

l. Long-distance Switchboard AN/TTC-13: This board has 100 trunks to other long-distance boards and 60 trunks to local and tandem (Divisional) boards. It has positions for 2 operators and characteristics that enable 80 calls to be made simultaneously.

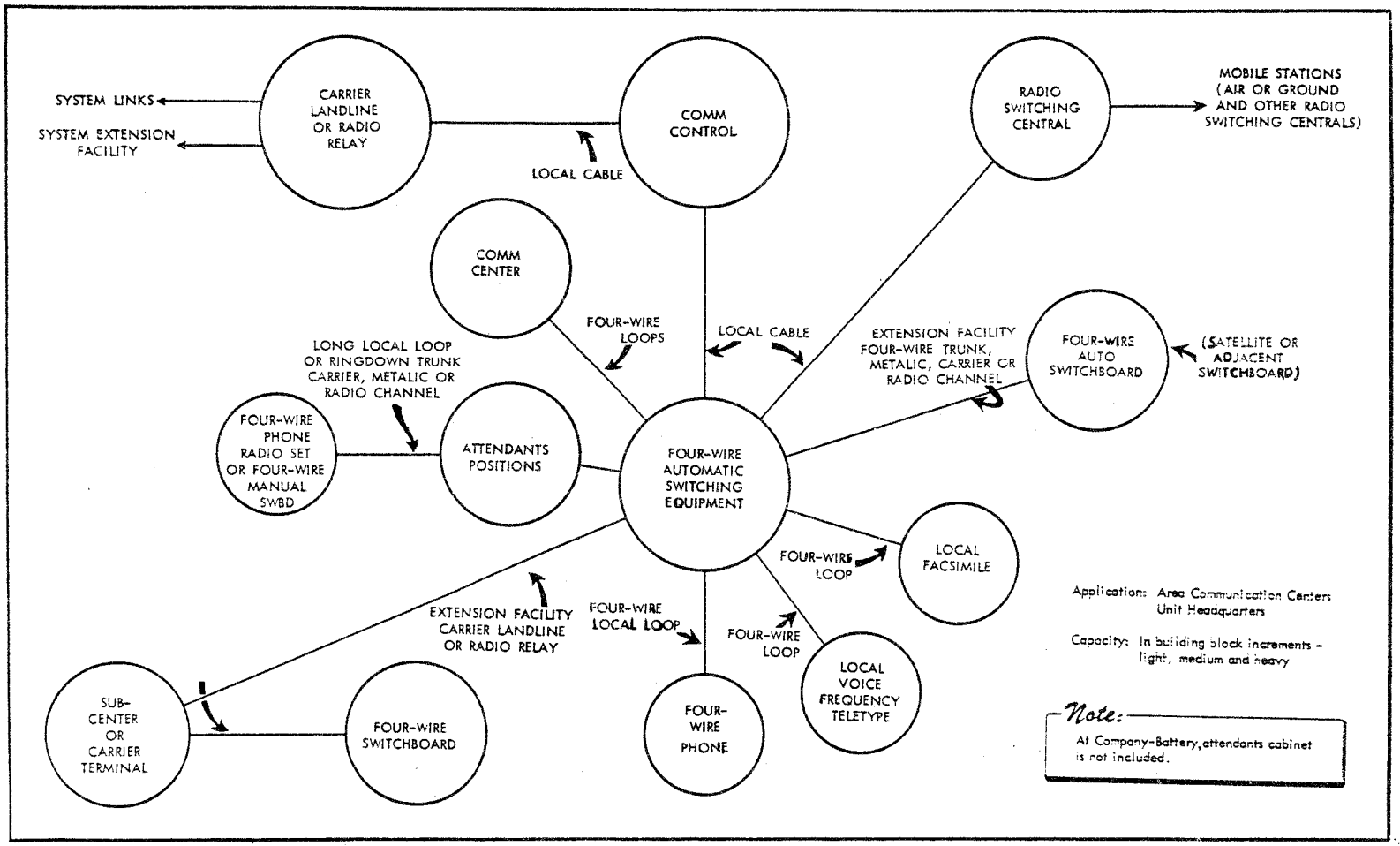
m. Lower-echelon Local Switchboard AN/TTC-14: This expandable board has a basic unit of 20 lines and 8 trunks, one auxiliary unit of 20 lines and 4 trunks, and another auxiliary unit that comprises the operator's position. The basic unit can be used alone or in combination with either or both of the others, and the operator's unit can be used as required in any of these combinations.

n. Division Area Tandem Switchboard AN/TTC-15: This board, with a built-in automatic prerouting facility, has a total of 138 trunks, 48 of these to other tandem switchboards, 18 to long-distance switching centers, and 72 to local 200-line exchanges. With this board, which has a position for 1 operator, 70 calls can be in progress at the same time.

o. In the end, however, all these equipments merely illustrate by their capabilities the answer to that question we began with: Why a 4-wire system? A vital characteristic of the pentomic army is its flexibility. It can be argued and the laboratory engineers believe that flexibility resides in the use of the 4-wire system and of the automatic switching devices which the 4-wire system makes possible.

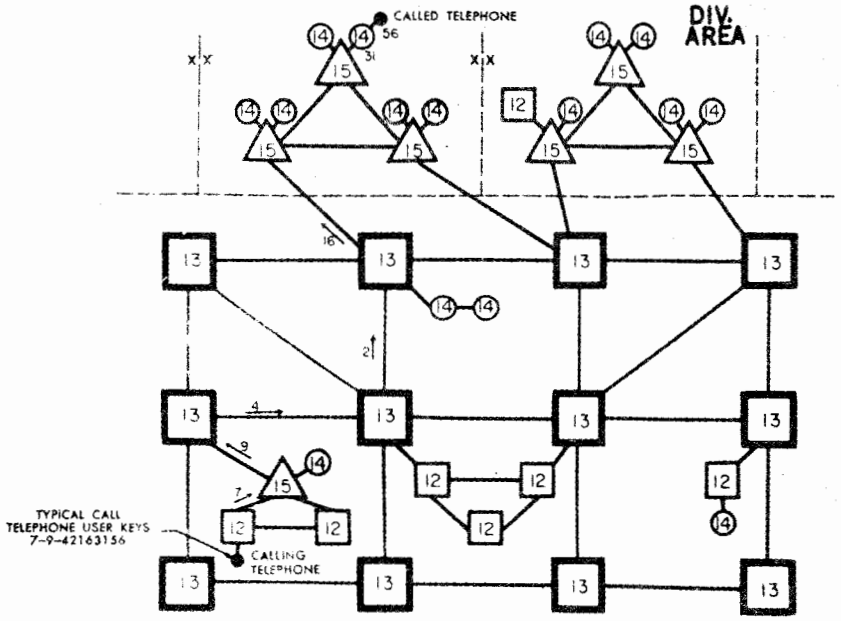


INFANTRY RIFLE COMPANY AUTOMATIC SWITCHING SCHEME



FOUR-WIRE AUTOMATIC SWITCHING CONCEPT

ARMY AREA COMMUNICATION SYSTEM



12 — Electronic Telephone Central Office AN/TTC-12 200 Line Local Switchboard.

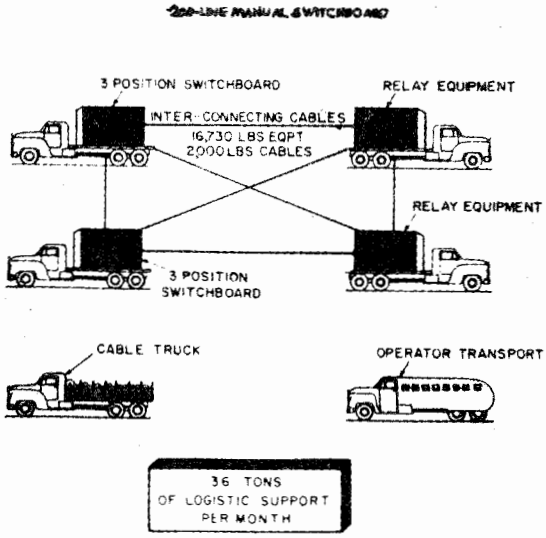
13 — Electronic Telephone Central Office AN/TTC-13 Long Distance Switching Center.

(14) — Electronic Telephone Central Office AN/TTC-14 20/60 Line Local Switchboard.

15 — Electronic Telephone Central Office AN/TTC-15 Tandem Switchboard.

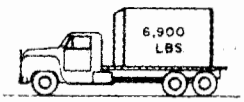
● — Telephone Set TA-341/PT.

MANUAL VERSUS ELECTRONIC SWITCHING



36 TONS OF LOGISTIC SUPPORT PER MONTH

200-LINE ELECTRONIC SWITCHING CENTER



4 OPERATORS — 700 LBS.

6 TONS OF LOGISTIC SUPPORT PER MONTH

DESCRIPTION

4-WIRE ELECTRONIC SWITCHING SYSTEMS

The 4-Wire Electronic Switching Systems contain the most advanced designs of present day engineering. The use of solid state devices along with miniaturization and modular construction has lent itself ideally toward developing standardized plug-in packaged units common to all switching centers.

AN/TTC-12 (Local Switchboard)

The AN/TTC-12 provides complete communication facilities as a 200-line local switchboard for use at large headquarters. All equipment is mounted in a transportable shelter. Included in the shelter is one operator's desk, four switching equipment cabinets, one transmission equipment cabinet, a main distributing frame, power supply, and an AC power distribution panel. Also included as part of the shelter are air conditioners, heater, test equipment, fans and blowers, tools, storage compartments, and a bulletin board. The facilities provided within the switchboard are as follows:

200 Telephone lines.

30 Trunks to a long distance switching center.

50 Trunks to local 200-line and tandem switchboard. These trunks can be divided into as many as six groups with a maximum of 50 trunks in a group.

1 Operator's position for information to local telephones and assistance on incoming calls.

60 Simultaneous calls can be in progress at one time.

AN/TTC-13 (Long Distance Switchboard)

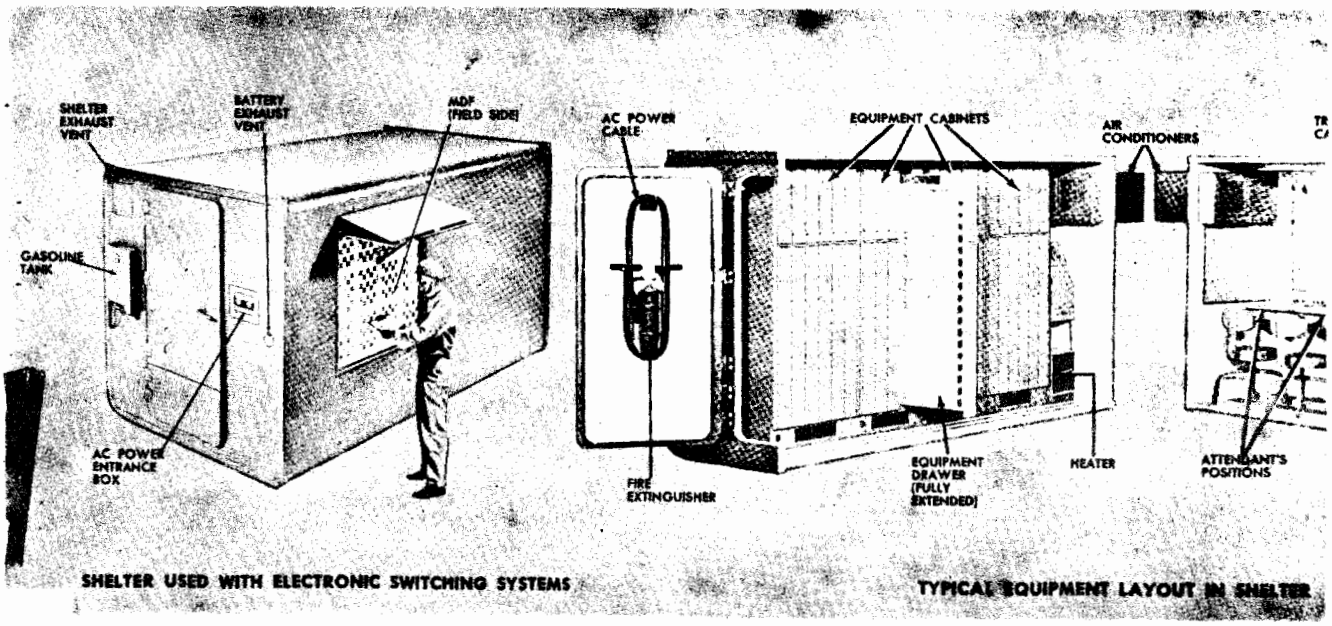
The AN/TTC-13 is a long distance switching center that has trunks to other long distance switchboards and to lower formations. All equipment is mounted in a transportable shelter. The hardware included in the shelter is similar to that housed in the AN/TTC-12 (Local Switchboard) except it has two operator's positions. The facilities provided within the switchboard are:

100 Trunks to other long distance switchboards. These trunks can be divided into as many as 8 groups with 50 trunks in any one group.

60 Trunks to local and tandem (divisional) switchboards. These trunks can be divided into as many as 10 groups with a maximum of 60 trunks in a group.

2 Operator's positions for assistance as required.

80 Simultaneous calls can be in progress at one time.



SHELTER USED WITH ELECTRONIC SWITCHING SYSTEMS

TYPICAL EQUIPMENT LAYOUT IN SHELTER

AN/TTC-15 (Divisional Area Tandem Switchboard)

The AN/TTC-15 is a switchboard that has trunks to other divisional tandem switching centers, to long distance switching centers, and to lower formations. All equipment is mounted in a transportable shelter. The hardware included in the shelter is similar to that housed in the AN/TTC-12 and AN/TTC-13. Like the AN/TTC-12, it has a one position operator's desk. The AN/TTC-15 Divisional Tandem Switchboard will normally be provided in groups of three and the facilities are:

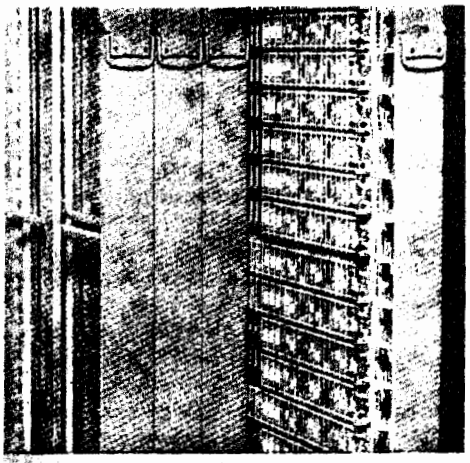
48 Trunks to other tandem switchboards divided into 2 groups with as many as 48 trunks in a group.

18 Trunks to long distance switching centers.

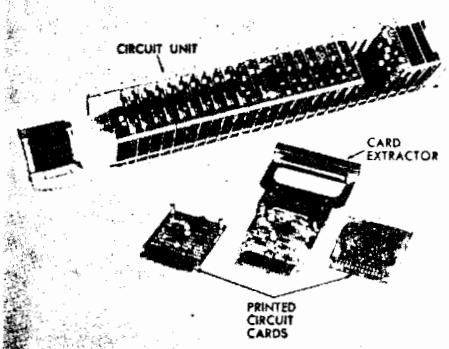
72 Trunks to local 200-line exchanges divided into 15 groups with a maximum of 72 trunks in any one group.

1 Operator's position for information and assistance.

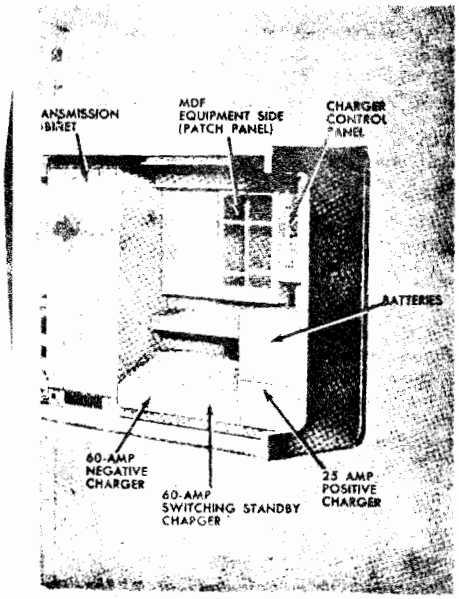
70 Simultaneous calls can be in progress at one time. Built into this switchboard is an automatic pre-routing facility.



TYPICAL DRAWER ASSEMBLY



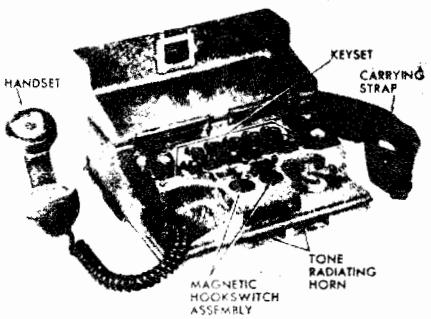
CIRCUIT UNIT AND COMPONENTS



TA-341/PT (Transistorized Telephone Set)

A completely new concept of a telephone instrument has been developed for use with the 4-Wire Electronic Switching Systems. The TA-341/PT is a sturdy, transportable set using transistors, circuitry encapsulated plug-in units, and printed wiring. This set is waterproof, shockproof and temperature resistant, ready for headquarter/field use. Telephone Set TA-341/PT is a 4-wire, battery operated instrument that employs voice-frequency supervision and signaling. A keyset is used instead of the conventional dial. It is simpler to operate, faster, and allows the use of compound tone signaling. The tones operate the equipment in a manner comparable to dial pulses in the conventional dial telephone system.

The TA-341/PT can also function independent of the switchboard equipment —point-to-point wire (DC) or point-to-point radio (AC).



TELEPHONE SET TA-341/PT

AN/TTC-12

Operating Temperature	−40° F to +149° F
Number of Line and Trunk Circuits	280
Trunking Facilities	40% (60 simultaneous transmission paths)
Transmission Bandwidth	250 to 4500 cps ±1 db with respect to 1000 cps
Type of Switching	4-wire
Types of Equipment Connected to	Radio relay, microwave, carrier, wire line or any equipment having a bandwidth of 300 to 3000 cps
Insertion Loss (line-to-line, trunk-to-trunk)	0 db ±.25 db with respect to reference level
Power Requirements	110 volts, 50 to 60 cps, single phase
Input Impedance	600 ohms ±10% between 300 to 3500 cps at a phase angle of less than 30°
Signaling Tones	Dial tone (600 cps) Busy tone (600 cps interrupted) Seize tone (1700 cps) Ring tone (600 cps interrupted) Keying tones (1700 to 2900 cps combination of two provide 10 different digits) Interlocking tones are provided between AN/TTC-13, -15 and other centers to minimize effects of radio fade
Shelter Size	81 in. h x 141 in. lg x 83 in. wd

AN/TTC-13

Operating Temperature	−40° to +149° F
Number of Trunks	160
Trunking Facilities	100% (80 simultaneous transmission paths)
Transmission Bandwidth	250 to 4500 cps, ±1 db with respect to 1000 cps
Type of Switching	4-wire
Types of Equipment Connected to	Radio relay, microwave, carrier, wire line or any equipment having a bandwidth of 300 to 3000 cps
Insertion Loss (trunk-to-trunk)	0 db ±.25 db with respect to reference level
Power Requirements	110 volts, 50 to 60 cps, single phase
Input Impedance	600 ohms ±10% between 300 to 3500 cps at a phase angle of less than 30°
Signaling Tones	Dial tone (600 cps) Busy tone (600 cps interrupted) Seize tone (1700 cps) Ring tone (600 cps interrupted) Keying tones (1700 to 2900 cps combination of two provide 10 different digits) Interlocking tones are provided between AN/TTC-12, -15 and other centers to minimize effects of radio fade
Shelter Size	81 in. h x 141 in. lg x 83 in. wd

AN/TTC-15

Operating Temperature	−40° F to +149° F
Number of Trunks	138
Trunking Facilities	100% (70 simultaneous transmission paths)
Transmission Bandwidth	250 to 4500 cps, ±1 db with respect to 1000 cps
Type of Switching	4-wire
Types of Equipment connected to	Radio relay, microwave, carrier, wire line or any equipment having a bandwidth of 300 to 3000 cps
Insertion Loss	0 db ±.25 db with respect to reference level
Power Requirements	110 volts, 50 to 60 cps, single phase
Input Impedance	600 ohms ±10% between 300 to 3500 cps at a phase angle of less than 30°
Signaling Tones	Dial tone (600 cps) Busy tone (600 cps interrupted) Seize tone (1700 cps) Ring tone (600 cps interrupted) Keying tones (1700 to 2900 cps combination of two provide 10 different digits) Interlocking tones are provided between AN/TTC-12, -13 and other centers to minimize effects of radio fade
Shelter Size	81 in. h x 141 in. lg x 83 in. wd

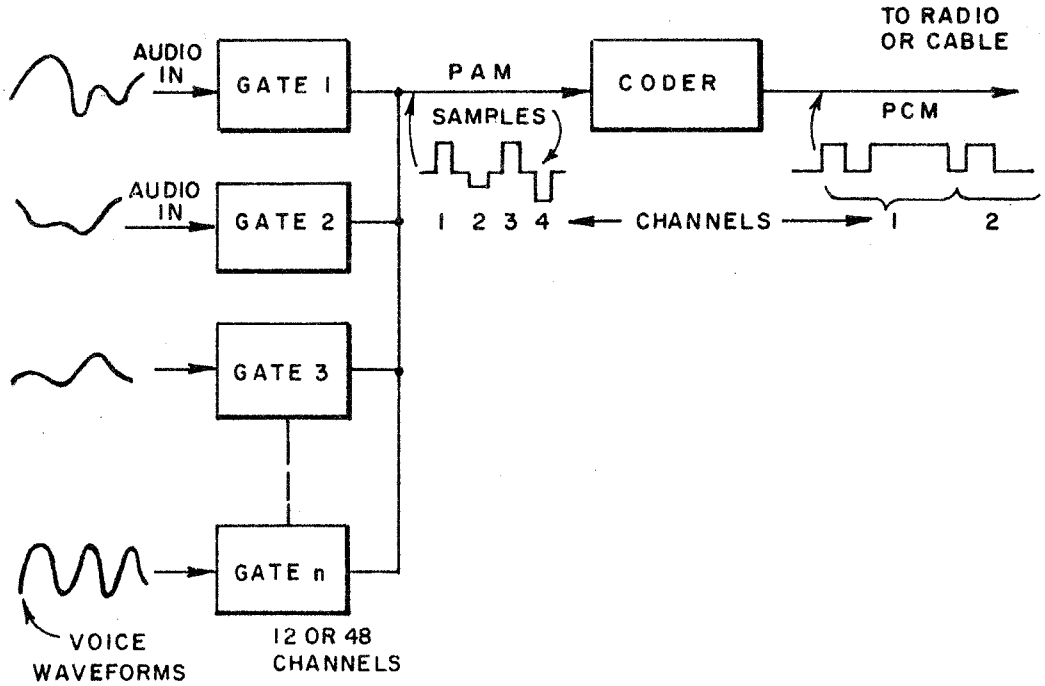
TA-341/PT

Power Supply	Self contained dry cells
Number Batteries Required	6 C size flashlight cells (BA-42)
Operating Temperature	−40° F to +149° F
Transmission Frequency Range	300 to 3500 cps
Ringing Level	80 db RAP maximum at 3 feet
Output Transmission Levels	−9 dbm nominal voice −4 dbm nominal compound signaling tone
Size	3¾ in. h x 9⅛ in. lg x 10⅝ in. wd
Weight	10.5 lbs
Material	Color impregnated, glass filled polyester
Color	Olive drab, dull finish

Section IV. Pulse Code Modulation

The 96-Channel PCM System represents an important contribution to planned military communications networks. The increased military use of computers and data-processing equipment and the communciations needs of weapons systems have established a trend indicating that transmission in the future will be dominated by digital traffic. PCM is the most efficient method for handling this type of traffic, provides the best performance over most types of transmission facilities, and achieves the aim of flexibility by meeting the majority of communications requirements with a single type of system. This rugged, fully transistorized equip-

GENERATION OF PCM



ment provides for multichannel voice and data transmission over radio and/or cable links; its digital form allows easy and complete regeneration at repeaters, which provides the key to preserving the high quality of the voice circuits through many links in long-distance circuits.

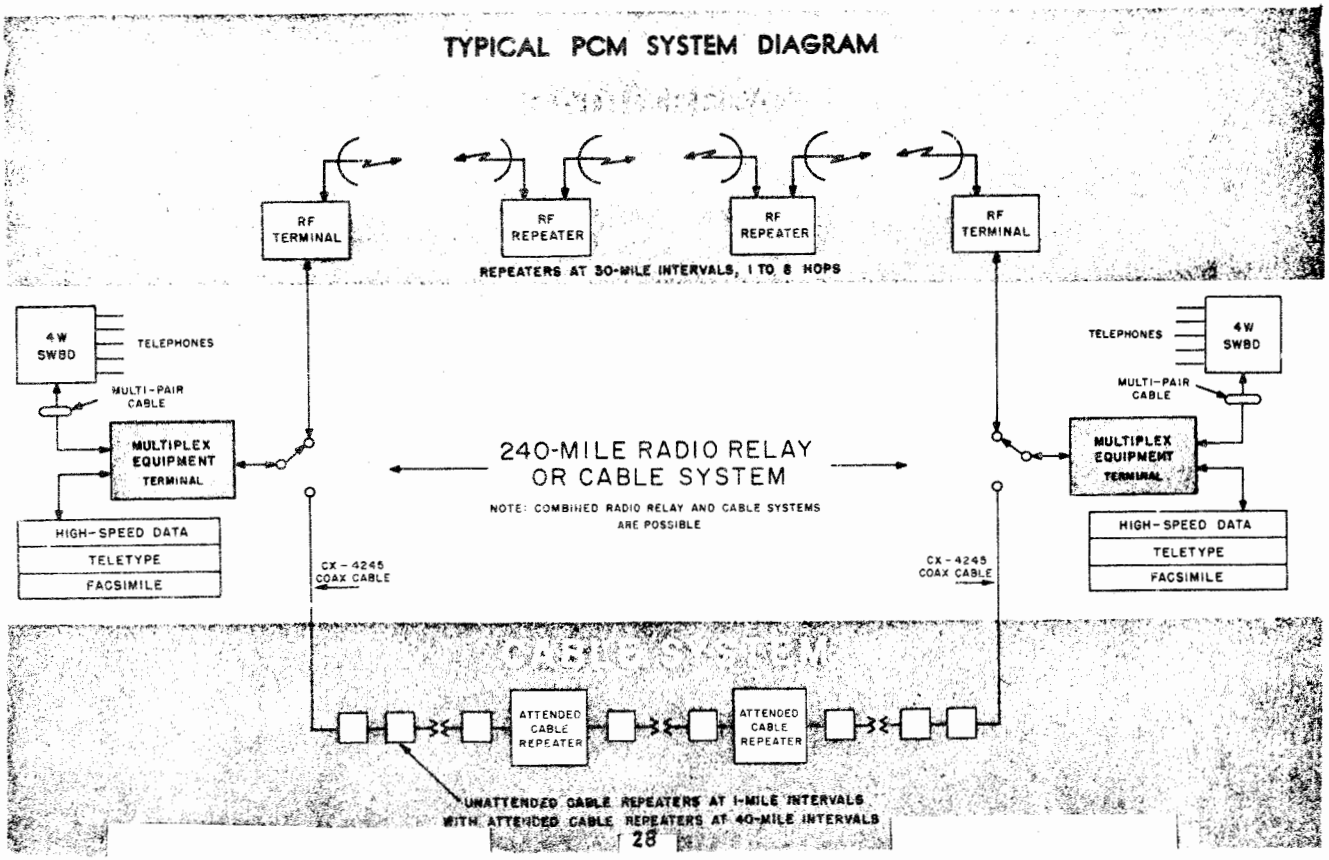
The PCM System transmits and receives 12, 24, 48 or 96 voice-frequency signals in digital form over a radio system and 12, 24, or 48 channels over a cable system by time-division multiplexing and pulse-code modulation. It provides a most modern, highly efficient telephone link to meet increasing communications requirements, while at the same time achieving high reliability, small size, and economy.

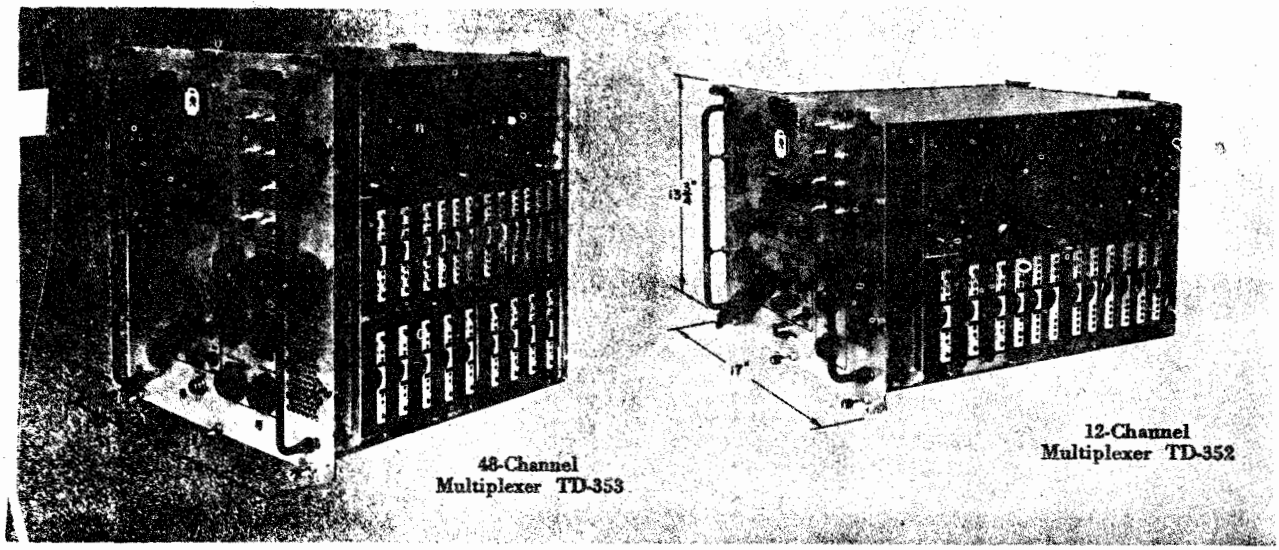
Reliability

In PCM, the transmission amplitude variations do not affect the signal. Simple repeaters furnish complete signal regeneration, eliminating the effects of noise, distortion, interference, cross-talk and channel-loading problems in the transmission medium. It is necessary only for the PCM receiver terminal to recognize the presence or absence of a pulse. Noise build-up therefore can be excessive by analog standards, and as long as the interfering level is not within a few db of the information pulse, regeneration eliminates the interference without error. This means that high-quality, multichannel voice circuits can be provided over a low-quality transmission media.

Economy

The cost of PCM terminal equipment per channel is less than conventional systems. Both voice and digital data are handled. Both the radio and the cable system integrate with the military ground-communications network.





48-Channel
Multiplexer TD-353

12-Channel
Multiplexer TD-352

EQUIPMENT

Two types of multiplexers are used, one type for 12 and 24 channels, the other tyype for 48 and 96 channels. Two types of combiners are used, one type for transmission and reception of multichannel voice and digital data over radio, the other type for the same traffic over cable. System length in either radio or cable can be up to at least 240 miles.

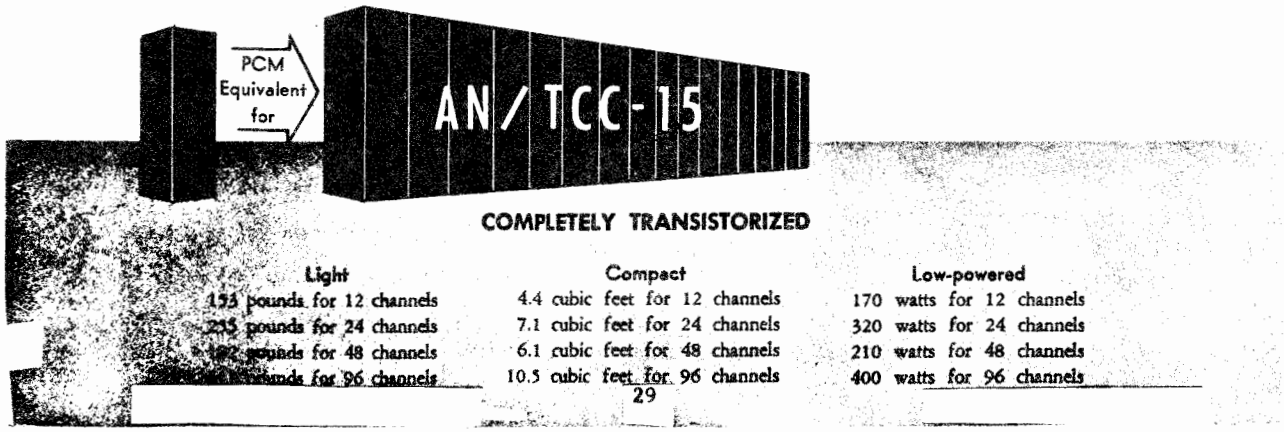
The equipment is housed in standard Signal Corps cases and consists of the following items:

12-channel multiplexer, TD-352
48-channel multiplexer, TD-353
48/96-channel combiner for radio systems, TD-202
12/24-channel combiner for radio systems, TD-203
12/24/48-channel combiner for cable systems, TD-204
12/24/48-channel unattended repeater for use with CX-4245 cable, TD-206

Combinations of the above equipment are made to fill various applications: a 96-channel radio terminal uses two TD-353's, one TD-202, and the appropriate radio set; a 12-channel cable terminal uses one TD-352, one TD-204, and one TD-206 repeater in each mile of cable; a conversion between a radio system and a cable system handling 24 channels uses one TD-203 and one TD-204.

Other stations, such as drop-and-insert points and attended repeaters, are assembled from the above units. The radio and cable combiners have been designed so that 12 of the 24 channels or 48 of the 96 channels can be dropped and reinserted at any of the attended points.

Many novel circuit and packaging techniques are employed. High-speed switching transistors and diodes are used extensively. Modular techniques embodying printed circuits are used throughout, and modules are plastic-coated to insure rigidity and protection to the components.

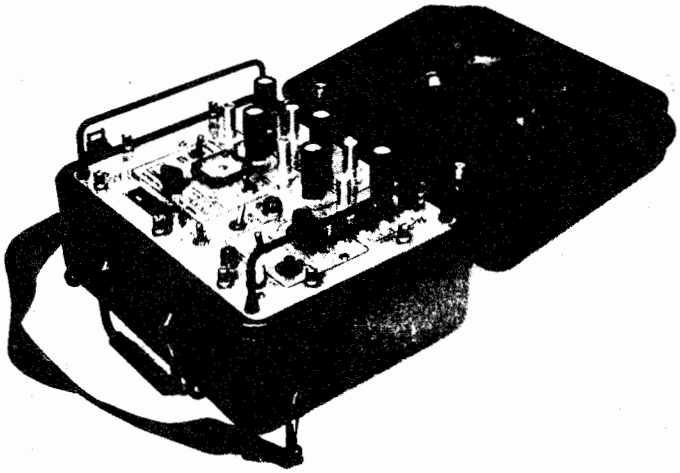


COMPLETELY TRANSISTORIZED

Light	Compact	Low-powered
153 pounds for 12 channels	4.4 cubic feet for 12 channels	170 watts for 12 channels
235 pounds for 24 channels	7.1 cubic feet for 24 channels	320 watts for 24 channels
192 pounds for 48 channels	6.1 cubic feet for 48 channels	210 watts for 48 channels
[illegible] pounds for 96 channels	10.5 cubic feet for 96 channels	400 watts for 96 channels

Additional Items

Additional items designed and developed for the PCM system are a lineman's test set for the checking of cable repeaters; a video-filter unit to simulate for test purposes the characteristics of the radio relay with which the system will integrate; and a probe to locate inoperative cable systems.



Lineman's Test Set
Telephone TS-1323/PT

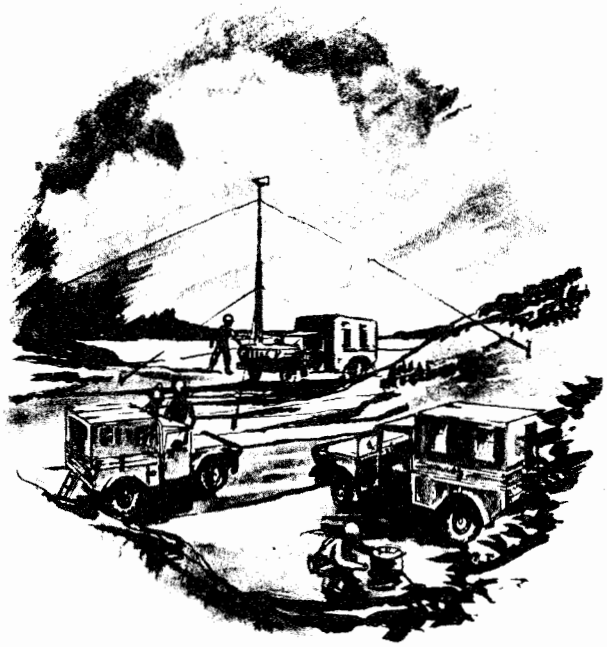
OPERATION

Any multichannel communication system provides for the transmission of a number of signals simultaneously. To do this, the signals must first be multiplexed and modulated — in other words, the signals must be combined for transmission over a common transmission medium, but combined in such a way that they will not interfere with each other and will be received in distinct form.

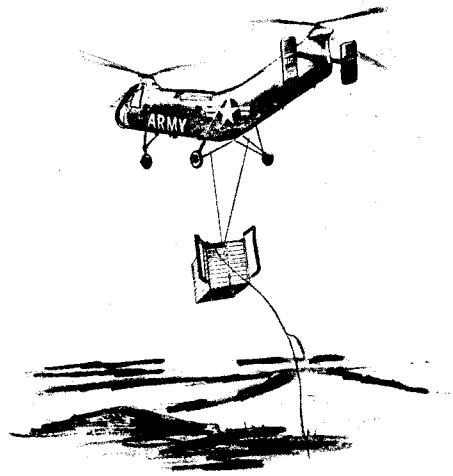
In PCM, the terminal accepts 12, 24, 48 or 96 voice-frequency signals, samples them, codes these samples in a 6-digit binary code, and transmits the coded signal to the input of the radio-relay set or over the coaxial cable. In addition, the terminal accepts the incoming PCM pulse train from the radio or cable, decodes these signals, and distributes them to the proper voice channel. Provisions for handling two high-speed data channels are included, each having a maximum information capacity of 48,000 bits per second.

Radio System

In the radio system, the equipment can work with the AN/GRC-50 radio set for 12 or 24 channels, and with the AN/GRC-59, 62, and 66 radio sets for 48 or 96 channels. In each radio, the bandwidth is not changed to double the traffic capacity. The half-traffic cases (12 and 48 channels) are transmitted on a straight binary basis. A method of transmission known as bi-ternary is used for handling the full-traffic cases (24 and 96 channels). A baseband voice-frequency order wire is also provided.



Typical Radio Relay PCM Terminal Site



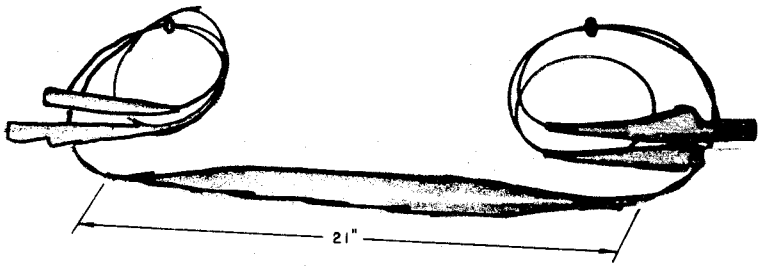
Paying Out Unattended Repeaters TD-206 with Cable CX-4245

Cable System

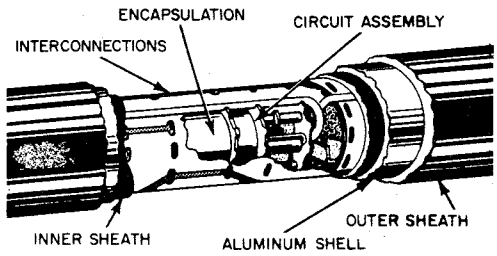
The cable system can carry 12, 24, or 48 channels without changing equipment. Ninety-six-channel systems are provided by operating two 48-channel systems in parallel. The cable is a small, strong, lightweight twin coax, and, with repeaters connected every mile, can be laid by helicopter at speeds up to 60 mph, as well as by more conventional techniques. It is operable even when submerged to a depth of several feet.

The cable system can have as many as 39 unattended repeaters before an attended one is necessary. Power for the repeaters is obtained from a constant-current supply located in the terminals and using the center conductors of the cable. A means for locating faulty unattended repeaters is available at attended points, and a connection to radio systems can be made there also. The unattended repeaters include circuits to re-time completely the received pulse train in both directions of transmission and to condition the pulses for re-transmission. In this process, each received pulse is replaced by a new one, standardized in timing, magnitude, and pulse shape, thus eliminating the accumulation of distortion due to noise and bandwidth limitations.

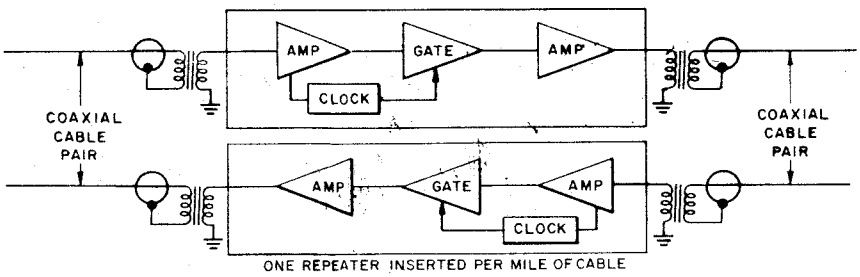
The cable system has an order-wire circuit at voice frequency which is independent of failure of traffic or any active circuits in the unattended repeaters. The order-wire signal is added to the PCM signal at attended points. Each attended repeater separates the order-wire and PCM signals. The PCM signal is sent through the pulse-regeneration circuits of the repeater, and the order-wire signal is sent through a loading coil. Thus, the repeater inserts no active elements into the order-wire circuit, and the order wire is independent of repeater failure.



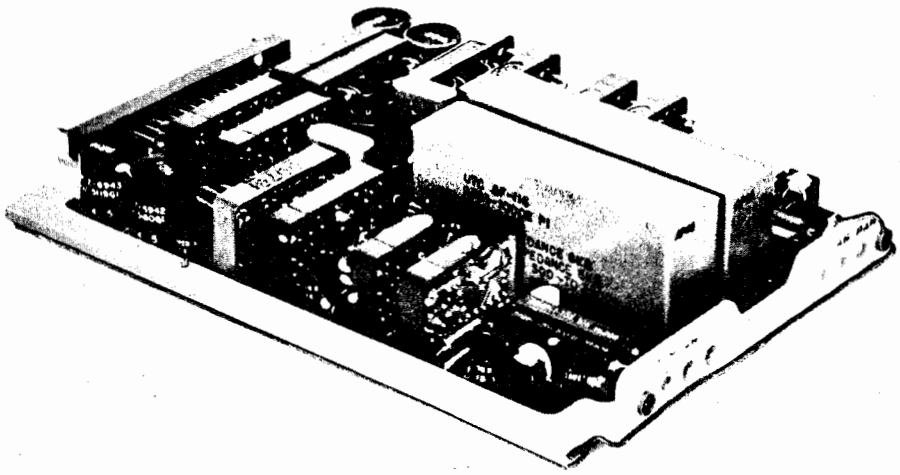
Unattended Repeater TD-206



Cutaway View of Unattended Repeater



Block Diagram of PCM Circuit in Unattended Repeater



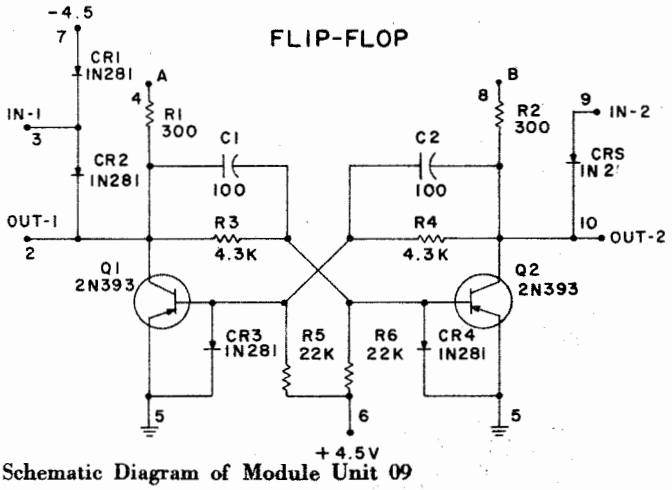
Plug-in Printed-circuit Panel – Double-channel Modulator/Demodulator

MAINTENANCE EASE

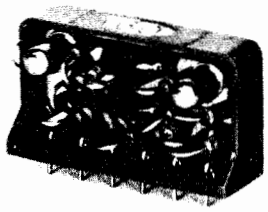
Special care has been given to the selection and inspection of components and to ease of maintenance, since it is expected that this equipment generally will remain in continuous, round-the-clock service. This equipment will meet all of the rugged environmental conditions imposed by the Signal Corps, including operation from −29°C to +55°C (−20°F to 132°F).

The equipment is designed to permit rapid performance checks by inexperienced operators. Front-panel resemblance among all the units, with the same types of connectors and controls located in the same places on all the units, makes the equipment easier to understand and service.

Groups of modules and other components are mounted on plug-in printed-circuit panels, so arranged that a complete major-circuit function is performed on each panel; a few require more than one panel. Each panel has test points for fault analysis and has provisions for determining from a front-panel meter which function is at fault, thus permitting rapid replacement of plug-in panels. The panels are plugged into the main frame of the unit, and cabling between panels is accomplished completely on the main frame. Heavier power supply components are mounted on metal subchassis.



Schematic Diagram of Module Unit 09



Module Unit 09
(shown actual size)

TECHNICAL CHARACTERISTICS

	LOW-TRAFFIC SYSTEM MULTIPLEXER SET AN/TCC-44 (12 channels) AN/TCC-45 (24 channels)	HIGH-TRAFFIC SYSTEM MULTIPLEXER SET AN/TCC-46 (48 channels) AN/TCC-47 (96 channels)
GENERAL		
1. No. of audio channels	12 channels with 1 multiplexer 24 channels with 2 multiplexers	48 channels with 1 multiplexer 96 channels with 2 multiplexers
2. Radio sets	AN/GRC-50	AN/GRC-59 AN/GRC-62 AN/GRC-66
3. Cable	Coax cable CX-4245	Coax cable CX-4245
4. Type of multiplexing	Time division	Time division
5. Type of modulation	Pulse code	Pulse code
6. No. of PCM digits	6 digits per channel sample	6 digits per channel sample
7. Channel sampling rate	8 kc	8 kc
8. Power supply input	115 v, 47-63 cps	115 v, 47-63 cps
9. Power consumption (for use with radio)	170 w for 12 channels 320 w for 24 channels	210 w for 48 channels 400 w for 96 channels
10. Weight (including cases) (terminal of 1 or 2 multiplexers and 1 combiner)	153 lb for 12 channels 255 lb for 24 channels	182 lb for 48 channels 313 lb for 96 channels
11. Volume (terminal of 1 or 2 multiplexers and 1 combiner)	4.4 cu ft for 12 channels 7.1 cu ft for 24 channels	6.1 cu ft for 48 channels 10.5 cu ft for 96 channels
AUDIO		
1. Input level for full modulation	−4 dbm (4-wire)	−4 dbm (4-wire)
2. Output level for full modulation	−4 dbm (adj) (4-wire) or 0 dbm (2-wire)	−4 dbm (adj) (4-wire) or 0 dbm (2-wire)
3. Termination impedance	600 ohms (balanced)	600 ohms (balanced)
4. Modulating bandwidth	300 to 3500 cps	300 to 3500 cps
5. Signal-to-noise ratio (F1A)	55 db	55 db
6. Signal-to-noise plus crosstalk ratio	53 db	53 db
7. Distortion	Less than 4%	Less than 4%
VIDEO		
1. Impedance input-output	50 ohms	50 ohms
2. Pulse amplitudes input-output	±0.5 to ±1.0 v (radio)	±0.5 to ±1.0 v (radio)
3. PCM pulse width	Full width (radio) Half width (cable)	Full width (radio) Half width (cable)
4. Pulse interval	1.735 microsec (12 channels)	0.44 microsec (48 channels)
5. Frame interval	125 microsec (8 kc)	125 microsec (8 kc)
6. Channel interval	10.4 microsec (96 kc)	2.6 microsec (384 kc)
7. Pulse rate	576 kc for 12 channels 1152 kc for 24 channels	2.304 mc for 48 channels 4.608 mc for 96 channels
8. Bandwidth (at 3-db point)	240 kc (radio) 1-mc bandpass (cable)	935 kc (radio) 1-mc bandpass (cable)
9. Bandshape	Gaussian low pass (radio) Gaussian bandpass (cable)	Gaussian low pass (radio) Gaussian bandpass (cable)
10. Pulse type	Binary (12-channel radio) Binary dipulse (12/24-channel cable) Bi-ternary (24-channel radio)	Binary (48-channel radio) Binary dipulse (48-channel cable) Bi-ternary (96-channel radio)

SIG 5 BACK - 2

The AN/VRC-24 is a vehicular radio communication set designed for operation as the ground terminal in a ground-to-air communication system (figure 1). Such a system is used to control tactical aircraft operating in a close support of ground forces. The new radio set will be operated by tactical air control parties in liaison with ground combat units.

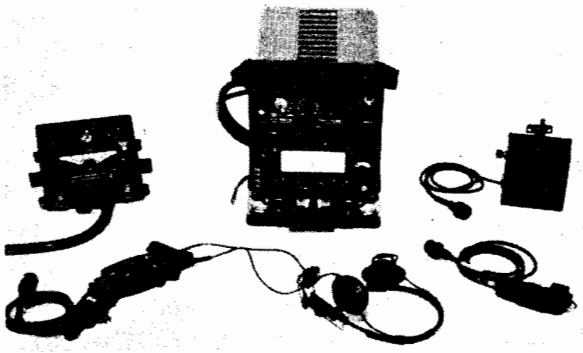


Figure 1. Radio Set AN/VRC-24
and accessories.

During World War II, the tactical necessity of close support between ground and air was strikingly emphasized. As an interim measure, Radio Set AN/ARC-27, originally designed for use in aircraft, was employed as a ground terminal set. The AN/ARC-27() was to be continued in use until a radio set could be specially designed for combat vehicular operation on an air-to-ground basis.

In addition to operation in climatic extremes, the proposed radio set would have to be capable of withstanding such service conditions as sustained vibration, ballistic shock, submersion, dust, spray, and the negative acceleration incident to delivery by parachute. The successful design of Radio Set AN/VRC-24 fulfills all of the enumerated specifications.

The AN/VRC-24, which has been classified as standard, replaces the AN/ARC-27() for field operation. Its volume of 1.29 cubic feet permits installation in new vehicles such as the tank, 76mm gun, T-92 -- formerly, the 2.68 cubic feet of volume of the AN/ARC-27() made such installation impractical. A saving in total weight is also realized -- the AN/VRC-24 weighs 80 pounds as compared to an approximate 126 pounds for the AN/ARC-27(). In addition, the AN/VRC-24 has power input requirement of 260 watts in receive and 355 watts in transmit; this compares favorably with the 450- and 525-watt requirements of the AN/ARC-27().

Other salient features of the new equipment include increased reliability, improved performance, ease of maintenance, and cost reduction. The dual use of RF, IF, and audio circuitry for both receive and transmit has resulted in a total tube count of 28 tubes of six types; indirectly, this has let to a 40 percent reduction in the total of all components required. To emphasize the comparison, the AN/ARC-27() uses 44 tubes of ten tube types, while a UHF aircraft set of recent design uses 59 tubes of 21 types.

In the AN/VRC-24, a simplified mechanical tuning system tunes each channel for maximum performance. Unitized construction has made readily accessible all adjustment and alignment devices. Such devices are now useable without removal of the subassemblies, and the eventual testing of these subassemblies under operating conditions.

Radio Set AN/VRC-24 provides transmission and reception of amplitude-modulated radio telephone signals within the frequency range of 225 to 399.9 megacycles. This radio set is also capable of security transmissions when operated in conjunction with cipher equipment.

There are 1,750 crystal-controlled channels with a 100 kc spacing. Channels may be selected individually by use of three manual frequency selector switches. In addition, any 19 of these 1,750 channels may be present and then individually selected by use of a single preset selector switch, which is either provided on the front panel of the radio set or at a remote control station.

The basic radio set, when available by stock number at United States

Army Signal Corps Depots, will contain the following items in one wooden crate:

Radio Receiver-Transmitter RT-323/VRC-24 (figure 2).
Dynamotor DY-151/U.
Base Stand MT-1436()/VRC-24.
Antenna AT-803()/VR.
Dynamic Loudspeaker LS-166/U.
Microphone M-29/U.
Radio Frequency Cable Assembly CG-1650/U.
Technical Manual.

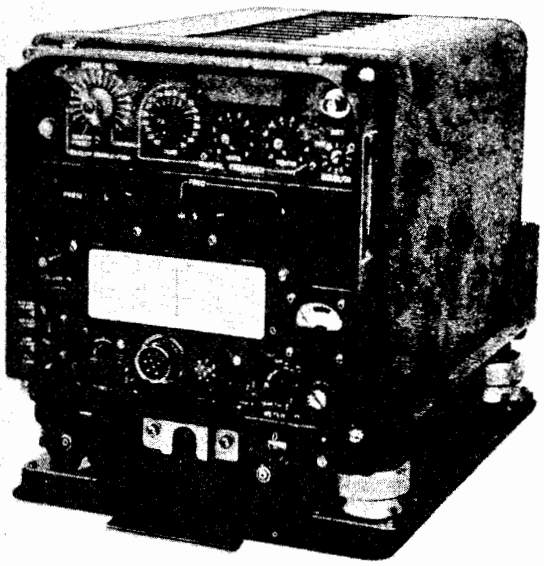


Figure 2. Receiver-Transmitter RT-323/VRC-24 showing control panel details.

Installation kits with materials and instructions for installing the basic unit will be issued by stock number at the depots.

The complete technical characteristics of Radio Set AN/VRC-24 follow:

General:

Frequency range - 225.0 to 399.9 mc.
Channel spacing - 100 kc per channel.
Number of channels - 1,750.
Number of preset channels - 19.
Time required to preset single channel - 10 seconds.
Channel selection time - 7 seconds maximum.

Automatic channel selection - rotary switch (either from front panel or remote control unit).
Number of crystals - 35.
Number of tubes - 28.
Number of tube types - 6.
Number of silicon diodes - 8.
Type of modulation - amplitude.
Type of transmission - voice data.
Power source - vehicular 24-volt battery.
Power requirements - receive: 26.4 vd-c nominal at 9.4 amps, 14.2 amps when frequency selector is running.
Transmit: 26.4 vd-c at 14 amps, full modulation maximum starting current, 150 amps.

Internal power source: Dynamotor DN-151()/U.
Antenna AT-803()/VR - cylinder 2 1/4" diam x 9 1/2" high, mounted on steel plate 20" x 9".

Tuning: Preset channel and frequency indication read through transparent windows on front panel. Channel is also indicated by switch position.

Weight: Less mounting base - 60.5 lbs.
With mounting base - 80.0 lbs.

Size: Less mounting base - 11 3/4" x 9-15/16" x 15 1/2" (HWD).
With mounting base - 12 3/32" x 10-5/8" x 17-3/32" (HWD).
Transmitter:

Power output - 16 watts into 52 ohms resistive load.
Modulation - high level amplitude modulation.
Oscillator - 0.1 mc 3.0 - 3.9 mc.
1.0 mc 19.0 - 26.0 mc.
10.0 mc 31.1 to 45.0 mc.
Microphone - M-29/U.
Microphone input impedance - 150 ohms nominal.
Range - approximately line of sight.
Duty cycle - 9 minutes receive to 1 minute transmit.
1 hour continuous transmit at 65° F.

Receiver:

Type - superheterodyne, triple conversion, a-m.
Sensitivity - 6 microvolts or less in series with 500 ohms for a 10 db signal plus noise/noise ratio.
Oscillators - same as for transmit.
IF amplifiers -
1st IF (variable) 20.0 to 29.9 mc.
2nd IF (variable) 3.0 to 3.9 mc.
3rd IF (fixed) 500 kc.
Audio outputs - speaker output - 1 watt, 600 ohms, receive.

Headset - 100 mw, 600 ohms, receive, sidetone.
Remote output - 100 mw, 100 mw per headset (one to six headsets), receive, sidetone.
Remote, low level - 50 mw, 600 ohm, receive, sidetone.

It is anticipated that operating personnel who are familiar with such vehicular radio sets as the AN/GRC-3 through -8 will be able to operate the AN/VRC-24 with about three hours of instruction.

After an appropriate period of on-the-job training, military personnel trained in field and depot maintenance should be capable of maintaining the AN/VRC-24 at their assigned echelon. At both echelons pertinent technical literature is prerequisite.

Section II. Radio Set AN/PRC-25

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Set AN/PRC-25 is a short range, man-pack, FM receiver-transmitter used for two-way communications in forward areas. It is completely transistorized, except for the transmitter power output tube, and employs module form construction using printed circuits.

The AN/PRC-25 may be switched into any one of the following four modes of operation by means of a function-selector switch mounted on the control panel. (1) Receive-Transmit, (2) Receive-Transmit plus auxiliary receiver, (3) Remote (from telephone line), (4) and Relay operation. Relay operation permits reception on one frequency and retransmission on another without attention.

The AN/PRC-25 will replace Radio Sets AN/PRC-8, -9 and -10.

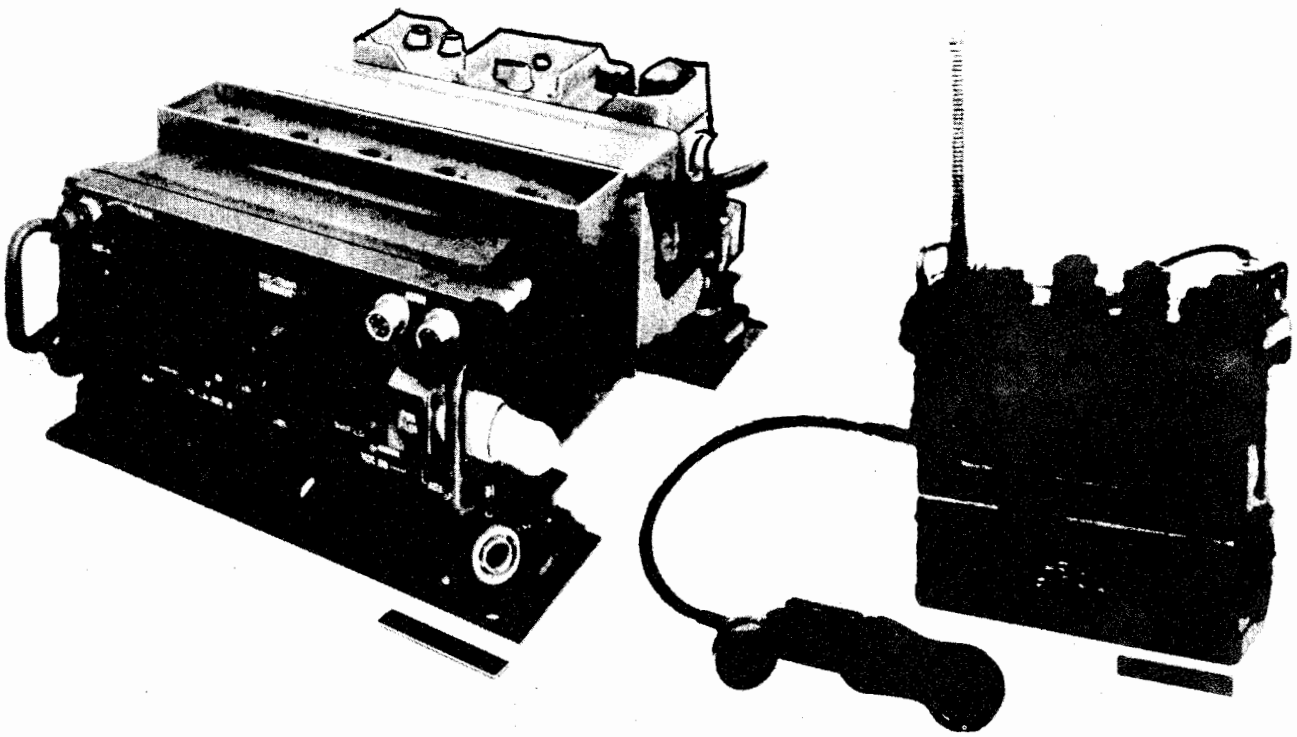
USE:

Short range, man-pack, receiver-transmitter used in forward areas.

INSTALLATION:

Portable or vehicular mounted.

SIG 6 FRONT - 1



Radio Set AN/PRC-25.

TECHNICAL CHARACTERISTICS
TRANSCEIVER

MODULATION:

FM

FREQUENCY RANGE:

30 mc to 75.95 mc.
30 mc to 52.95 mc (low band).
53 mc to 75.95 mc (high band).

SENSITIVITY:

0.7 uv rf to give 10 db signal-to-noise ratio.

LIMITING:

Less than 3 db change in audio for rf variation of 3 to 10,000 uv.

I-F FREQUENCY:

11.5 mc.

I-F BANDWIDTH:

6 db - 35 kc.

AUDIO RESPONSE:

3 db response - 300 cps and 3,000 cps.

AUDIO OUTPUT:

5 mv max.

TRANSMITTER OUTPUT:

1.5 w.

DEVIATION:

$\pm$ 10 kc.

AUXILIARY RECEIVER

FREQUENCY RANGE:

30 mc to 70 mc.

SENSITIVITY:

1 to 6 uv r-f to give 10 db signal-to-noise ratio.

TUNING:

Continuous.

GENERAL

POWER SOURCE:

3 v, 15 v, and 150 v required. Available from either low-voltage battery and converter, high-voltage battery, or vehicular power supply and converter.

BATTERY LIFE:

20 hrs with 9 to 1 receive-transmit cycle.

CONTROL SYSTEM:

On-off, Receive-Transmit, R-T plus Auxiliary Receiver, Remote, and Relay.

ANTENNAS:

Short Antenna (3-ft length) and long antenna (10-ft length).

PHYSICAL CHARACTERISTICS

Item	Dimensions (in.)	Weight (lb)
Radio Set AN/PRC-25	11 x 4 x 11	17

SIG 6 BACK - 2

Section III. Radio Sets AN/PRC-34 and -36

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Sets AN/PRC-34 and -36 are subminiature radio sets for forward area, short distance, man-to-man communications. Both are completely transistorized (except for the transmitter power amplifier) and employ module form construction and printed circuits.

Radio Set AN/PRC-34 and AN/PRC-36 are electrically identical, but they are mounted differently. The AN/PRC-34 is the helmet-radio and the AN/PRC-36 is the pouch-type radio.

These sets have two modes of operation: voice and tone. When voice operation is used, the carrier is frequency-modulated by pressing the push-to-talk switch on the microphone and talking into the microphone. When tone operation is used, a tone switch is used to activate a 1,000-cps multivibrator which produces an output to frequency-modulate the transmitter oscillator.

Because these sets are operated with low power and at VHF frequencies, the operating location greatly affects their operating range. The range under ideal conditions is 500 yards. If the other station can be seen, operation is probable. An intervening hill or tall building may hamper or prevent contact with other stations. Valleys, depressions, densely wooded areas, and low terrain are poor sites. Operating on a hilltop, tower, or flat terrain is very good for reception.

USE:

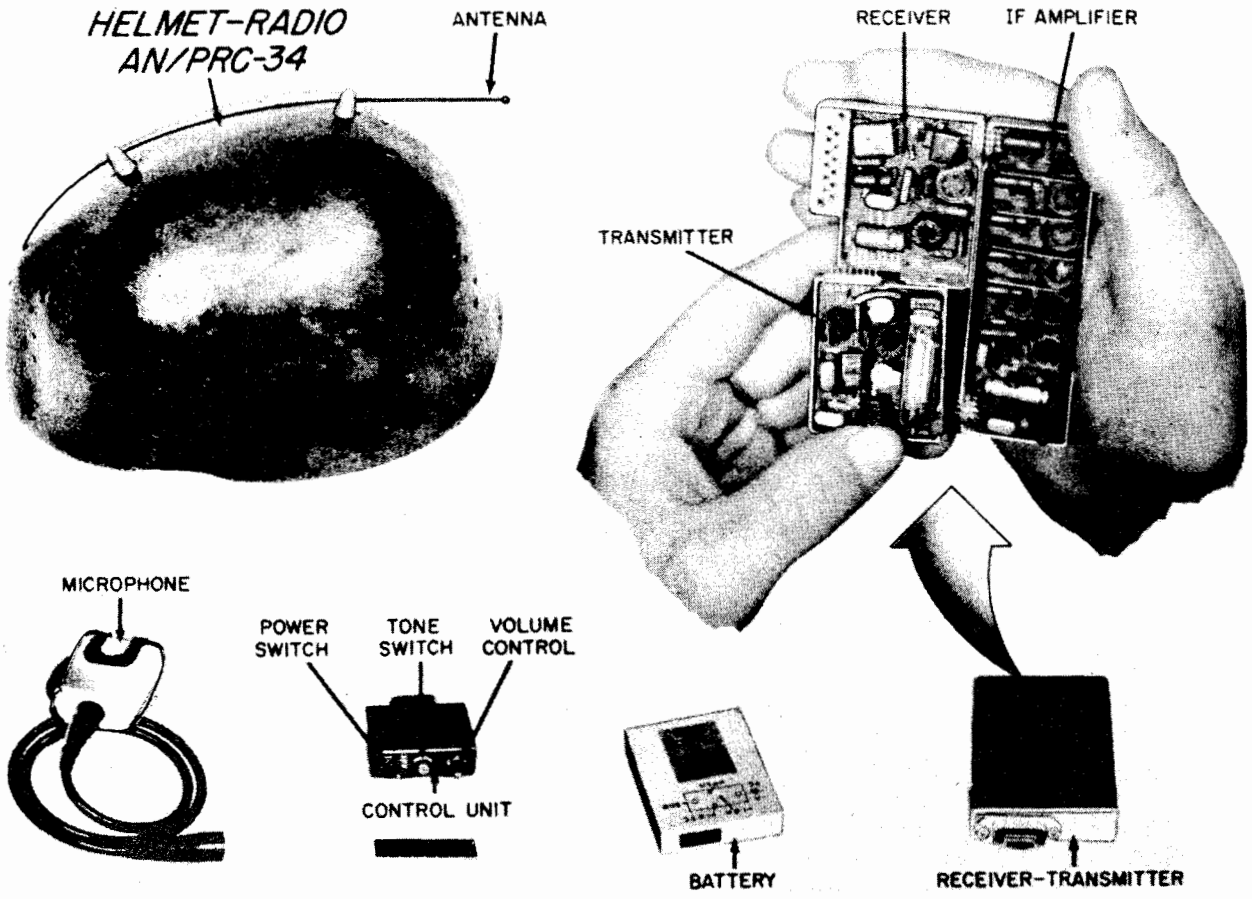
Both the AN/PRC-34 and AN/PRC-36 are short range, man-to-man communication sets for use in combat areas.

INSTALLATION:

AN/PRC-34: Helmet-radio with all components contained in the helmet.

AN/PRC-36: Pouch-type radio worn on belt or under shoulder

Antenna and earphone assembly are strapped to a helmet.



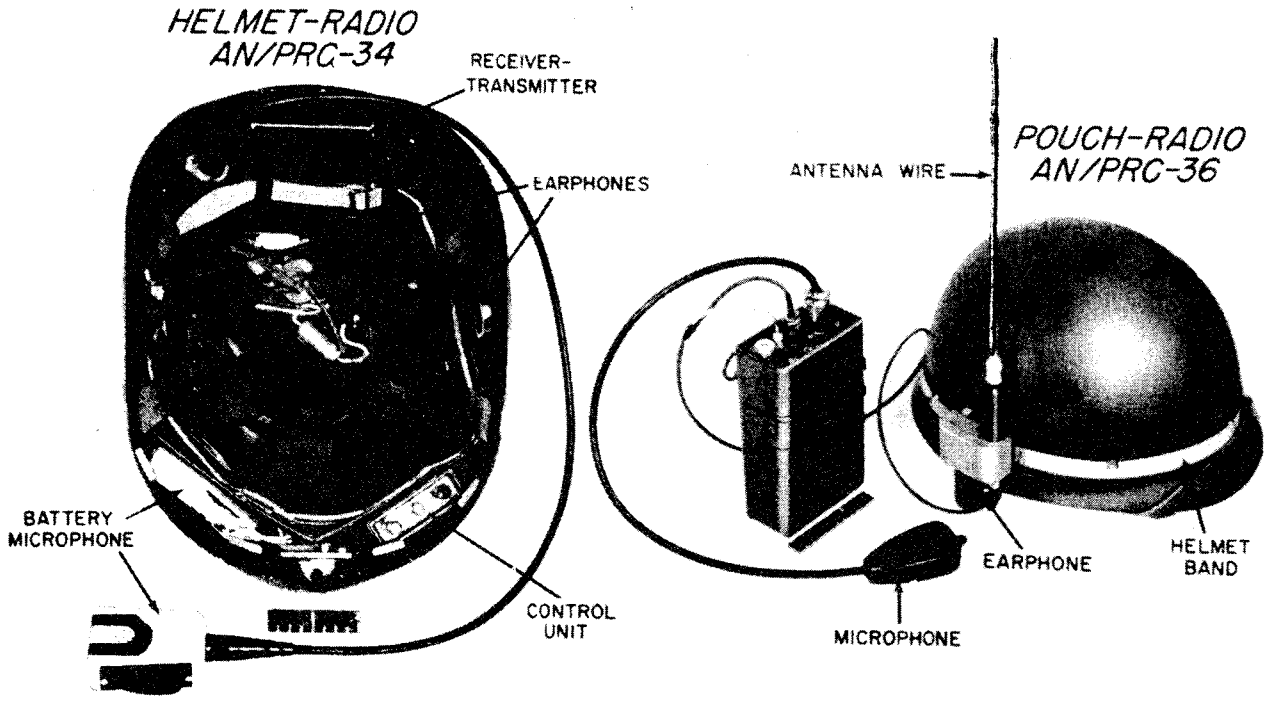
Radio Set AN/PRC-34 showing component parts.

TECHNICAL CHARACTERISTICS
RECEIVER-TRANSMITTER UNIT

FREQUENCY:

AN/PRC-34: 38 to 38.8 and 47.8 to 51.0 mcs spaced at 400-kc intervals.

AN/PRC-36: 47.8 to 51.0 mcs.



Radio Sets AN/PRC-34 and -36.

CHANNELS:

One of 12 factory preset. Frequency change accomplished by exchange of rf and transmitter modules.

RANGE:

AN/PRC-34: Nominal terrain - 350 yds antenna restrained, 500 yds antenna extended.
AN/PRC-36: 600 yds.

DIMENSIONS:

H-4-9/16" x W-2-7/8" x TH-3/4".

WEIGHT:

12 oz.

RECEIVER

TYPE:

FM superheterodyne.

SENSITIVITY:

3 uv.

BANDWIDTH:

70 kc nominal at 6 db; 550 kc max at 60 db.

AUDIO POWER OUTPUT:

1.5 mw.

POWER INPUT:

+1.5 v at 8 ma = 12 mw max
-4.5 v at 13 ma = 58.5 mw max
70.5 mw at max voltage
50 mw at nominal voltage

TRANSMITTER

POWER OUTPUT:

50 mw nominal.

MODULATION:

FM 15 kc deviation. Voice of 1,000 cps tone.

POWER INPUT:

0.500 w nominal.
1.25 v at 100 ma and 37.5 v at 11 ma nominal.

POWER SUPPLY DRY BATTERY

+1.5 v at 9 ma continuous and 100 ma 1/10 time.
+51 v at 12 ma 1/10 operating time.
-4.5 v at 13 ma continuous.

WEIGHT:

4 oz.

LIFE:

12 to 20 hours.

CONTROL HEADERS

POWER SWITCH.

TRANSMITTER WITH TONE MODULATION SWITCH.

VOLUME CONTROL.

ANTENNA

AN/PRC-34: 12 in. whip affixed and contoured to helmet.
AN/PRC-36: 12 in. whip affixed to elastic band which encircles standard helmet or liner.

PHYSICAL CHARACTERISTICS

Item	Dimensions (in.)	Weight
AN/PRC-34	2-7/32 x 3/4 x 2-5/16	3-1/2 oz.
AN/PRC-36	2-7/8 x 1-15/32 x 1-25/32	5 oz.
Case, AN/PRC-34 (helmet)	11-13/16 x 8-1/2 x 7	3 lbs.
Case, AN/PRC-36	5-27/32 x 3-5/16 x 1-13/16	1 lb, 10 oz.

Section IV. Radio Set AN/PRC-35

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Set AN/PRC-35 is a compact, man-portable, short range, FM transceiver used in forward areas. The transceiver, which is completely transistorized and battery-powered, contains six modules mounted on a main chassis. Printed wiring boards and subminiature parts are used in the modules. A timing mechanism permits presetting of four frequency channels by means of a single front panel selector switch.

Two modes of transceiver operation can be selected at the front panel. In one mode this set will net with other FM communications equipment. In the second or selective call mode, netting can occur only when the transmissions are accompanied by a 170-cps tone signal. Two AN/PRC-35 sets, both operating in this second mode, can thus carry on uninterrupted communications in the presence of other transmissions at the same carrier frequency. The transmitter is voice-actuated so that the transmitter carrier is turned on (and the receiver turned off) as each group of words is spoken into the handset. Hence, other AN/PRC-35 sets in a communications net can employ break-in operation during the pauses between phrases in normal speech.

USE:

The AN/PRC-35 is a forward area radio set which will be used with Radio Sets AN/VRC-1 and AN/PRC-25. It will replace Radio Set AN/PRC-6.

INSTALLATION:

The AN/PRC-35 may be worn on the operator's back or on his side. Better range is obtained when the set is worn on the back. The most suitable sites are hilltop, tower, flat terrain, and away from trees or buildings.

TECHNICAL CHARACTERISTICS

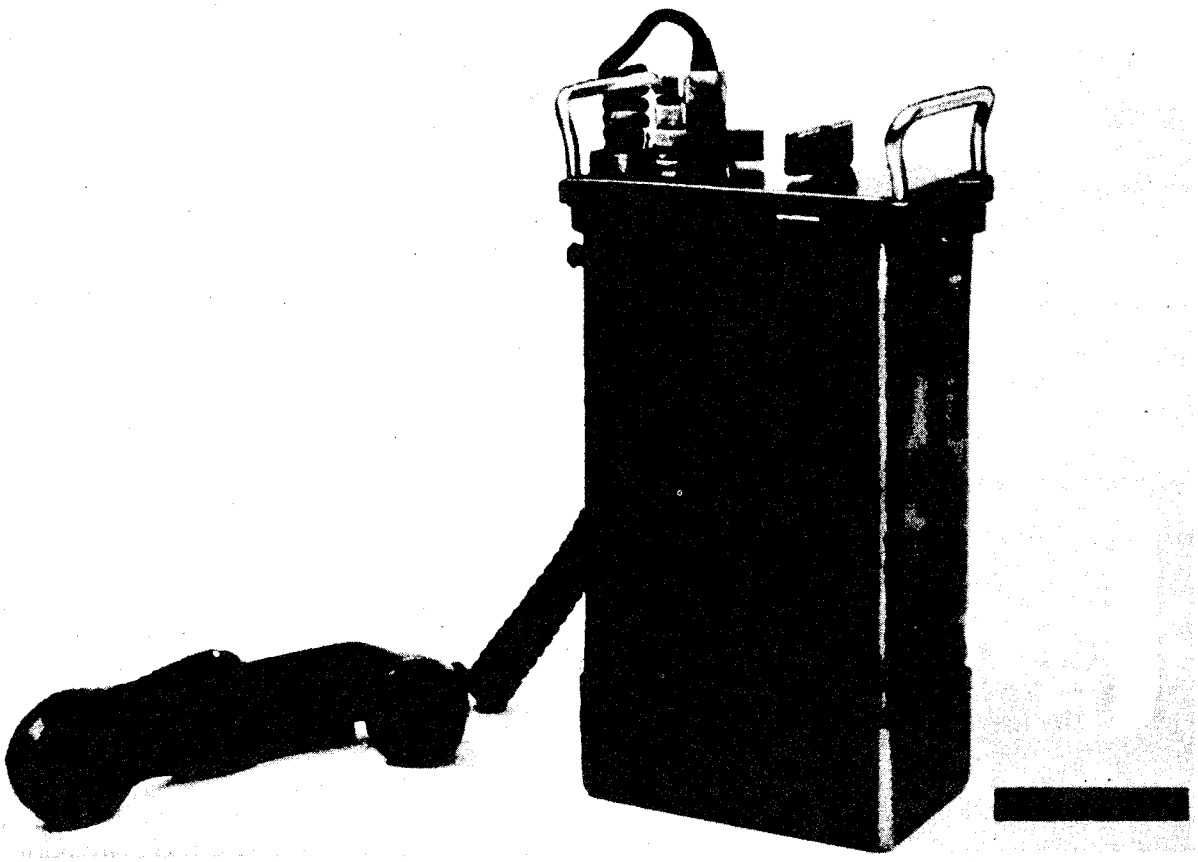
GENERAL

FREQUENCY RANGE:

30 to 69.950 mc in 50 kc intervals.

NUMBER OF TRANSISTORS:

34.



Radio Set AN/PRC-35.

NUMBER OF CRYSTAL DIODES:

33.

NUMBER OF MODULES:

6.

NUMBER OF RESONANT CRYSTALS:

20.

TUNING:

Four of the 800 frequencies are preset for front panel selection.

TYPE OF MODULATION:

Narrow band FM.

TYPE OF TRANSMISSION:

Voice.

POWER SOURCE:

20-cell dry battery, tapped at 9 cells to give voltages of 11.7 and 26 v at 1.3 v per cell.

BATTERY LIFE:

10 hours continuous operation.

DUTY CYCLE:

1 minute transmit, 9 minutes receive.

ANTENNA:

3-ft whip (also provision for 50-ohm AUX. ANT. input). Counterpoise woven into harness.

TRANSMITTER

POWER OUTPUT:

300 mw into 50 ohms at any frequency in the 30 to 69.950 mc range.

METHOD OF DEVIATION:

Capacity diode frequency modulates crystal.

MAXIMUM PEAK DEVIATION:

$\pm$ 12 kc.

NOMINAL PEAK DEVIATION:

$\pm$10 kc.

RANGE:

Approximately 2 mi under favorable terrain conditions.

SELECTIVE TONE FREQUENCY

170 cps.

PEAK SELECTIVE TONE DEVIATION:

$\pm$2 kc.

RECEIVER

RECEIVER TYPE:

Superheterodyne.

INTERMEDIATE FREQUENCY:

10 mc.

SIG 7 FRONT - 1

SENSITIVITY:

1.0 uv.

SELECTIVITY:

35 kc min (6 db down), 60/6 db shape factor, 2.5 max.

OUTPUT IMPEDANCE:

1,000 ohms (handset earphone).

Section V. Radio Set AN/VRC-24

Status: Standard A.

Stock Nr: Not yet available.

Reference: TM 11-5820-222-10, -20, -35.

GENERAL INFORMATION

Radio Set AN/VRC-24 is tentatively scheduled for production in spring 1960. Technical manuals (listed above) and stock numbers will be available after production.

Radio Set AN/VRC-24 is a rugged, small size, immersion proof constructed, VHF-UHF, AM vehicular radio set intended for transmission and reception between field and air support operations. It may be used in conjunction with Radio Sets AN/ARC-27 and -33 which are used in the aircraft. The AN/VRC-24 may be installed with Radio Sets AN/GRC-3 to -8 series and provide retransmission over these sets.

The AN/VRC-24 is the basic set forming Radio Set AN/TRC-68. The AN/TRC-68 is actually an ac operated AN/VRC-24. It contains Power Supply PP-1494( )/U mounted beside the basic AN/VRC-24. This permits operation with a 115 or 230 volt, 50-60 cps, ac source.

USE:

The AN/VRC-24 is intended for transmission and reception between field and air support operations.

INSTALLATION:

The AN/VRC-24 is a vehicular radio set. It may be installed with the AN/VRC-12.

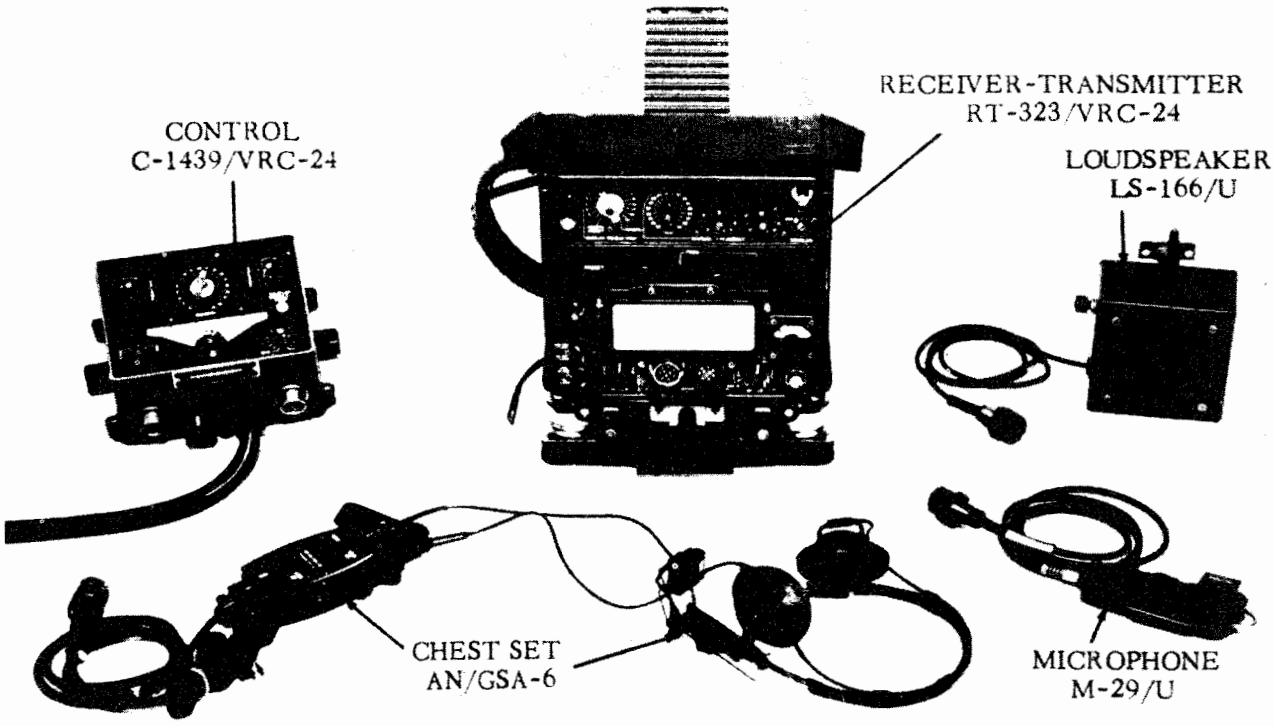
TECHNICAL CHARACTERISTICS

FREQUENCY RANGE:

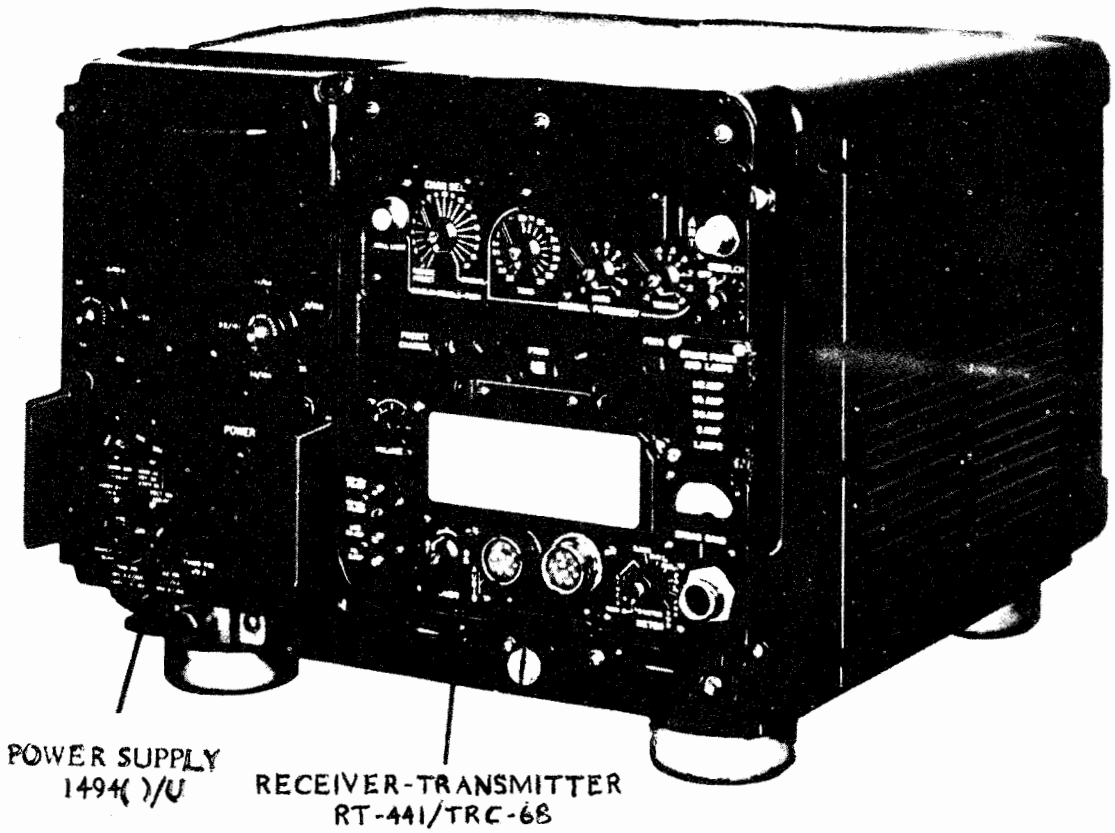
225.0 mc to 399.9 mc.

MODULATION:

AM.



Radio Set AN/VRC-24.



Radio Set AN/TRC-68.

POWER OUTPUT:

16 w min into 52 ohms, noninductive load.

RANGE:

Approx 30 mi (1,000 ft air elevation), 100 mi (10,000 ft elevation).

NUMBER OF CHANNELS:

1,750, all usable.

CHANNEL SPACING:

100 kc per ch.

FREQUENCY STABILITY:

Within +10 kc of nominal channel frequency over ambient temperature range of -55° C to +65° C.

FREQUENCY CONTROL:

Completely crystal-controlled.

NUMBER OF CRYSTALS:

35.

CHANNEL SELECTION TIME:

5 sec max.

PRESET SINGLE CHANNEL:

10 sec (approx).

PRESET CHANNELS:

19 preset channels plus 1 manual.

AUTOMATIC CHANNEL SELECTION:

Rotary Selector Switch on front panel or on control unit.

MANUAL CHANNEL SELECTION:

Available from front panel.

POWER REQUIRED:

Receive: 260 w.
Transmit: 360 w (full modulation).

DC POWER SUPPLY:

Dynamotor.

RECEIVER SENSITIVITY:

6 uv or less (in series with 50 ohms) for a 10-db signal plus noise-to-noise ratio.

RECEIVER SELECTIVITY:

Attenuation:	6 db. 60 db.
Bandwidth:	80 kc min. 150 kc max.

I-F AMPLIFIERS:

First i-f amplifier (variable):	20.0 to 29.9 mc.
Second i-f amplifier (variable):	3.0 to 3.9 mc.
Third i-f amplifier (fixed freq):	500 kc.

I-F REJECTION:

More than 100-db atten.

IMAGE RESPONSE:

More than 60-db atten.

AUDIO FIDELITY:

Within $\pm$2 db from 300 to 3,000 cps.

EXTENDED RANGE:

100 cps to 25,000 cps.

AUDIO OUTPUTS:

Speaker Output:	1 w, 600 ohms (receiver and sidetone).
Remote Unit Output:	600 mw, 600 ohms (receiver and sidetone).
Fixed Level:	50 mw, 600 ohms (receive audio).
Headset Output:	250 mw, 600 ohms (receive and sidetone audio).
Extended Range:	2 mw, 600 ohms.

PHYSICAL CHARACTERISTICS

Item	Dimensions (in.)	Weight (lb)
AN/VRC-24, Receiver-Transmitter and Mounting	16-15/32 x 12-3/32 x 10-5/8	72
AN/VRC-24 Control Unit	4 x 7 x 9-1/2	5.2

Section VI. Radio Sets AN/GRC-53, -54, and -55

Status: Developmental.

Stock: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Sets AN/GRC-53, -54, and -55 are intermediate and forward area, lightweight, VHF radio relay sets. Although adaptable to ground and vehicular (jeep and mule-mounted) operations, they will normally be mounted in Shelter S-144G. Radio Set AN/GRC-53 is the basic set forming Radio Terminal Set AN/GRC-54 and Radio Repeater Set AN/GRC-55. The AN/GRC-54 consists of 2 Radio Sets AN/GRC-53 (one operating, one spare). The AN/GRC-55 consists of 3 Radio Sets AN/GRC-53 (two operating, one spare).

115

These radio relay sets will replace Radio Sets AN/TRC-1, -3, and -4, and Radio Sets AN/GRC-10, -39, and -40.

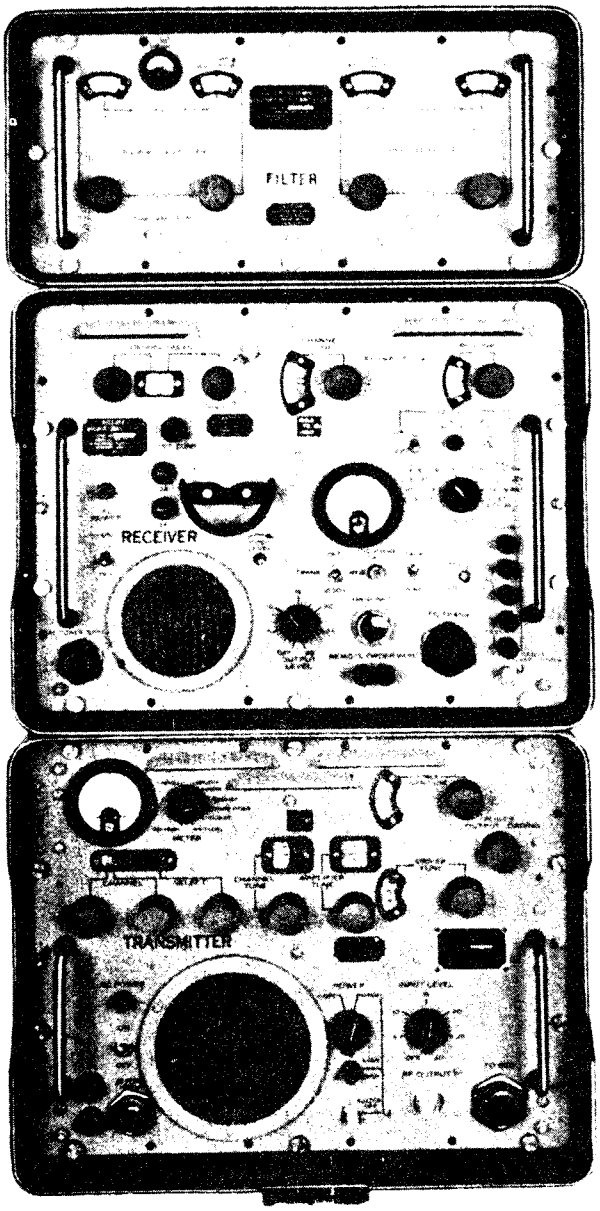
The AN/GRC-53, -54, and -55 provide facilities for multiplex equipment AN/TCC-3, AN/TCC-7, and developmental types AN/TCC-24 and AN/TCC-42, but they are not issued as parts of these radio sets. Multiplex equipment issued with two Radio Sets AN/GRC-53 forms Mobile Radio Set AN/MRC-76.

USE:

Intermediate and forward areas. May be used with Telephone Terminal Sets AN/TCC-3, -7, -24, and -42.

INSTALLATION:

Ground, vehicular, shelter, or mobile installations.



Radio Set AN/GRC-53.

TECHNICAL CHARACTERISTICS

RADIO RECEIVER R-880( )/GRC

FREQUENCY RANGE:

Continuous 50.125 to 149.875 mc.

TYPE OF RECEIVER:

Single conversion superheterodyne (equipped for reception of FM signals).

TYPES OF SIGNALS RECEIVED:

Voice and multichannel carrier telephone.

BASE-BAND FREQUENCY RANGE:

250 to 68,000 cps.

ORDERWIRE FREQUENCY RANGE:

300 to 1,800 cps.

ORDERWIRE SIGNALLING FREQUENCY:

1,600 cps.

POWER SUPPLY INPUT:

115 v, $\pm$10%, 60 cps, ac.

RADIO TRANSMITTER T-682( )/GRC

FREQUENCY RANGE:

50.125 to 149.875 mc in 400 discrete hf channels.

TYPE OF TRANSMITTER:

Direct FM -- intermediate power amplifier, final power amplifier.

TYPES OF SIGNALS TRANSMITTED:

Radio frequency, modulated by voice and multichannel carrier telephone.

RANGE:

Approx 20 mi over an unobstructed path.

POWER OUTPUT:

40 w (min).

BASE-BAND FREQUENCY RANGE:

250 to 68,000 cps.

POWER SUPPLY INPUT:

115 v, ±10%, 60 cps, ac.

ELECTRICAL FILTER ASSEMBLY F-399( )/GRC

FREQUENCY:

50 to 150 mc continuous.

INSERTION LOSS:

Less than 1.5 db over the band.

ATTENUATION:

30 db (Min) at ±15 mc from resonance.

DIMENSIONS:

8-1/2" high, 17" wide, 15" deep (single package for both receiver and transmitter filters).

Section VII. Radio Sets AN/GRC-59, -60, and -61

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Sets AN/GRC-59, -60, and -61 are intermediate and rear area multichannel, lightweight, SHF radio relay sets which may be installed in or outside shelters. Normally they will be installed in shelters located on 2-1/2-ton trucks. These radio sets provide facilities for TDM and other wide-band equipment (less than ±1.5 mc).

Radio Set AN/GRC-59 consists of a Radio Transmitter T-676( )/GRC and Radio Receiver R-873( )/GRC which are basic in forming Radio Terminal Set AN/GRC-60 and Radio Repeater Set AN/GRC-61. The AN/GRC-60 consists of two Radio Sets AN/GRC-59 (one operating, one spare). The AN/GRC-61 consists of three Radio Sets AN/GRC-59 (two operating, one spare).

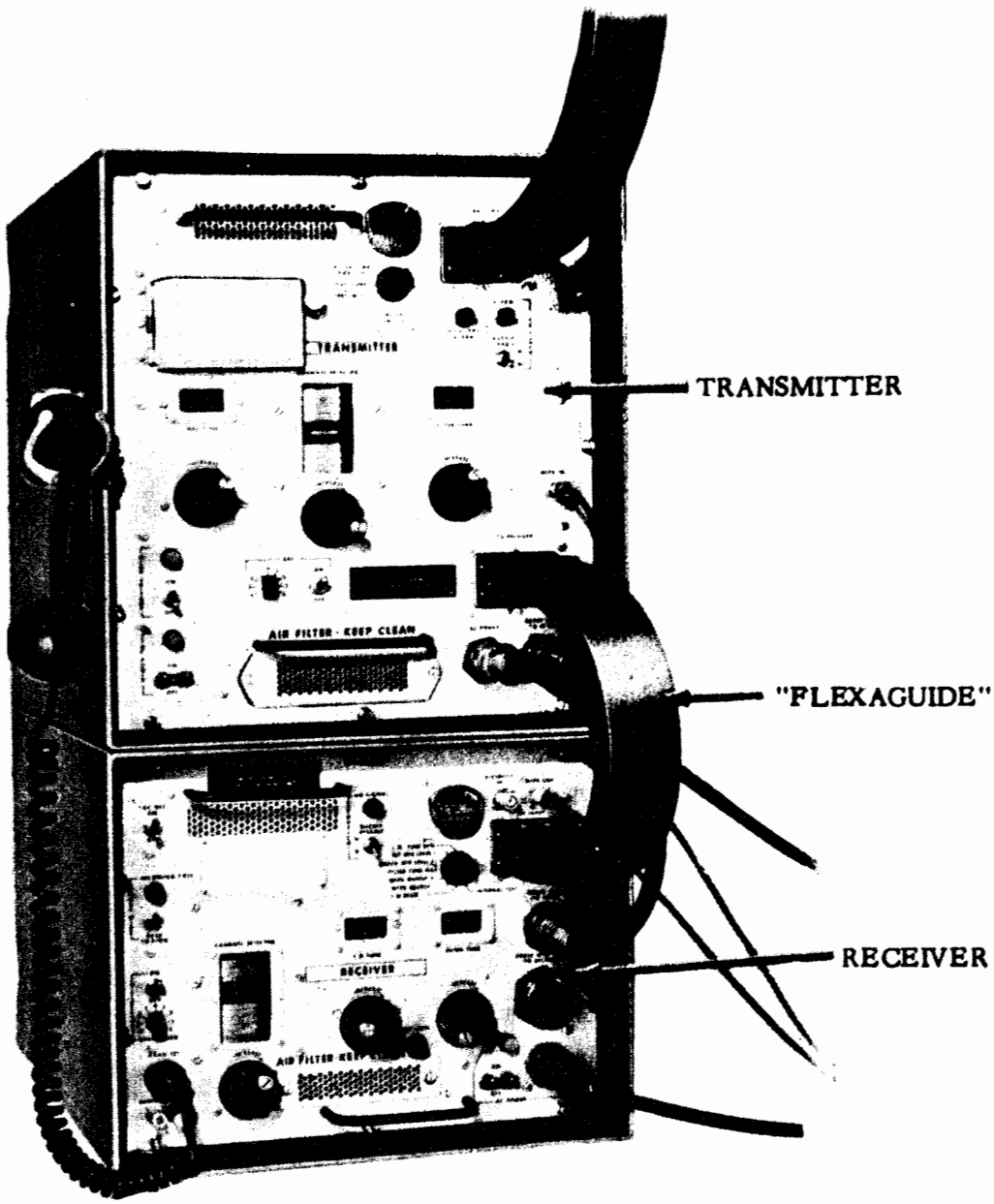
The AN/GRC-59 together with multiplexing equipment, antenna systems, and power unit in a truck-trailer combination forms Radio Set AN/MRC-77 which is used as a mobile radio, double terminal or repeater set.

USE:

Intermediate and rear area, multichannel, radio relay set.

INSTALLATION:

Normally installed in a shelter mounted on a 2-1/2-ton truck.



Radio Set AN/GRC-59

TECHNICAL CHARACTERISTICS

FREQUENCY RANGE:

4,400 to 5,000 mc.

DISTANCE RANGE:

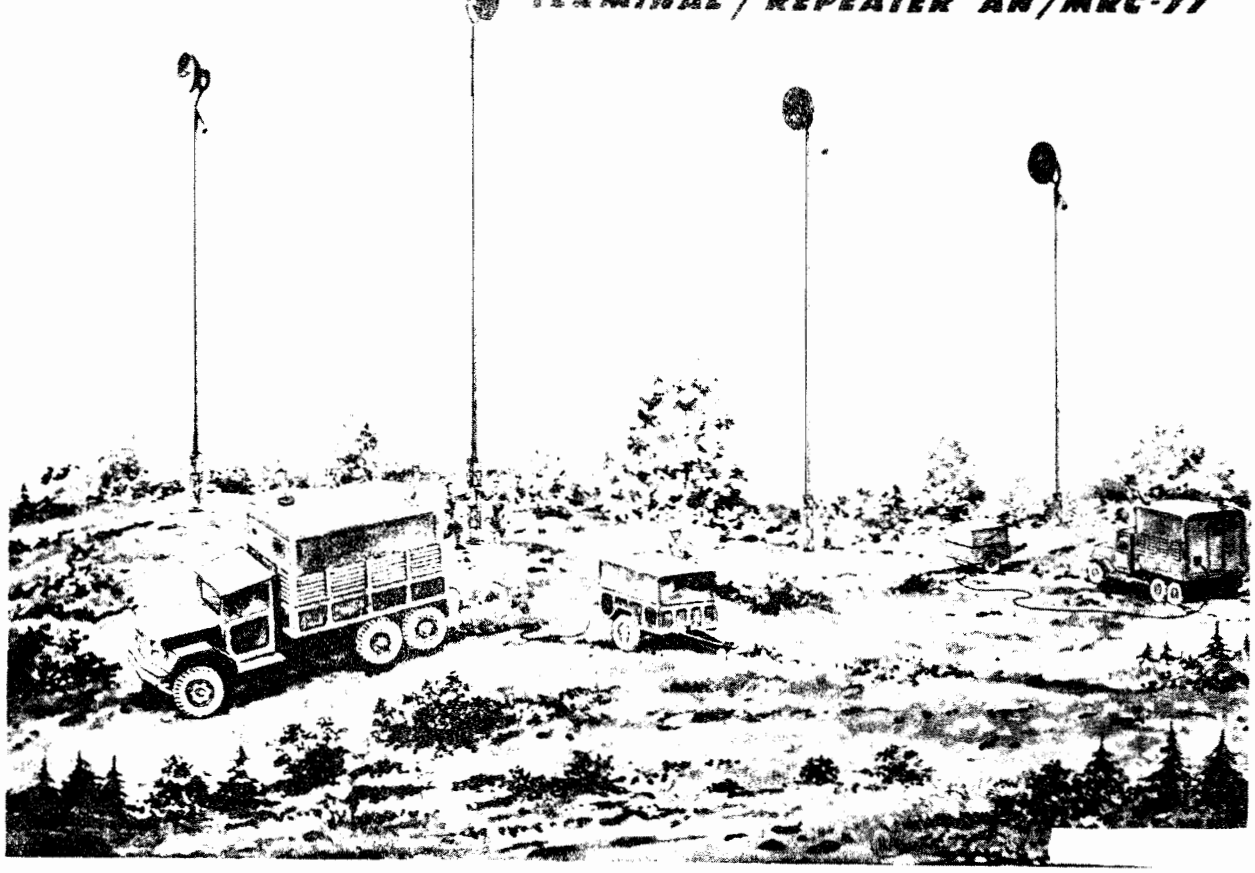
30 mi.

NUMBER OF RF CHANNELS:

60

HIGH TRAFFIC CAPACITY RADIO

TERMINAL / REPEATER AN/MRC-77



Typical AN/MRC-77 installation

NUMBER OF TANDEM HOPS:

8.

POWER OUTPUT:

1 w.

TYPE OF MODULATION:

PPM - FM and PCM - FM.

DEVIATION:

$\pm$1.5 mc.

RECEIVER NOISE FIGURE:

13 db.

NUMBER OF TRAFFIC CHANNELS:

46 - PPM.
96 - PCM.

ANTENNA TYPE:

4-1/2-ft parabola.

MAST HEIGHT:

50 ft.

ANTENNA TRANSMISSION LINE:

"G" line.

FREQUENCY STABILITY:

$\pm$0.01%.

FREQUENCY CONTROL TYPE:

Reference cavity.

POWER CONSUMPTION:

Radio Transmitter T-676( )/GRC: 243 w.
Radio Receiver R-873( )/GRC: 182 w.

PHYSICAL CHARACTERISTICS

Item	Volume (ft)	Weight (lb)
Radio Transmitter T-676( )/GRC	3.75	125
Radio Receiver R-873( )/GRC	2.75	125

Section VIII. Radio Sets AN/GRC-66, -67, and -68

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Sets AN/GRC-66, -67, and -68 are intermediate and rear-area multichannel, VHF radio relay sets installed in a shelter usually mounted on a 2-1/2-ton truck, but they may be mounted on the ground. These radio sets provide facilities for TDM or FDM equipment and other wide-band equipment having a bandwidth not wider than 1 megacycle. Radio Set AN/GRC-66 is the basic radio relay set forming Radio Terminal Set AN/GRC-66 and Radio Repeater Set AN/GRC-68. The AN/GRC-67 consists of two Radio Sets AN/GRC-66 (one in use, one spare). The AN/GRC-68 consists of three Radio Sets AN/GRC-66 (two in use, one spare).

The AN/GRC-66 consists of a radio transmitter and receiver, order wire receiver, and two power supplies. The set contains approximately the same number of transistors as vacuum tubes. The order-wire chassis is completely transistorized and modularized. The radio transmitter and receiver is partially transistorized and modularized, and the power supplies operate exclusively with semiconductors.

Two Radio Sets AN/GRC-66 together with four Radio Teletypewriter Sets AN/GRC-26, multiplex equipment, and accessories installed in a shelter mounted on a 2-1/2-ton truck form a mobile terminal or repeater Radio Set AN/MRC-78.

USE:

Intermediate and rear area, multichannel, VHF radio relay set.

INSTALLATION:

Normally installed in a shelter mounted on a 2-1/2-ton truck.

TECHNICAL CHARACTERISTICS

FREQUENCY BAND:

1,700 to 2,400 mcs.

NUMBER OF RF CHANNELS:

70 (140 with scatter).

STABILITY:

.005% crystal controlled.

OPERATING RANGE:

30 mi (line-of-sight).

TYPE OF MODULATION:

FM, 1 mc deviation.

COMMUNICATION BANDWIDTH:

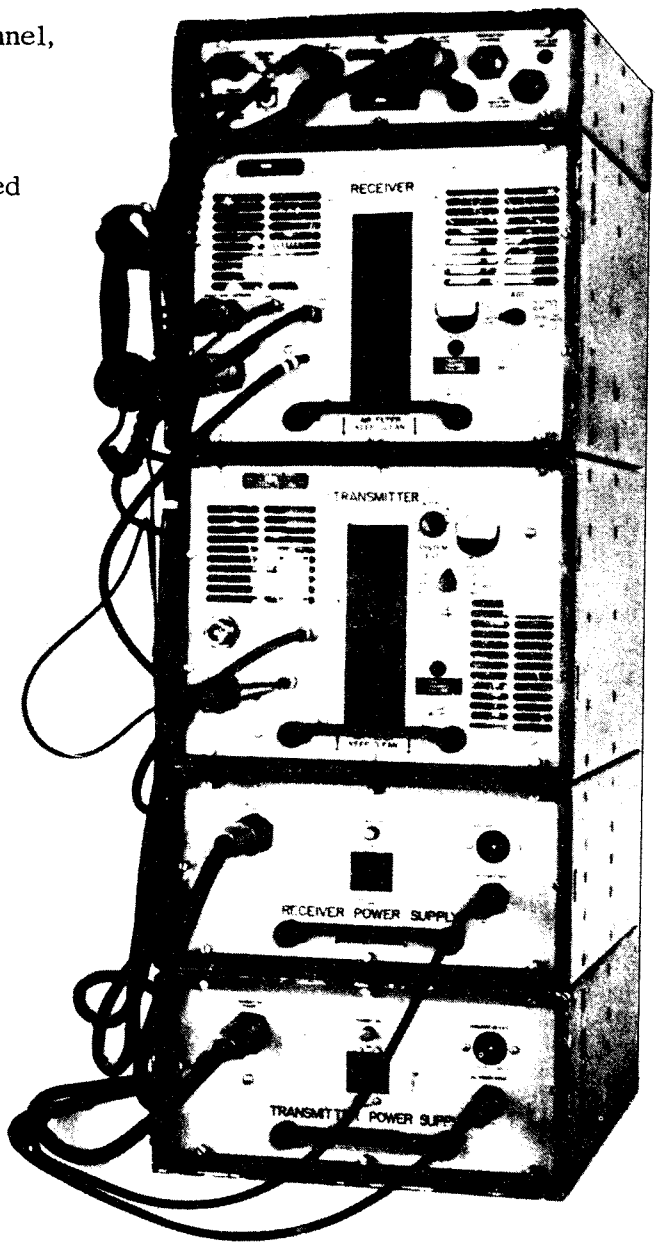
2.6 mc (3 db points) I-F amplifier.

TRANSMITTER POWER:

5 to 15 w.

TRAFFIC CAPACITY:

46 PTM voice channels.
92 TDM -PCM channels w/TCC-37.
100 FDM channels.



Radio Set AN/GRC-66

POWER INPUT:

850 w (with 46 TDM channels).

ANTENNAS AND SUPPORTS:

Standard:	6-ft sectional parabolic antenna. 50- to 100-ft lightweight tower. 50-ft pneumatic mast or Port-a-mast.
Optional:	2-ft square horn of AN/GRC-50 type. 50-ft Port-a-mast, 5 in. diameter.
Operation:	"Cigar" antenna of low gain. 21-ft pneumatic mast.

POWER SOURCE:

1-1/2-ton trailer, 2 ea, 3KVA Engine Gen.

PHYSICAL CHARACTERISTICS

Item	Dimensions (in.)	Weight (lb)
Transmitter	31-3/4 x 17 x 20	70
Receiver	13-3/4 x 17 x 20	60
Orderwire	5 x 17 x 20	35
Transmitter Power Supply	8-1/2 x 17 x 20	95
Receiver Power Supply	8-1/2 x 17 x 20	70
Total Weight		332 lbs with cases, 240 lbs without case

Section IX. Tower AB-585()/G

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Tower AB-585( )/G is a lightweight, rugged, portable, antenna support for tactical and semi-permanent installations. Although designed specifically for Radio Sets AN/MRC-78 and AN/GRC-66, it can be used with the AN/TRC-24, AN/GRC-50, and AN/GRC-59.

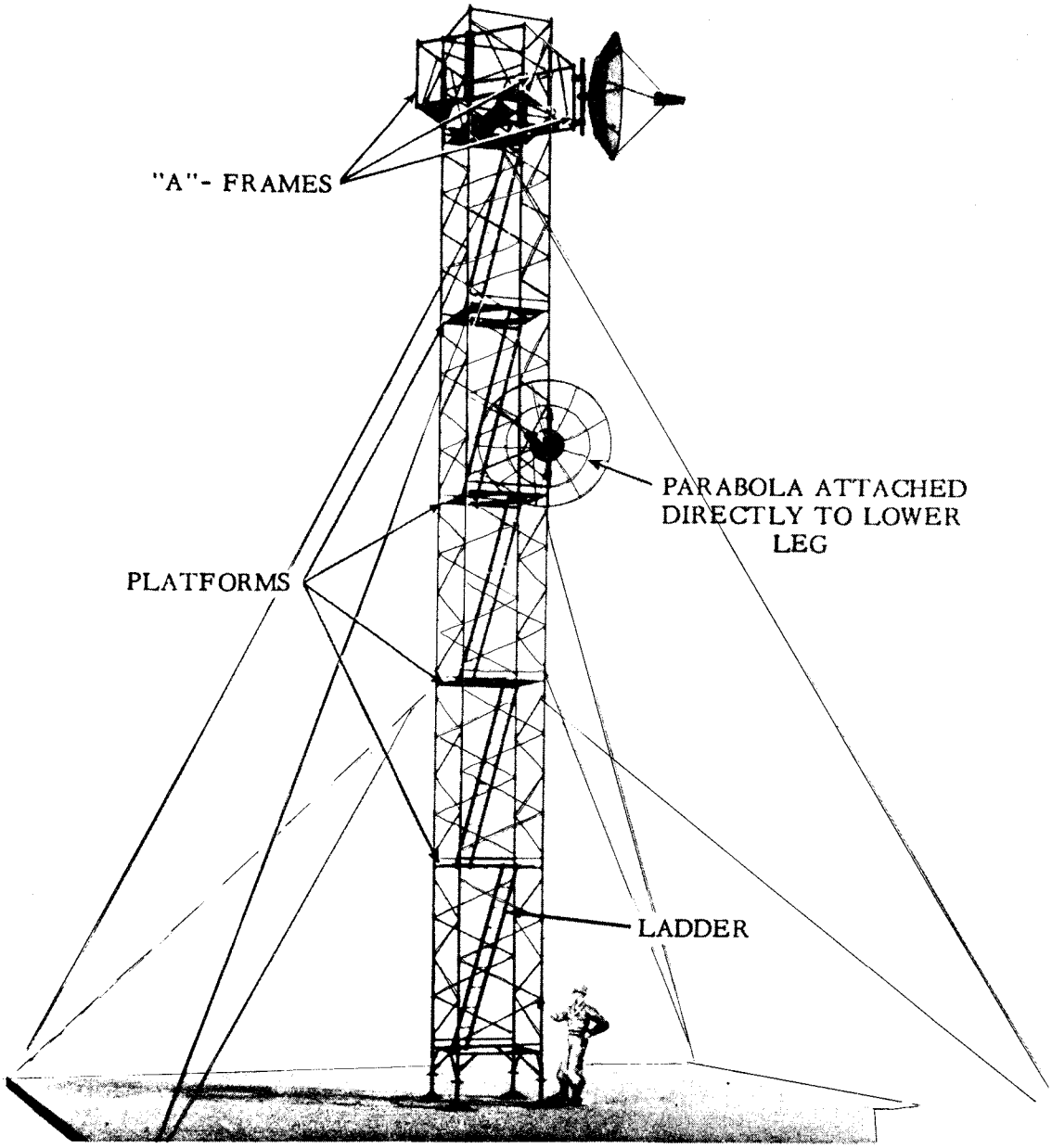
The tower is made of fold-up sections fabricated from tubular aluminum. A ladder extends diagonally within each tower section to provide easy climbing. A platform is located at the top of each section. A davit is used to place each section in place. The davit has a heavy duty section for raising heavy antennas and equipment.

USE:

Antenna support for tactical and semi-permanent installations.

INSTALLATION:

May be used with Radio Sets AN/MRC-78, AN/GRC-50, -59 and AN/TRC-24.



Tower AB-585( )/G

TECHNICAL CHARACTERISTICS

HEIGHT:

106 ft (max).
Two 50-ft towers can be formed from basic 106-ft tower.

SECTIONS:

Eleven (4' x 4' x 9').
One (4' x 4' x 4-1/2') used for top.
One "A-frame" for each parabola.
One base frame.

GUYS:

Guyed at four levels.
Four additional guys at top.

ANTENNAS:

Four 6-ft parabolas or two 8-ft parabolas.

WEIGHT:

14 lbs/ft.
125 lbs/9.5 section.
1,500 lbs/106 tower.

INSTALLATION TIME:

Approx 4 hrs (6 trained men).

STORAGE AND TRANSPORTATION:

One M-35, 6x6 cargo truck with tarpaulin and bows in place.

Section X. Radio Set AN/TRC-60

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Radio Set AN/TRC-60 is a tactical troposcatter communications system which extends the range of conventional radio-relay equipment up to 100 miles, or more, by over-the-horizon radio paths. It provides communications over natural and man-made obstacles and requires fewer sites, less equipment, and fewer men than conventional radio-relay systems.

The AN/TRC-60 consists of a modified AN/TRC-24, and a Telephone Terminal AN/TCC-7 (12 channels), together with inflatable parabolas, towers, and accessories.

The AN/TRC-24 is modified to include the following:

a. Amplifier-Converter AM-2068( )/TRC used to improve the performance of Receiver R-417/TRC with better sensitivity, selectivity, and provide a lower over-all noise figure.

b. Selector Receiver Signal SA-607( )/TRC used with the two Receivers R-417/TRC to make a dual-diversity receiving system which overcomes severe fading of the troposcatter transmission path.

c. Amplifier-Power Supply AM-2066( )/TRC increases the 100-watt output of the Transmitter T-302/TRC to 1,000 watts to overcome the high losses of the troposcatter path.

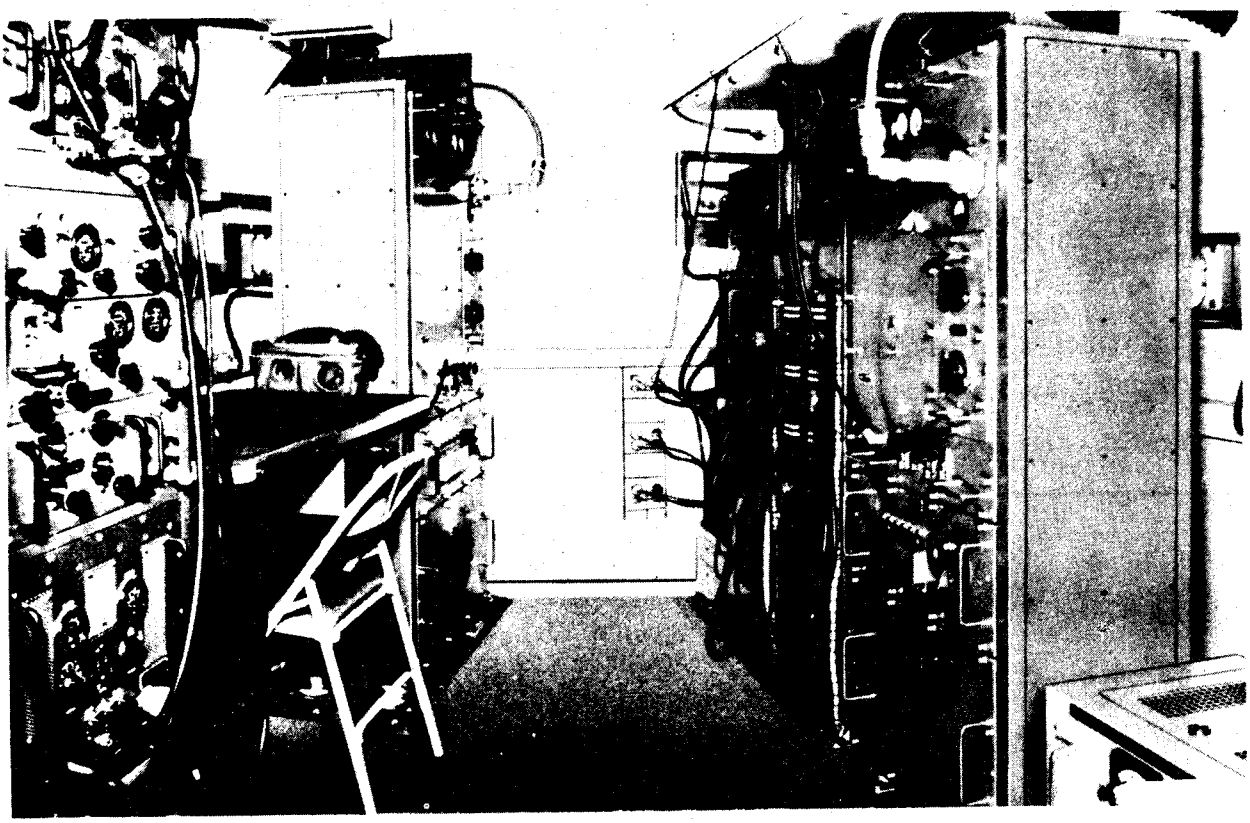
The AN/MRC-80 is the mobile version of the AN/TRC-60 installed in Shelter S-141. In addition, the AN/MRC-80 has a spare transmitter. The AN/MRC-80 provides highly mobile transmission facilities in army mobile communications systems.

USE:

Tactical troposcatter communications system.

INSTALLATION:

Shelter.



Radio Set AN/TRC-60 (used as part of AN/MRC-80)

TECHNICAL CHARACTERISTICS

FREQUENCY RANGE:

350-600 mc.

DISTANCE RANGE:

100 mi.

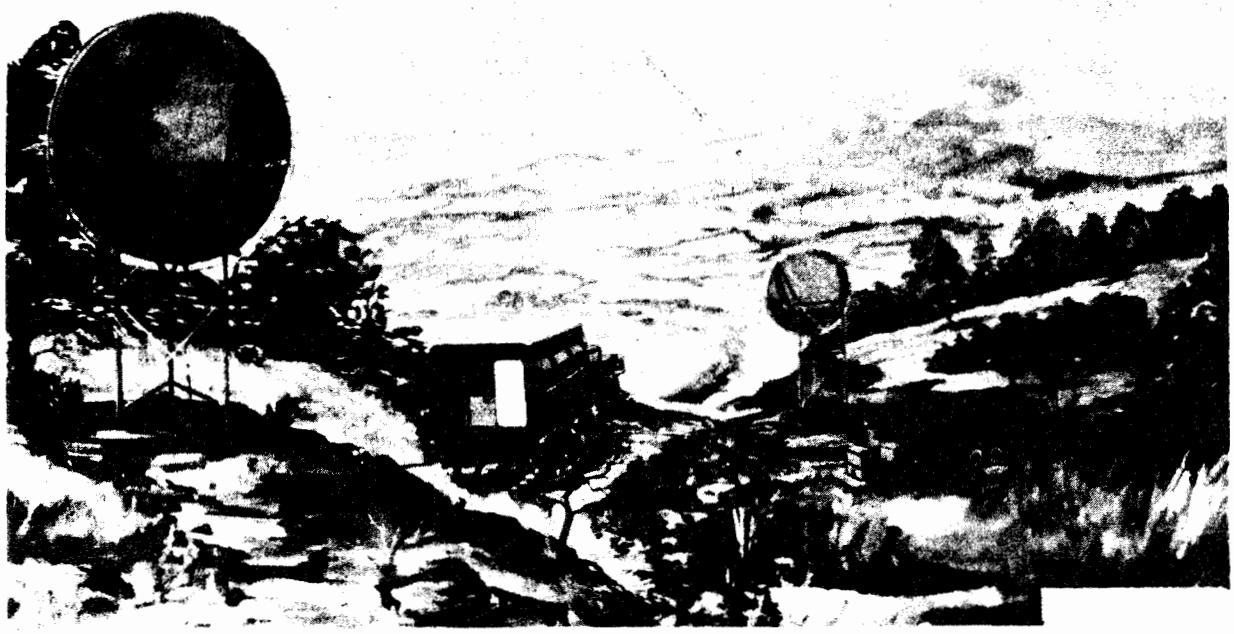
RF CHANNELS:

183.

POWER OUTPUT:

1 kw with 100 w drive.

AN/TRC-60 TERMINAL STATION
RADIO SET AN/MRC-80



Typical AN/MRC-80 site

TYPE MODULATION:

FM.

DEVIATION:

186 kc.

RECEIVER NOISE FIGURE:

7 db.

INTERMEDIATE FREQUENCY:

30 mc.

RECEIVER I-F BANDWIDTH:

250 kc.

DIVERSITY:

Dual space.

TRAFFIC CHANNELS:

12.

ANTENNA TYPE:

15-ft inflatable.

ANTENNA HEIGHT:

22 ft.

SHELTER TYPE:

S-141.

INSTALLATION WEIGHT:

5,000 lbs.

POWER SOURCE TYPE:

PU-378.

Section XI. Multiplexers AN/TCC-37 and -41

Status: Developmental.

Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Multiplex Sets AN/TCC-37 and AN/TCC-41 are fully transistorized and modularized, multichannel TDM sets using pulse code modulation. Both are rugged, lightweight, and provide secure communications. The AN/TCC-37 is a high-capacity equipment providing facilities for either 48 or 96 channels, and is intended for corps and army communications systems. The AN/TCC-41 is a low-capacity equipment providing facilities for 12 or 24 channels and is intended for division area.

Both multiplexer sets may be used to transmit either by cable or radio. With radio relay sets, trunk quality, long range communications, and high reliability multichannel communications may be obtained in situations where large land and water areas must be bridged. When cable systems are used, special purpose, air lay cable, twin Coax CX-4245( )/G is utilized.

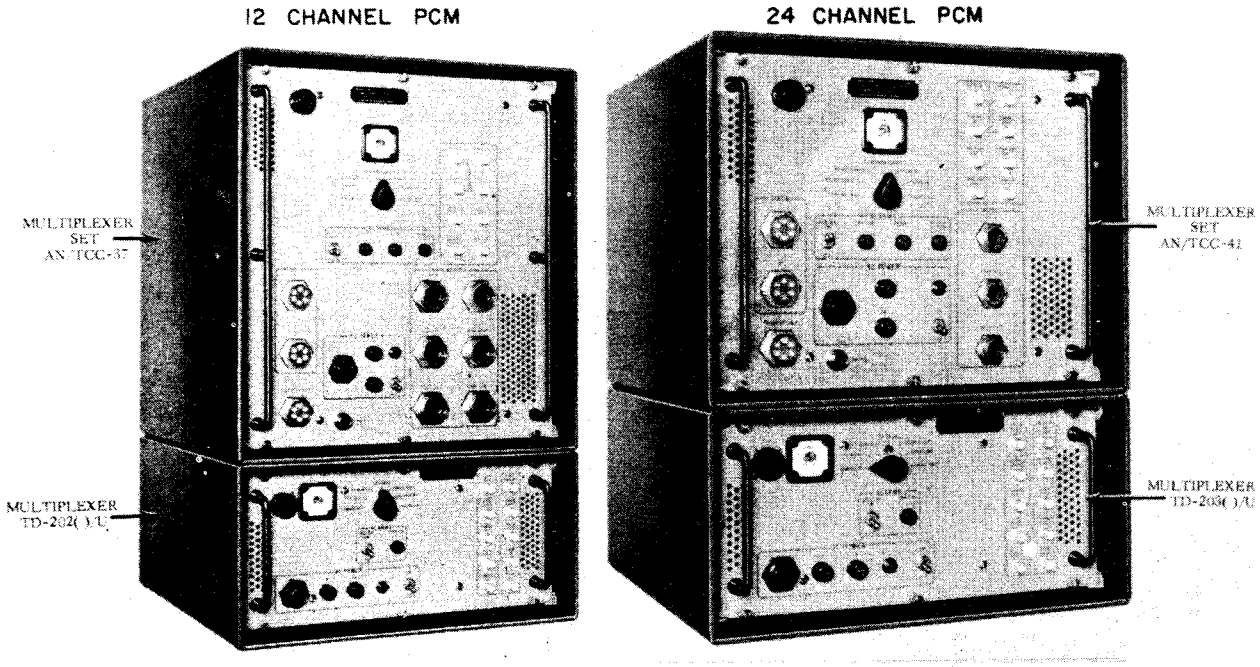
Unattended repeaters are spaced at one-mile intervals and attended repeaters at forty-mile intervals. The unattended repeaters are powered over the cable from the attended repeaters and terminal stations.

When the AN/TCC-37 and AN/TCC-41 operate in cable systems, Multiplexer TD-204( )/U must be used. Cable systems limit the AN/TCC-37 to 48 channels.

APPLICATION IN RADIO RELAY SYSTEMS

Multiplexer Set	Audio Channels	Radio Sets
1 AN/TCC-37 1 TD-202( )/U	48	AN/GRC-59, AN/GRC-62, or AN/GRC-66
2 AN/TCC-37 1 TD-202( )/U	96	AN/GRC-59, AN/GRC-62, or AN/GRC-66
1 AN/TCC-41 1 TD-203( )/U	12	AN/GRC-50
2 AN/TCC-41 1 TD-203( )/U	24	AN/GRC-50

PCM Equipment For Radio Relay Systems



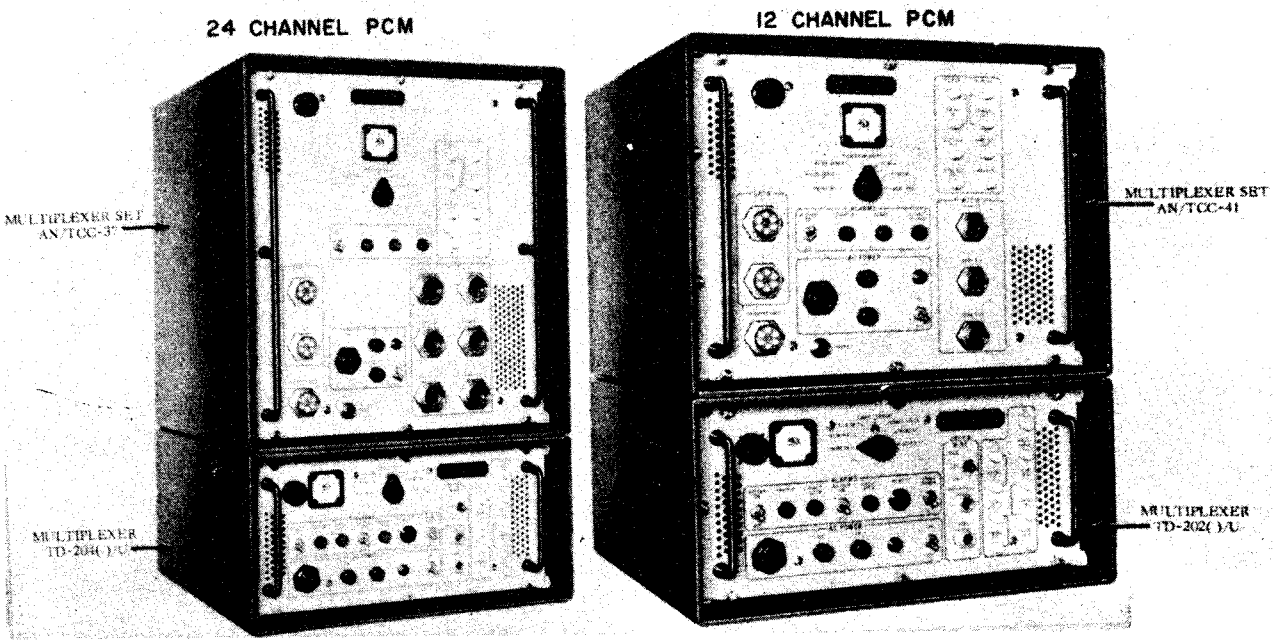
AN/TCC-37 and -41 for radio relay operation.

APPLICATION IN CABLE (CX-4245) SYSTEMS

12-CHANNEL EQUIPMENT TERMINAL:	1 ea AN/TCC-41
	1 ea TD-204( )/U
Attended Repeaters:	2 ea TD-204( )/U
Unattended Repeaters:	1 ea TD-206( )/U
24-CHANNEL EQUIPMENT TERMINAL:	2 ea AN/TCC-41
	1 ea TD-204( )/U
Attended Repeater:	2 ea TD-204( )/U
Unattended Repeater:	1 ea TD-206( )/G
48-CHANNEL EQUIPMENT TERMINAL:	1 ea AN/TCC-37
	1 ea TD-204( )/U
Attended Repeater:	2 ea TD-204( )/U
Unattended Repeater:	1 ea TD-206( )/G

96-channel systems are provided by operating two 48-channel systems in parallel.

PCM Equipment For Cable Systems



AN/TCC-37 and -41 for cable operation.

TECHNICAL CHARACTERISTICS

GENERAL

	MULTIPLEXER SET AN/TCC-41	MULTIPLEXER SET AN/TCC-37
NR OF AUDIO CHANNELS:	12, 24 ch with 2 sets.	48, 96 ch with 2 sets.
RADIO SETS:	AN/GRC-50.	AN/GRC-59, -62, -66.
CABLE:	Coax Cable CX-4245.	Coax Cable CX-4245.
SECURITY:	TSEC/KG-5 (optional equip).	TSEC/KG-5 (optional equip).
TYPE OF MULTIPLEXING:	TDM.	TDM.
TYPE OF MODULATION:	PCM.	PCM.
NR OF PCM DIGITS:	6 digits/ch sample.	6 digits/ch sample.
CHANNEL SAMPLING RATE:	8 kc/sec.	8 kc/sec.
POWER SUPPLY INPUT:	115 v, ±10%, 60 cps, ac.	115 v ±10%, 60 cps, ac.
POWER CONSUMPTION:	170 w, 12 ch. 320 w, 24 ch.	200 w, for 48 ch. 380 w for 96 ch.

	MULTIPLEXER SET AN/TCC-41	MULTIPLEXER SET AN/TCC-37
WEIGHT (INCLUDING CASE):	113 lb for 12 ch. 182 lb for 24 ch.	160 lb for 48 ch. 270 lb for 96 ch.
VOLUME (CU. FT.):	4.5 (for 12 ch) 7 (for 24 ch).	5.5 (for 48 ch). 9 (for 96 ch).
	AUDIO	
INPUT LEVEL FOR FULL MODULATION:	-4 dbm (4-w).	-4 dbm (4-w).
OUTPUT LEVEL FOR FULL MODULATION:	-4 dbm (4-w).	-4 dbm (adj) (4-w).
TERMINATION IMPEDANCE:	600 ohms (bal).	600 ohms (bal).
MODULATING BANDWIDTH:	300 to 3,500 cps.	300 to 3,500 cps.
SIGNAL-TO-NOISE RADIO (FIA):	55 db.	55 db.
SIGNAL-TO-NOISE PLUS CROSSTALK RATIO:	53 db.	53 db.
DISTORTION:	Less than 4%.	Less than 4%.
	VIDEO	
IMPEDANCE INPUT-OUTPUT:	50 ohms	50 ohms.
PULSE AMPLITUDES (INPUT-OUTPUT):	$\pm$0.5 to $\pm$1.0 v.	$\pm$0.5 to $\pm$1.0 v.
PCM PULSE WIDTH:	Full Baud (radio). Half Baud (cable).	Full Baud (radio). Half Baud (cable).
BAUD INTERVAL:	1.735 usec.	0.44 usec.
FRAME INTERVAL:	125 usec (8 kc).	125 usec (8 kc).
CHANNEL INTERVAL:	10.4 usec (96 kc).	2.6 usec (384 kc).
PULSE RATE:	576 kc for 12 ch. 1,152 kc for 24 ch.	2.304 mc for 48 ch. 4.608 for 96 ch.
BANDWIDTH (at 3-db point):	240 kc (radio). 1 and 2 mc (cable).	935 kc (radio). 1 and 2 mc (cable).
SHAPE:	Gaussian low pass (radio). Gaussian band pass (cable).	Gaussian low pass (radio). Gaussian band pass (cable).
PULSE TYPE:	Binary (12 ch radio and 12/24 ch cable). Bi-Ternary (24 ch radio).	Binary (48 ch radio and cable). Bi-Ternary (96 ch radio).

SIG 9 BACK - 2

Section XII. Telephone Terminal Sets AN/TCC-24, -42, and -43

Status: Developmental.

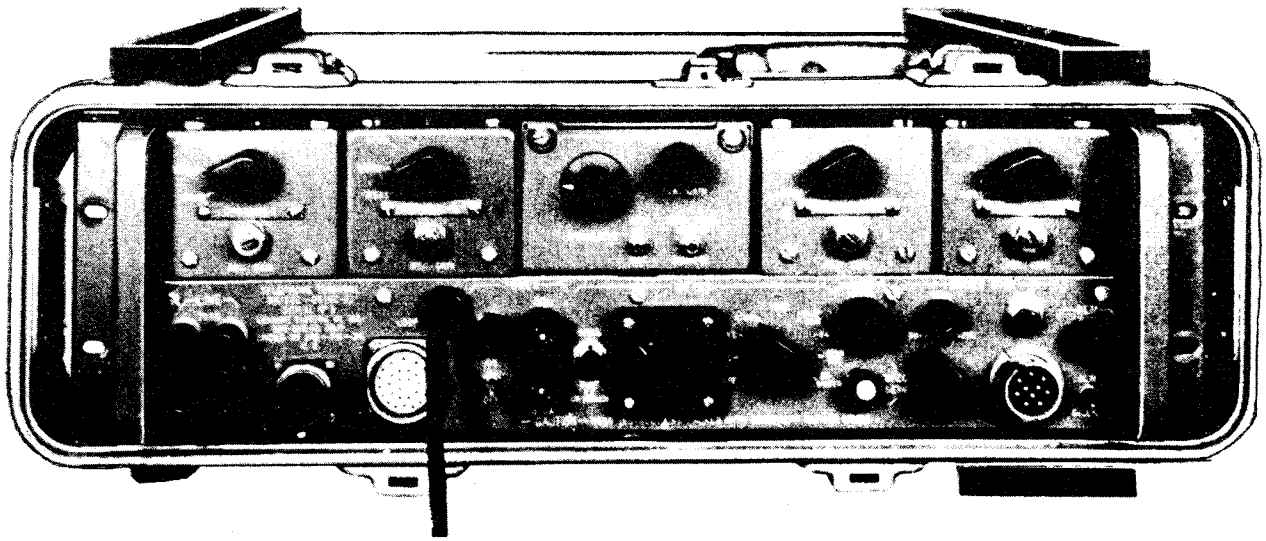
Stock Nr: Not for stock or issue.

Reference: None.

GENERAL INFORMATION

Telephone Terminal Sets AN/TCC-24, -42, and -43 are completely transistorized, modularized, multichannel telephone carriers for use on either spiral-four cable or radio relay systems. The AN/TCC-24, -42 and -43, respectively provide 4, 12 and 24 channels of telephone communications, plus order wire circuits. Each channel may be used for voice-frequency telegraph signals.

Telephone Terminal Sets AN/TCC-24 together with Telephone Modem TA-321/TCC and Telephone Repeaters AN/TCC-34 form the basic components for the AN/TCC-42 and AN/TCC-43, when used in a radio system.



Telephone Terminal AN/TCC-24.

TECHNICAL CHARACTERISTICS

NR OF CHANNELS:

Four traffic channels plus order wire.

CARRIER FREQUENCIES:

Channel 1: 8 kc $\pm$0.01%.
Channel 2: 12 kc $\pm$0.01%.
Channel 3: 16 kc $\pm$0.01%.
Channel 4: 20 kc $\pm$0.01%.

FREQUENCY BAND ALLOCATED TO CHANNELS:

Order Wire:	300 to 2,000 cps.
Channel 1:	4,500 to 7,700 cps.
Channel 2:	8,500 to 11,700 cps.
Channel 3:	12, 500 to 15,700 cps.
Channel 4:	16,500 to 19,700 cps.

FREQUENCY OF ORDER WIRE SIGNALING CIRCUITS:

1,600 cps.

FREQUENCY OF SYSTEM ALARM SIGNAL:

4,000 cps.

TRANSMISSION RANGE, NON-REPEATERED:

35 mi normal cable length.
50 mi maximum cable length.

TRANSMISSION RANGE, REPEATERED:

210 mi with loaded spiral-four Cable Assemblies CX-1065/G and suitable telephone repeaters.

TYPE OF MODULATION:

AM, single sideband, suppressed carrier.

POWER SOURCE:

115 or 230 v, $\pm$10%, 60 cps, ac.

POWER CONSUMPTION:

25 w (approx).

TECHNICAL CHARACTERISTICS OF THE AN/TCC-42 AND -43

VOICE CHANNELS

NUMBER:

12 or 24.

FREQUENCY BAND:

300 to 3,500 cps.

IMPEDANCE:

600 ohms.

INPUT LEVEL:

2-wire: 0 db (ref point).
4-wire: -4 db.

OUTPUT LEVEL:

2-wire: -3 db.
4-wire: +1 db.

RADIO TRANSMISSION

RADIO SET IMPEDANCE:

135 ohms (transmit and receive).

FREQUENCIES TRANSMITTED TO RADIO:

4 to 108 kc.

OUTPUT LEVEL TO RADIO (4-108 kc):

0 db.

PILOT FREQUENCY:

56 kc.

PILOT LEVEL OUTPUT:

-20 dbm.

ORDER WIRE

FREQUENCY RANGE:

300 to 1,600 cps.

SIGNALING FREQUENCY:

1,600 cps.

SIGNALING TONE OUTPUT LEVEL:

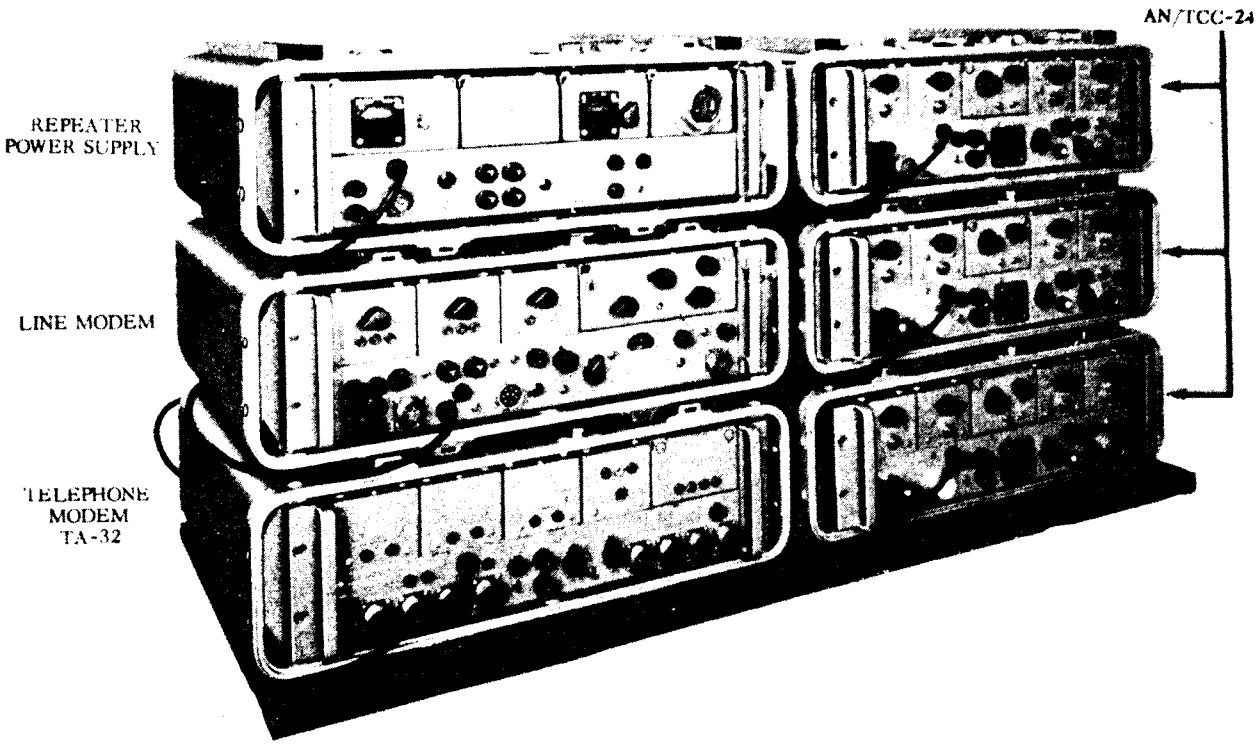
0 to +10 dbm.

VOICE TRANSMITTING LEVEL TO RADIO:

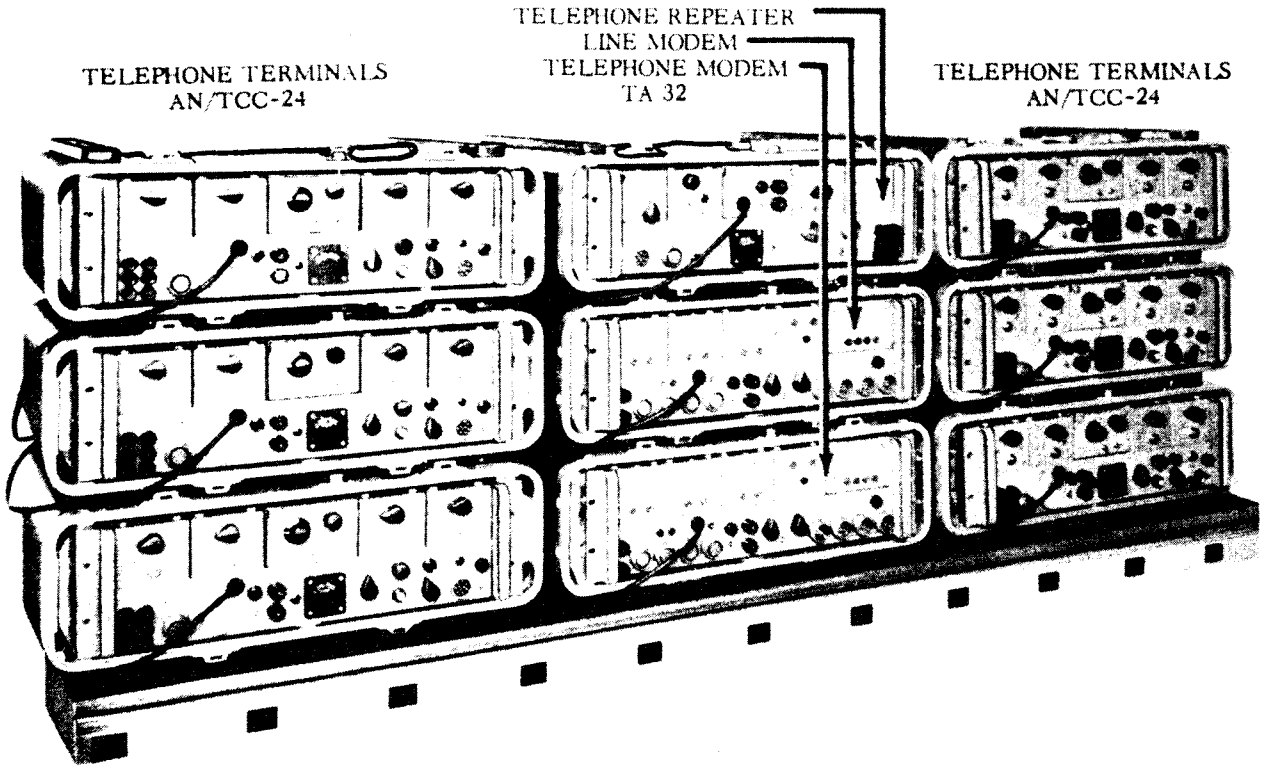
0 dbm.

1-KC TEST TONE OUTPUT LEVEL:

0 or +10 dbm.



Telephone Terminal AN/TCC-42.



Telephone Terminal AN/TCC-43.

2-WIRE EXTENSION CIRCUIT:

Impedance:	600 ohms.
Transmitting Level:	0 dbm.
Receiving Level:	-25 db.

POWER REQUIREMENTS

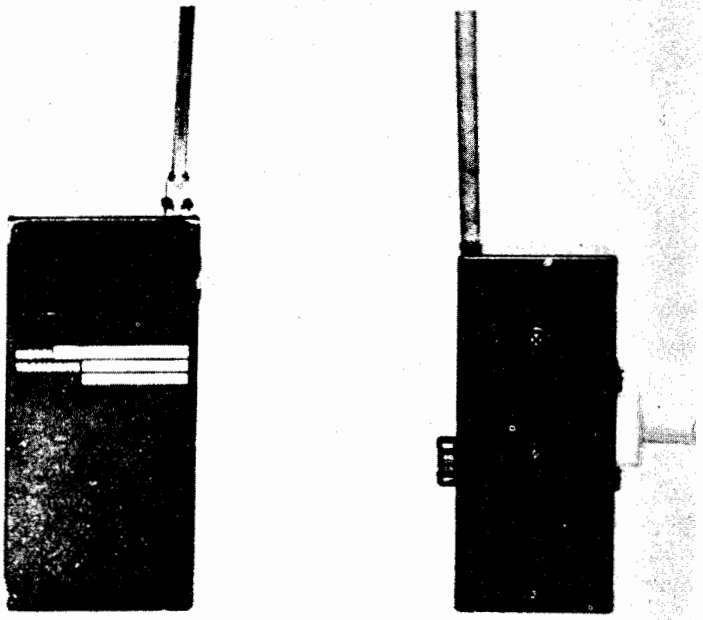
SOURCE:

115 or 230 v, ±10%, 60 cps, single phase, ac.

POWER CONSUMED PER TERMINAL:

12-channel:	275 w (incl. Signal Converters).
24-channel:	540 w (incl. Signal Converters).

Section XIII. Lightweight Radio Set

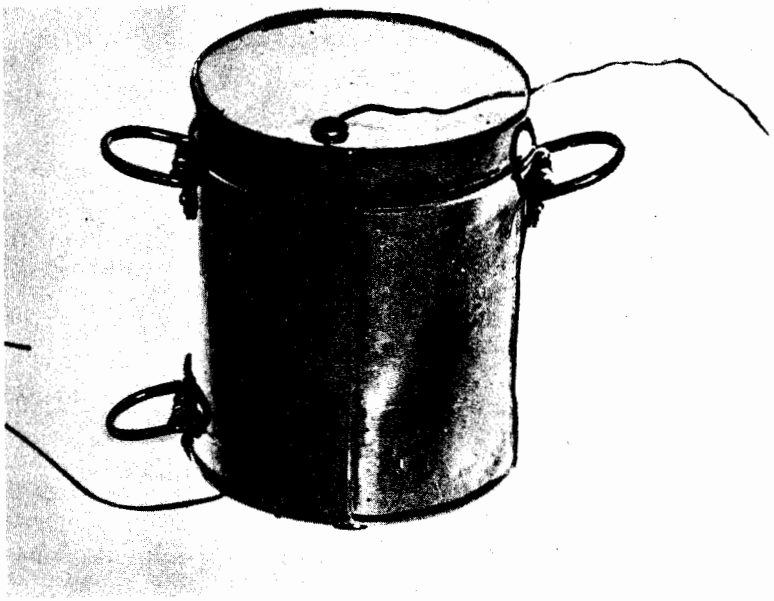


Radio Set Lightweight.

The lightweight radio set will consist of a six to eight ounce helmet mountable receiver and a six to ten ounce two channel transmitter, having a 1 1/2 km and a 500 meter range capability. Two channels are required to provide communications from the squad leader to selected members of the squad and to the platoon leader. This radio set will have a minimum of 90 channels with two preset channels for the transmitter and one preset channel for the receiver. The frequency coverage will be compatible with the AN/VRC-12 family of radio sets.

Status: Under Development

Section XIV. Ultra-Lightweight Assault Cable



This assault wire is a parallel pair of 23 AWG solid aluminum conductor with polyethelyne insulation. The wire has a tensile strength of 25 pounds and weighs 9 pounds per mile. It was developed by the Canadian Army and is intended for use at Platoon and Company level. This equipment has been evaluated and is being made available for further test for possible use by US Ground Forces.

Section XV. Radio Set AN/GRC-106

FUNCTIONAL DESCRIPTION

Radio Set AN/GRC-106 is a newly standardized, vehicular, single-sideband, tactical, medium-high frequency radio set designed to replace Radio Set AN/GRC-19 and the radio communication components of other systems in the Army's communication network. It is designed to receive and transmit SSB voice (USB only), amplitude-modulated voice (compatible a-m), and frequency-shift radioteletype in the frequency range of 2.0 to 30.0 megacycles. An external applique unit and high capacity vehicular generating system (24 volts, 100 amperes) are required for radioteletype operation.

The radio set operates from the standard vehicular power source, in voice and c-w operations. Any one of 28,000 channels in locked 1-kc steps are readily available from the front panel. The equipment is intended to provide a medium, reliable range of 50 miles of mobile voice and c-w type communications. In semifixed positions, 50 miles of radioteletype and facsimile service are available to elements of the combat arms and services of the field army. Power output is rated at 400 watts PEP.

The radio set is completely transistorized with the exception of five tubes, and functional modular construction provides maximum ease of maintenance and rapid serviceability. The issued equipment will include audio accessories, antenna equipment, brackets, hardware, and mounting base. Remote control equipment and a 110/220 volt, 50/400 cycle a-c to 27.5 volt d-c converter must be obtained extra for special applications.

Volume of the basic equipment is 1.87 cubic feet. Weight of the equipment is 118 pounds less audio and antenna components. Its small volume and light weight permit considerable elasticity in vehicular installations which in turn, allow for greater usage in highly tactical applications.

TECHNICAL CHARACTERISTICS

Frequency range:	
Transmit:	2.0 to 29.999 mc in locked 1-kc steps.
Receive:	2.0 to 29.999 mc in locked 1-kc steps with vernier tuning between steps.
Types of service:	SSB voice (upper sideband). A-m voice (carrier and upper sideband). C-w (2 kc above indicated frequency). Audio FSK (with auxiliary equipment).
Frequency stability:	Within 1 part in 10^7 per week (locked in 1-kc steps).
Duty cycle:	Continuous duty from $-40^{\circ}C$ to $+65^{\circ}C$.

Primary input power @ 27.5 volts d-c:	
SSB voice, transmit:	30 amperes for full modulation.
Transmitter "Standby":	15 amperes.
Receive only:	1 ampere.
C-w, FSK, or compatible a-m:	35 amperes.

NOTE: Standard 25-ampere vehicular generating system is adequate for operation of AN/GRC-106 on normal SSB voice, compatible a-m voice, and c-w. Operation on FSK requires high capacity generating system on vehicle.

Power output:	
SSB voice:	400 watts peak envelope power.
Compatible a-m voice:	400 watts PEP (70 watt carrier).
C-w:	200 watts average.
FSK:	200 watts average.
Overall audio frequency response:	Flat within 2 db from 300 to 3,500 cycles.
Intermodulation distortion:	At least 35 db below either of two tones which produce rated PEP.
IF bandwidth (transmit or receive):	Flat within 1.5 db from 300 to 3,500 cycles.
Receiver noise figure:	12 db or better.
Receiver audio output:	2 watts maximum across 600 ohms.
Receiver audio distortion:	5% or less at 2 watts output

Section XVI. Radio Teletypewriter Set AN/GRC-108

FUNCTIONAL DESCRIPTION

Radio Teletypewriter Set AN/GRC-108 is a 3/4-ton shelter-mounted radio set providing full-duplex capability for single sideband voice, c-w, and secure radioteletype communication. Transmitter output is 2000 watts SSB (PEP) and 1000 watts average power on c-w and radioteletype, which provides the equipment a ground wave of at least 100 miles when using doublet antennas in a fixed location. Communication via sky wave extends this range to 1500 miles or more, under good propagation conditions and with the choice of proper frequencies. The complete equipment includes a trailer-mounted engine generator, and is capable of operation from 115/230 volt, single-phase 60/400 cycle commercial power.

Radio components include two Receiver-Transmitters, Radio RT-662/GRC; one is used to drive Amplifier, Radio Frequency AM-3399( )/GRC, and the other is used for reception in full-duplex service. Compatibility of operation is provided with older radioteletype sets on compatible a-m or 850-cycle FSK radioteletype (60 wpm). The installation also provides for simultaneous SSB voice and narrow shift (85 cycles) secure radioteletype communication in full-duplex capability.

Teletype equipment includes a separate page printer and a combination page printer, reperforator, distributor, and keyboard. There is also included equipment for remote control operation up to distances of 1 mile, and extension of teletype loops for radio/wire integration. The equipment employs a whip antenna for simplex operation while in motion and separate transmitting and receiving doublet antennas in fixed locations for full-duplex operations.

Operating frequency range is 2.0 to 30.0 megacycles. Any one of 28,000 channels are available in 1-kc steps from the front panel of the receiver-transmitter unit. The anticipated weight of this equipment will be approximately 3000 pounds including the shelter installation and the trailer installation. The entire equipment will be air transportable with or without the vehicle depending upon the type of aircraft employed.

TECHNICAL CHARACTERISTICS

Frequency range:	
Transmit:	2.0 to 29.999 mc in locked 1-kc steps.
Receive:	2.0 to 29.999 mc in locked 1-kc steps with vernier tuning between steps.
Types of service:	SSB voice (upper sideband). A-m voice (carrier and upper sideband). C-w (2 kc above indicated frequency). Audio FSK: 850 cycle shift centered at 2 kc; 85 cycle shifts centered at 2805 cycles. SSB voice and 85 cycle audio FSK: FSK centered at 2805 cycles.

Mode of operation:	**Full-duplex (separate doublet or whip** for transmitting and receiving).
Frequency stability:	Within 1 part in 10^7 per week (locked 1-kc steps).
Duty cycle:	Continuous duty from -40°C to +65°C
Primary power:	115/230 v, 50-60/400 cycle a-c, 7,500 watts maximum; 10-kw trailer-mounted power unit included as part of AN/GRC-108.
Power output:	
SSB voice	2,000 watts peak envelope power.
Compatible a-m voice	
C-w	1,000 watts average.
FSK	2,000 watts PEP; 1-kw single tone.
Overall audio frequency response:	Flat within 2 db from 300 to 3,500 cycles.
Intermodulation distortion:	At least 40 db below either of two tones which produce rated PEP.
IF bandwidth (transmit or receive):	Flat within 1.5 db from 300 to 3,500 cycles.
Receiver noise figure:	12 db or better.
Receiver audio output:	2 watts maximum across 600 ohms.
Receiver audio distortion:	5% or less at 2 watts output.
Ventilation and cooling:	Shelter includes heater and air conditioner. 2-kw power amplifier is forced-air cooled by outside air (filtered) or by recirculation within shelter. Receiver-transmitters are sealed units with convection cooling.
Size and weight:	Shelter S-153/G for mounting on 3/4-ton M-37 truck (gross weight: 1,500 lbs) with Trailer M-101; installed load: 1,500 lbs.
Tactical employment:	Replaces Radio Set AN/GRC-26.
Air transportability:	Shelter S-153/G mounted on truck, 3/4-ton, 4x4, M-37 with M-101 attached is transportable by C-123B assault aircraft.

COMPONENTS OF RADIO TELETYPEWRITER SET AN/GRC-108

Receiver, Transmitter, Radio, RT-662( )/GRC	2 ea
Amplifier, Radio AM-3399( )/GRC	1 ea
Coupler, Antenna CU-1075( )/GRC	1 ea
Power Supply PP-3440( )/GRC	1 ea
Radioteletype Modem Unit	1 ea
Teletypewriter AN/TGC-14( )	1 ea
Teletypewriter AN/TGC-15( )	1 ea
Power Inverter for AN/TGC-14 or AN/TGC-15	2 ea
Shelter S-153( )/G	1 ea
Air Conditioner-Heater CE6-A-400	1 ea
15' Whip antenna Assemblies (Receiving and Transmitting)	2 ea
Doublet Antenna Kits with Masts and Coaxial Cables	2 ea
Trailer M-101	1 ea
Trailer-Mounter Power Unit	1 ea
Audio Accessories - Microphone, Speaker, Headset, etc.	1 Set

Section XVII. Radio Teletypewriter Set AN/GRC-122

FUNCTIONAL DESCRIPTION

Radio Teletypewriter Set AN/GRC-122 is a proposed 3/4-ton shelter-mounted radio set providing full-duplex capability for single sideband voice, c-w, and secure radioteletype communication. Transmitter power is 400 watts SSB (PEP) and 200 watts average power on c-w and secure radioteletype, which provides a ground wave of at least 50 miles when using a doublet antenna in a fixed location. Communication via sky wave extends the range appreciably under good propagation conditions and with the choice of proper frequencies.

Primary power is drawn from a vehicle equipped with a high capacity (100-ampere) 24-volt electrical system. This radio set is a single vehicle system; no trailer-drawn power equipment is required. Greater tactical mobility of operation will be provided through this equipment configuration than is presently possible with larger systems. The equipment and shelter less vehicle will weigh approximately 1200-1300 pounds which will allow it to be readily air-transportable.

Radio components include one Radio Set AN/GRC-106 and one Receiver-Transmitter RT-662/GRC. The AN/GRC-106 is used for the transmit circuit and the second RT-662/GRC is used for the receive circuit in full-duplex operation. Compatibility of operation is provided with older radioteletype sets on compatible a-m or 850 cycle FSK radioteletype (60 wpm). The installation also provides for simultaneous SSB voice and narrow shift (85 cycles) secure radioteletype communication in full-duplex capability.

Teletype equipment includes a separate page printer and a combination page printer, reperforator, distributor, and keyboard. There is also included equipment for remote control up to distances of one mile, and extension of teletype loops for radio/wire integration. The system includes whip antenna for simplex operation while in motion and separate transmitting and receiving doublet antennas in fixed locations for full-duplex operations.

Operating frequency range is 2.0 to 30.0 megacycles. Any one of 28,000 channels are available in 1-kc steps from the front panel of the receiver-transmitter unit.

TECHNICAL CHARACTERISTICS

Frequency range:	
Transmit:	2.0 to 29.999 mc in locked 1-kc steps.
Receive:	2.0 to 29.999 mc in locked 1-kc steps with vernier tuning between steps.

Types of service:	SSB voice (upper sideband). A-m voice (carrier and upper sideband) C-w (2 kc above indicated frequency). Audio FSK; 850 cycle shift centered at 2 kc; 85 cycle shifts centered at 2805 cycles. SSB voice and 85 cycle audio FSK; FSK centered at 2805 cycles.
Mode of operation:	Full-duplex (separate doublet or whip for transmitting and receiving).
Frequency stability:	Within 1 part in 10^7 per week (locked in 1-kc steps).
Duty cycle:	Continuous duty from -40°C to +65°C.
Primary power:	27.5 volts d-c; power supplied by 100-ampere high-capacity generator system installed in 3/4-ton truck.
Power output:	
SSB voice:	400 watts peak envelope power.
Compatible voice:	400 watts PEP, (70 watts carrier).
C-w:	200 watts average.
FSK:	400 watts PEP; 200 watts single tone power.
Overall audio frequency response:	Flat within 2 db from 300 to 3,500 cycles.
Intermodulation distortion:	At least 35 db below either of two tones which produce rated PEP.
IF bandwidth (transmit and receive)	Flat within 1.5 db from 300 to 3,500 cycles.
Receiver noise figure:	12 db or better.
Receiver audio output:	2 watts maximum across 600 ohms.
Receiver audio distortion:	5% or less at 2 watts output.
Ventilation and cooling	Shelter includes personnel, heater, and fan. AN/GRC-106 is self-cooled. No outside air is circulated within equipment. RT-662( )/GRC used as auxiliary receiver is convection cooled in a sealed case.

Size and weight	Shelter S-153/G for mounting on 3/4-ton truck. Gross weight: approximately 1250 lbs.
Tactical employment	Replaces Radio Teletypewriter Set AN/GRC-46
Air transportability	Shelter S-153/G mounted on truck, 3/4-ton, 4x4, M-37 is transportable by C-123B Assault Aircraft.

COMPONENTS OF RADIO TELETYPEWRITER SET AN/GRC-122

Receiver Transmitter, Radio, RT-662( )/GRC	2 ea
Amplifier, Radio Frequency AM-3349( )/GRC-106	1 ea
Radioteletype Modem Unit	1 ea
Teletypewriter AN/TGC-14( )	1 ea
Teletypewriter AN/TGC-15( )	1 ea
Power Inverter for AN/TGC-14 and AN/TGC-15	2 ea
Shelter S-153( )/G	1 ea
Heater, Gasoline	1 ea
15 foot Whip Antenna Assemblies	2 ea
Doublet Antenna Kits AN/GRA-50 or equal	2 ea
Audio accessories - microphone, speaker, headset, etc.	

Background

In the current division of the present-day field army, communications are furnished through the medium of radio nets, point-to-point radio relay, field cable and wire service. Since dispersion and a higher degree of mobility are considered a defense against atomic and mass destruction weapons, time is not available for installation of an adequate field cable and wire system. This leaves the radio nets to carry the bulk of the traffic. A radio net has the advantage of passing information to a large number of users simultaneously, but has the disadvantage of a low volume of traffic capability per user which decreases as the number of users increase. This increases the waiting time to gain access to the net. Since all users can hear all transmissions, privacy of communications is lost.

An alternative to the radio nets and point-to-point radio is to bring a communication loop from each subscriber into a single location where the subscriber may be patched to communicate with other subscribers. This patching facility is called a *central.* If the majority of the communication loops to the *central* are via radio it would be called a *radio central.*

The equipment, Communication Central AN/MRC–66, developed by a commercial company for the Signal Corps, includes a Manual Telephone Switchboard SB–86, with a capacity of 30 or 60 line terminations. The present AN/MRC–66 requires only eight drops of the SB–86 to terminate the radio subscriber circuits.

Circuits for surveillance information, weapons control, air support, and air traffic control are some of the additional requirements now placed on the communications system. Undoubtedly, radio nets will continue to play an important role in satisfying the increased communications requirement. The use of radio sets, therefore, necessitates some sort of switched service while the user is moving.

A possible solution to the division communications problem appears to be an extension of the original radio central concept. This concept consists of a combination of multichannel radio (relay) systems, capable of being switched to satisfy the "long lines" requirement leaving the problem of local distribution over distances of 1/4 to 5 or 10 miles to radio and short haul wire. Thus having two kinds of radio centrals, compatible with each other, satisfies many of the communication problems and increases mobility of the division. A typical radio central system is shown in figure 1.

To satisfy the requirement of the local or satellite exchange, a study on an experimental communication central system was conducted and successfully completed. This study led to the fabrication of an "engineering test" model of a Communication (Radio) Central System, consisting of a central station with four subscribers or users, employing coordinated single-sideband (SSB) techniques. The successful testing of this system led to the construction of two additional systems, using coordinated SSB multiplexing at the central station and reduced-carrier SSB at the subscriber stations. In this system, 32 subscribers were possible with one radio central equipment.

The following design features have been included in the coordinated SSB system:

(1) Full-duplex operation.

(2) Conference capability controlled by the central station operator.

(3) Emergency conventional netting in event the central station becomes inoperative.

(4) Visual and audible signaling at the subscriber station from a conventional switchboard at the central station.

(5) Eight full-duplex voice channels available, with each subscriber having a choice of two channels.

(6) Automatic power output control at subscriber station to prevent blocking or desensitization of the central station receiver when located close in.

(7) Capability of operation while moving.

(8) Spectrum utilization of 7.6 kc per channel including guard bands.

(9) Out-of-range indicator on subscriber control unit.

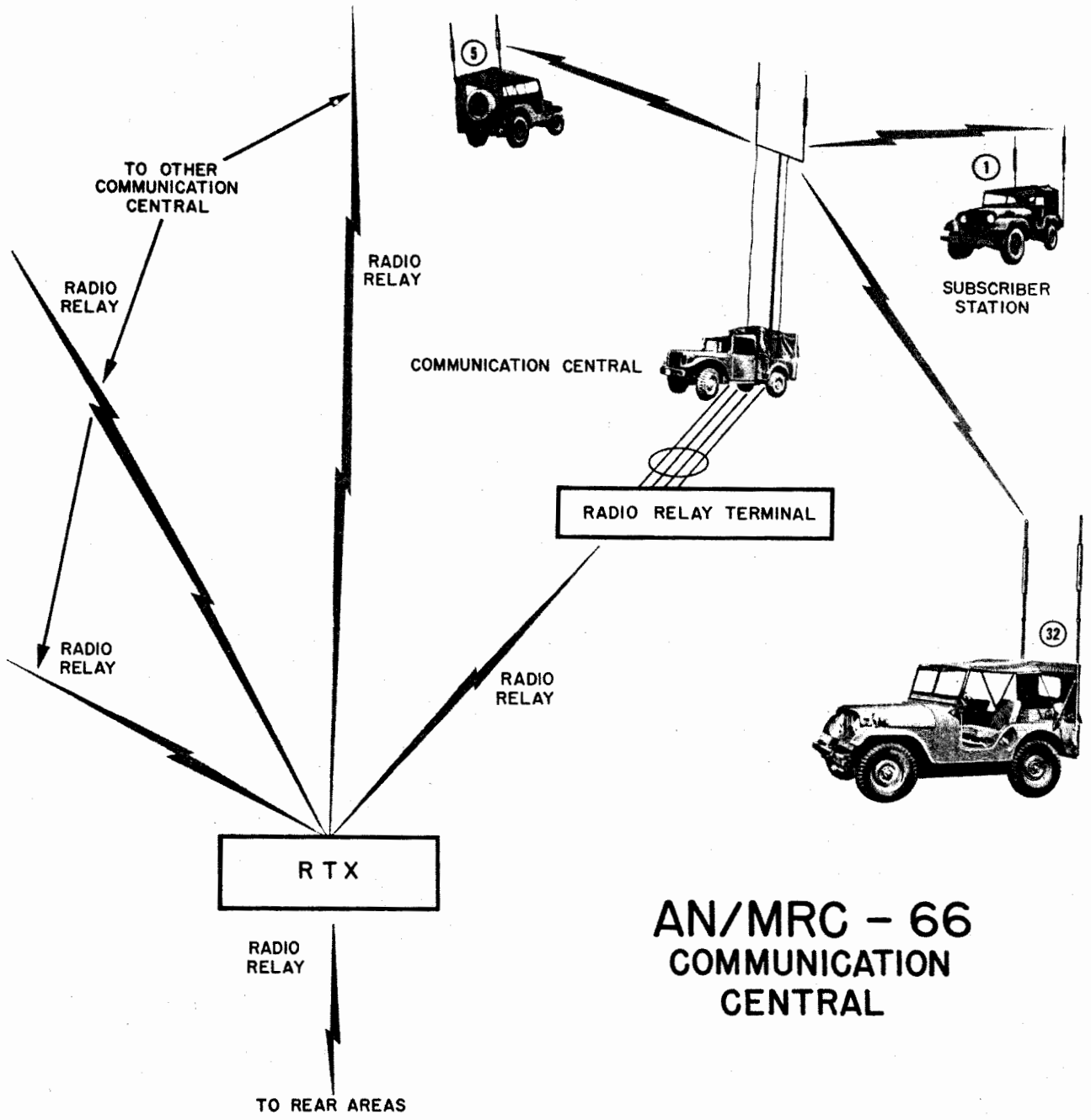


Figure 1. Radio central system.

Field tests were conducted the latter part of 1957 at the U. S. Army Electronic Proving Ground (USAEPG) to determine range in miles; interference within the system; interference between systems; signaling; netting capabilities in event that the central station becomes inoperative; susceptibility to jamming; and system characteristics.

The equipment tested was designed and constructed to evaluate the Communication Central AN/MRC–66 concept only. The field tests indicated that the basic system concept is sound. The radio central system provided military vehicles with telephone-type communications while using a minimum amount of the frequency spectrum.

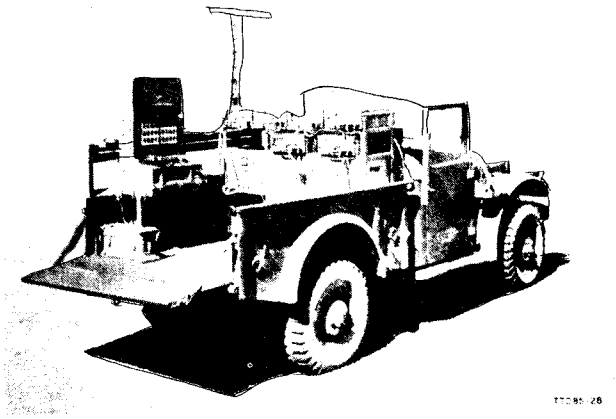


Figure 2. Central station equipment.

Two Communication (Radio) Central Systems were constructed. For purpose of experimentation, each of the two systems tested consisted of one radio central with 16 subscribers — one of the centrals had been intended as a spare central but during the test it was used in the system with 16 subscribers. As stated before, it is possible, however, to use 32 subscribers with one radio central. In final analysis then, each system, as tested, consisted of one central station with an SB–86 switchboard mounted in a ¾-ton truck (fig. 2), and 16 subscriber stations installed in a ¼-ton truck. Figures 3 and 4 show the subscriber station equipment mounted in a jeep. Three site locations for the central station were selected on and near USAEPG. Subscribers were located around the periphery of a circle at radii of 3, 6, 9, and 12 miles (fig. 5). The test was

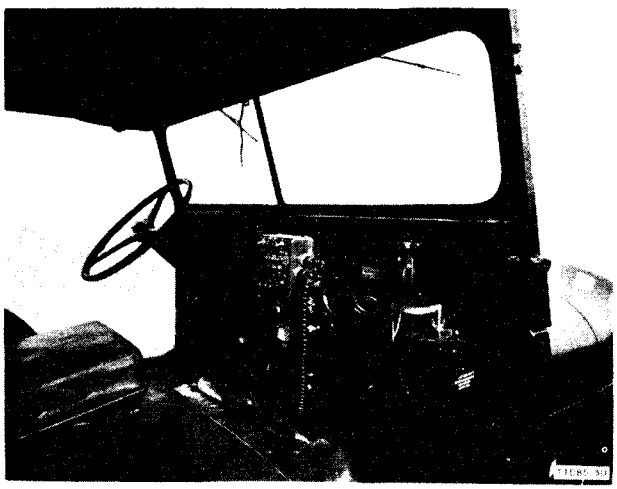


Figure 3. Subscriber station equipment mounted in front of 1/4-ton truck.

conducted with subscribers in motion and stationary, and with the central station in motion and stationary. The ability of the receiving subscriber to copy a message correctly was evaluated for each message in terms of percent copy. Then at each range (3, 6, 9, and 12 miles) of the test, a figure for overall percent copy was determined. This figure was compared to the percent copy under ideal conditions. At the end of all the tests, at one specific range, these figures were averaged together and compared with the standard. The percentage reduction from the

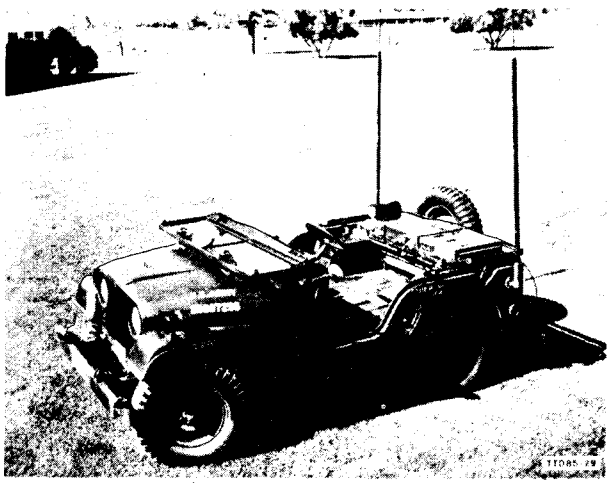


Figure 4. Subscriber station equipment mounted in rear of 1/4-ton truck.

standard was determined and from this data the reliable communications range of the equipment was ascertained.

As stated previously, these field tests indicated that the basic system concept is sound and workable. However, the SB–86 was found to be the weakest point of the system.

To replace the SB–86, an automatic switchboard, Electronic Telephone Central Office AN/TTC–14, being developed for wire usage, will be used at the central station for independent dial-type communication between subscribers. To accommodate the AN/TTC–14, the MRC–66 itself is being modified.

Present plans call for the AN/TTC–14 and the radio central to be field tested in the Spring of

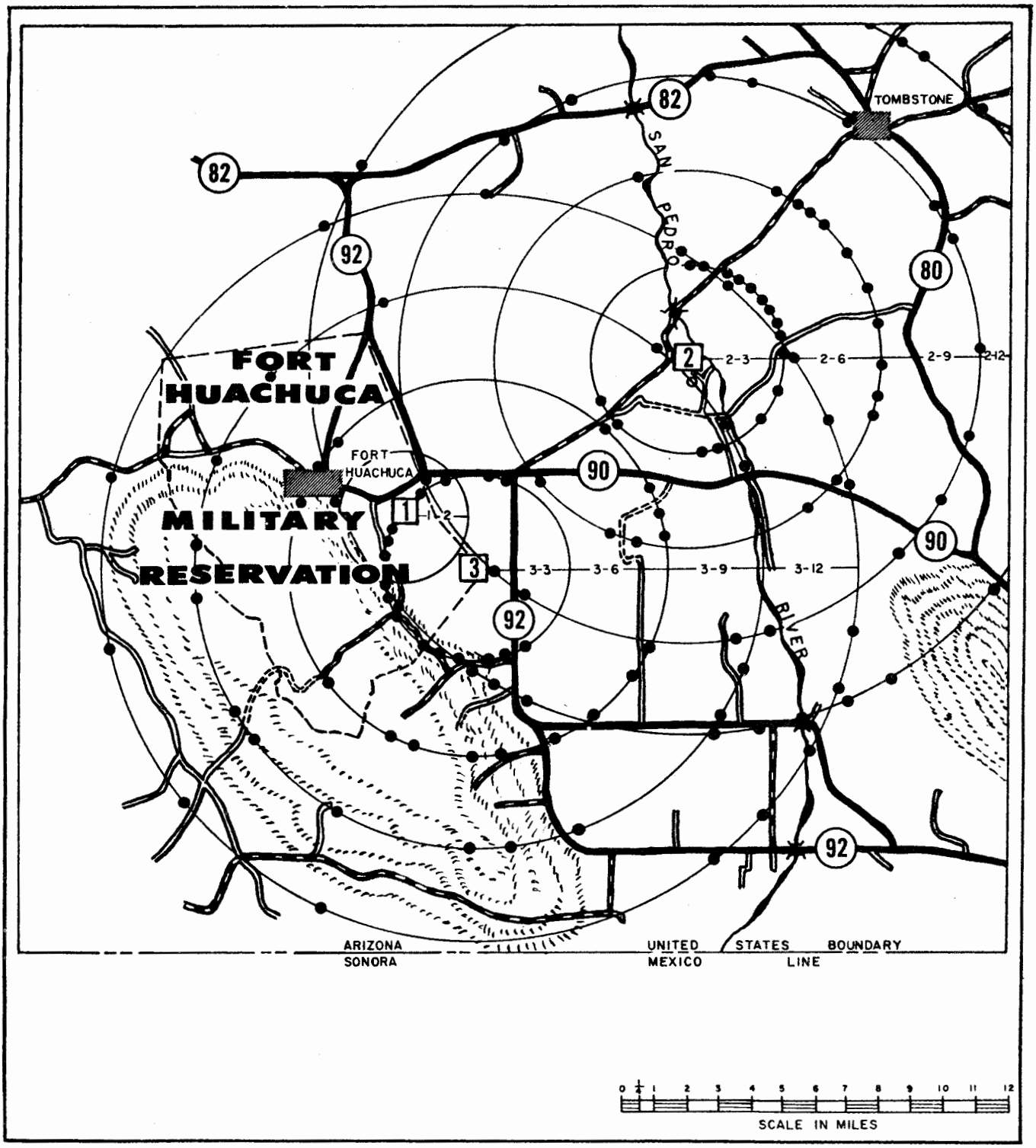


Figure 5. Test site locations.

1959. With the integration of this automatic equipment into the system, the SB–86 with its required switchboard operator, will be supplanted, and the subscribers will be provided with speedier and more direct communication.

Communication Central System

The equipment required for a Communication (Radio) Central System (AN/MRC–66) was developed by a commercial company for the U. S. Army Signal Research and Development Laboratory. As designed, the system utilizes coordinated multiplex single-sideband techniques with nine voice channels and is capable of 95 per cent coverage at 5 miles and 70 per cent coverage at 10 miles. It provides a spectrum utilization factor of approximately 1/8 of that of existing frequency-modulated (FM) equipment.

The central station consists of an SSB transmitter and receiver, the necessary multiplexing equipment to provide eight full-duplex voice channels plus a simplex voice channel, and a switchboard SB–86.

Figure 6 illustrates a Communication (Radio) Central System with a portion of its subscribers. When subscriber No. 1 wishes to talk to subscriber No. 5 he calls the operator at the central and asks for No. 5. The switchboard indicators and procedures for the operator are the same as when a call is processed from a wire subscriber.

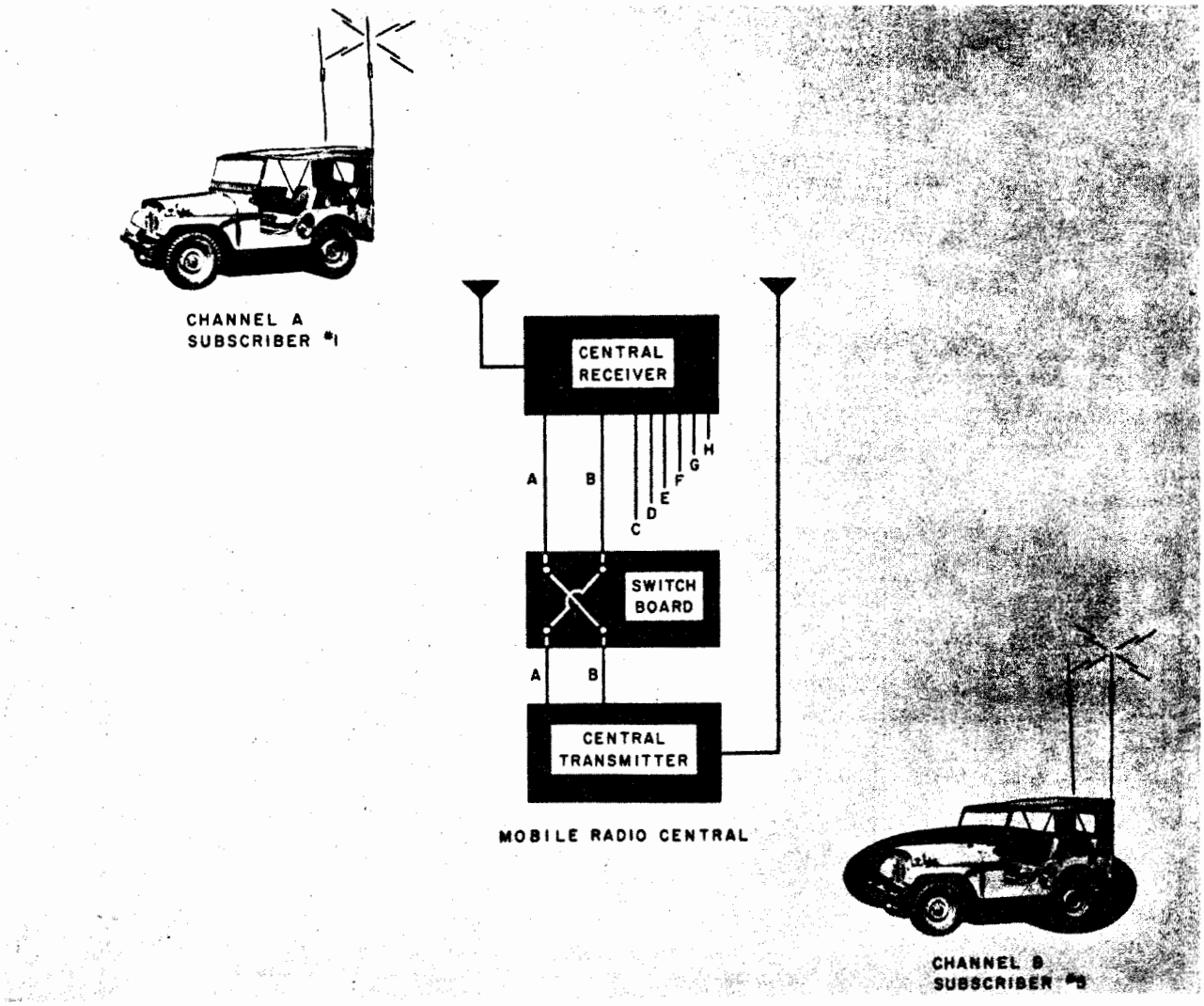


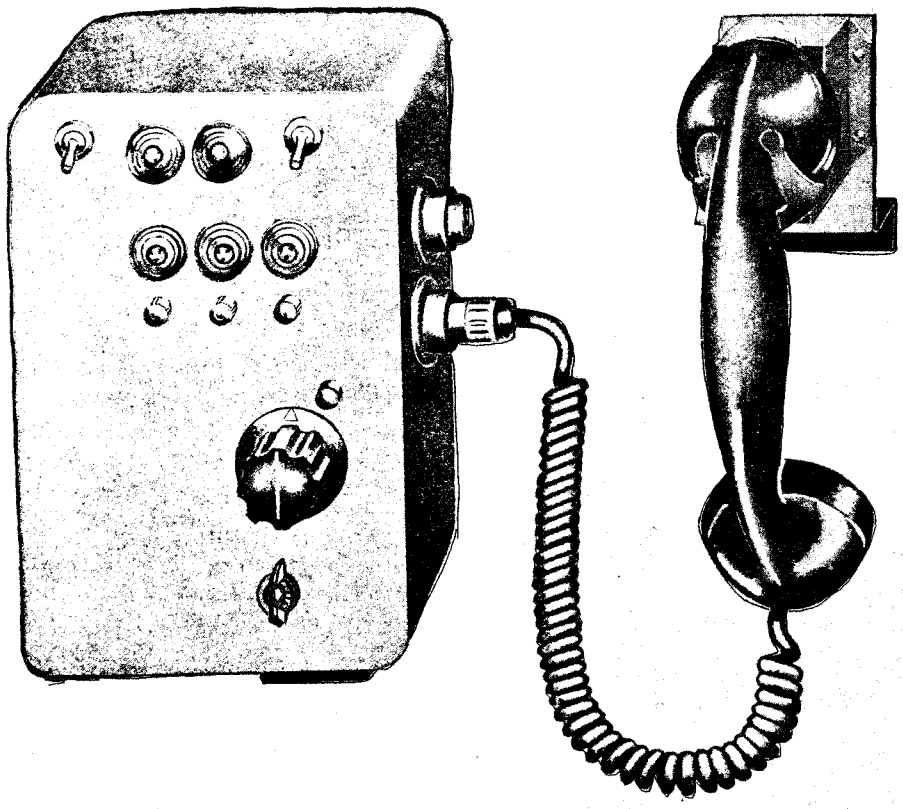
Figure 6. Communication (Radio) Central System.

The mobile radio subscriber uses his equipment in a manner very similar to telephone operating practices. He has a regular telephone-type handset which is normally placed in a hookswitch located on the dashboard of the vehicle (fig. 7). He is able to communicate over two regular channels shown as 1 and 2, and a conference channel marked CONF. Each channel has its own indicator light. If the central station should become inoperative, all subscribers may switch to the EMER NET position and communicate with each other on a push-to-talk basis.

Upon receiving a call, the subscriber is alerted by a buzzer. He then observes the lights on the control unit. The channel light, associated with the channel on which he is being called, is flashing. He then positions the channel selector switch to the indicated channel and answers the call. When he removes the handset from its hookswitch, the channel light changes from flashing to steady.

When initiating a call, the subscriber observes his control unit and rotates his channel selector switch to a channel which has neither a flashing nor a steady light showing. He then proceeds in a manner similar to that of a wire subscriber.

If the subscriber gets beyond transmission and reception range, the RANGE indicator glows to give instant warning.



SUBSCRIBER'S CONTROL UNIT

Figure 7. Subscriber's control unit.

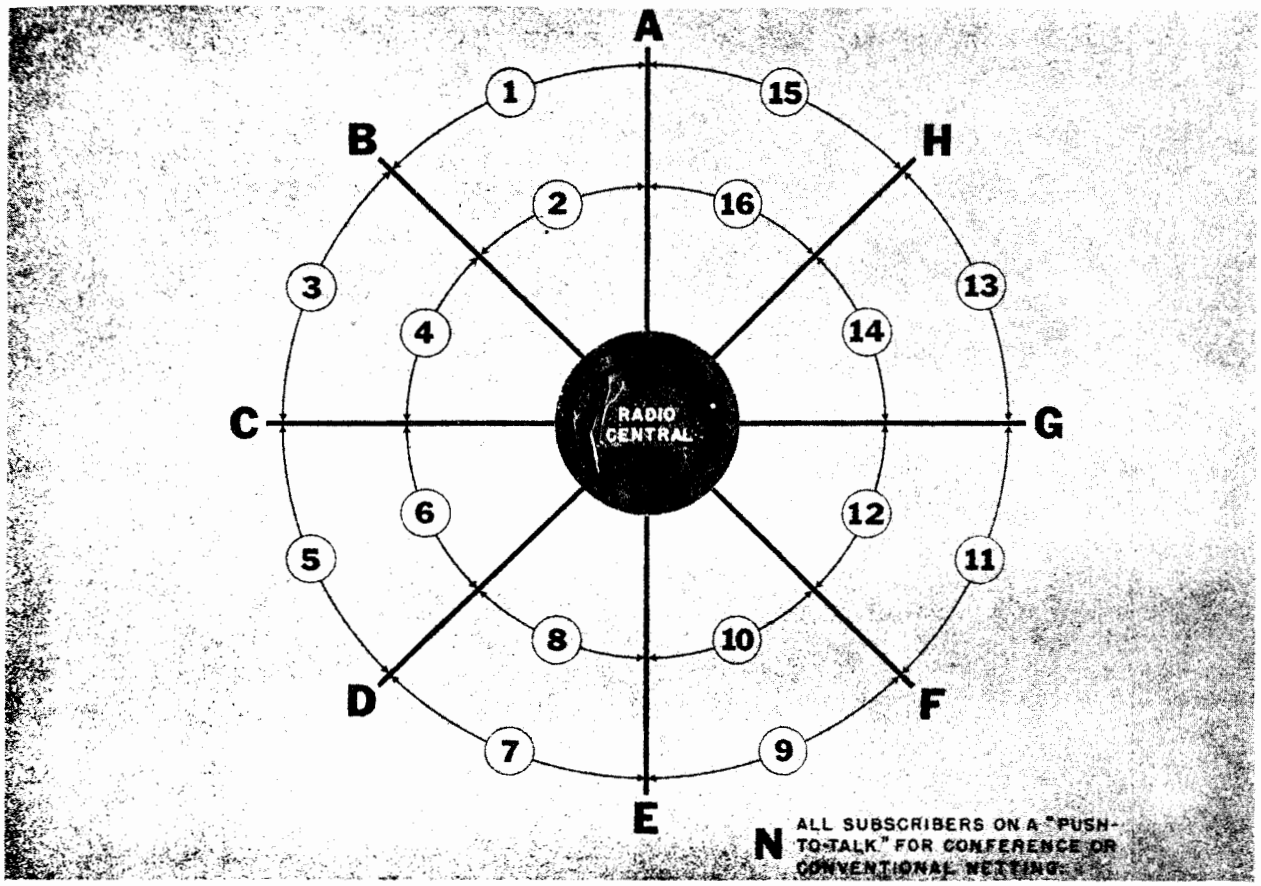


Figure 8. Channel assignment.

The 16 subscribers share the 8 voice channels (marked A through H) (fig. 8). Channel N is available to all subscribers for conference calls and emergency net operation. Note that this assignment is only one of many possible arrangements for providing service to subscribers. More channels and more subscribers may be added to the system with little difficulty. As emphasized several times previously, a total of 32 subscribers is possible in the system with one radio central equipment.

When the Communication (Radio) Central was developed, certain fundamental system objectives were required. These were intended to:

(1) Provide an eight-channel multiplex system.

(2) Occupy the minimum possible spectrum.

(3) Provide full-duplex communications.

(4) Provide communication while both the central and subscribers are in motion.

(5) Provide efficient use of available RF power.

Figure 9 shows a block diagram of communications between the subscriber and the central position. To achieve full-duplex communications, the operating frequencies of the subscriber's transmitter and receiver must differ by approximately 10 mc.

The antennas are separated about 6 feet when mounted on the vehicles. With proper equipment design, the transmitted power from one antenna will not degrade the performance of the receiver connected to the other antenna.

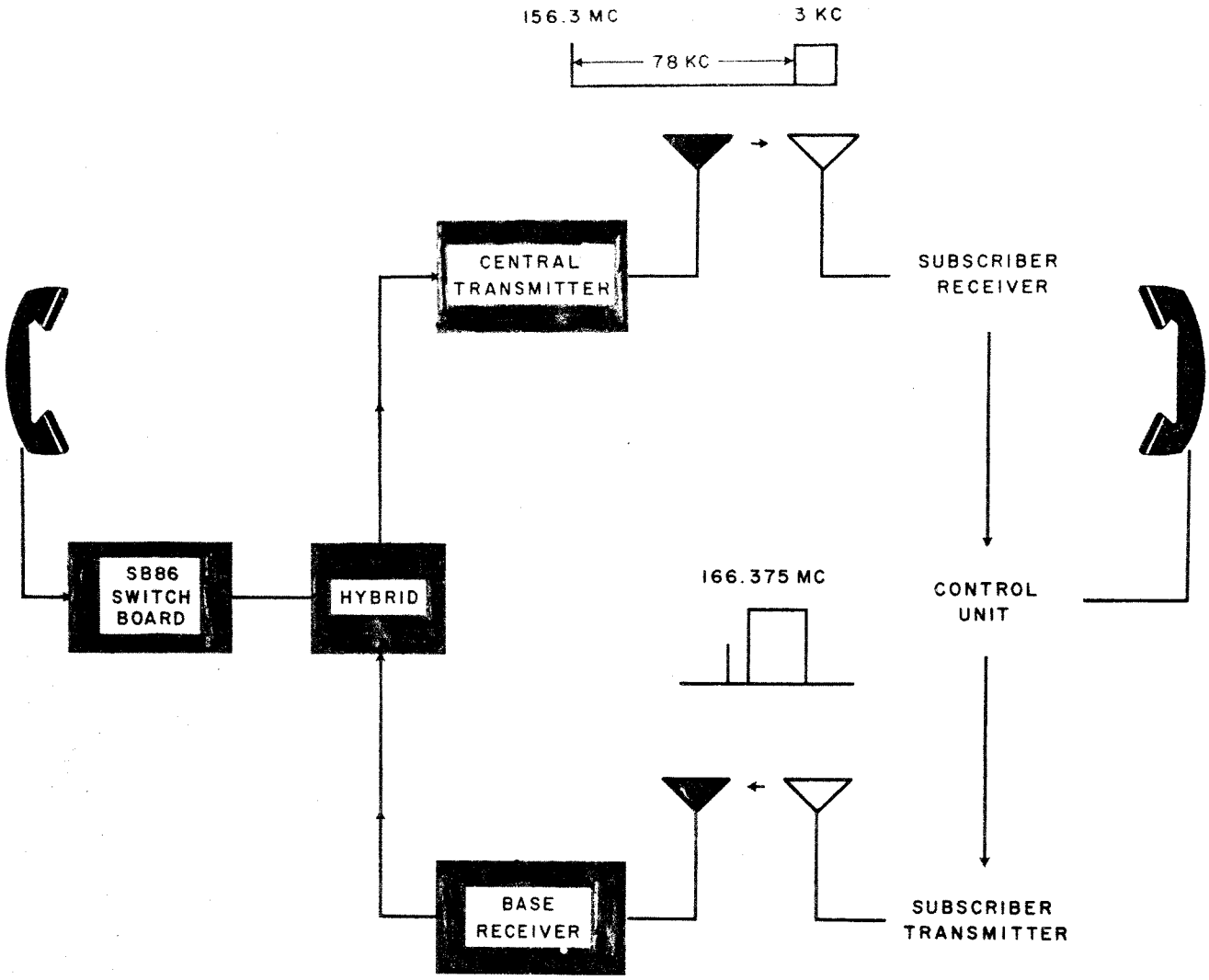


Figure 9. Communication between subscriber and central.

The method of generating a single sideband is quite conventional (fig. 10). Basically, the generator is a balanced modulator, a crystal-controlled oscillator, and a mechanical filter; the latter being the heart of the generator. Different oscillators and different filters are used to generate channels A through H and channel N.

It would be possible to partially fulfill some of the requirements for a radio central communication system by using a radio central equipment with a number of existing FM radio sets that are adjusted to different channel frequencies. However, the wide channel spacing required for existing equipment and self-interference problems indicated that a coordinated multiplex SSB type radio system would be a much more efficient solution.

The system chosen to best fulfill all of the above requirements was a coordinated multiplex single-sideband system operating in the 150-170 mc frequency range. This frequency range was chosen for the following reasons:

(1) The congestion within the tactical military spectrum below 100 mc indicated that those frequencies should not be used.

(2) Interference with other systems would be minimized due to the absence of "sky waves."

(3) Atmospheric noise in the 150 mc region is negligible.

(4) The generation of the necessary amounts of linear single-sideband power can be practically achieved at 150 mc with existing tubes and circuits.

The SSB multiplex spectrum (left, fig. 11) is transmitted by the central station. A continuous reference signal is transmitted at 156.3 mc. This reference signal serves a number of purposes:

(1) It locks all the subscribers on frequency thereby allowing SSB intelligence to be demodulated with negligible frequency distortion.

(2) It provides a carrier for selective calling and signaling tones.

(3) It provides a steady signal at the subscriber's receiver. This steady signal is necessary for receiver automatic gain control and for transmitter automatic output control.

(4) It provides a means of operating the "out-of-range" light at the subscriber's station.

The reference signal is spaced 78 kc from the closest sideband for two major reasons:

(1) To insure that the intermodulation products formed by the combination of the reference signal and the voice sidebands fall in the gap between channel A and the reference signal.

(2) To simplify the problem of separating the reference signal from the sidebands in the subscriber's receiver.

The spectrum transmitted by the subscriber is shown on the right side of figure 8. Each channel consists of a reduced-carrier single-sideband signal. The carrier is adjusted so that the peak sideband power is 13 db higher than the carrier power.

Where a large number of radio central systems are used to provide communications for many units in a military organization, it is proposed that the frequencies be interleaved and assigned as shown in figure 12. There will undoubtedly be some restrictions concerning the geographical location of adjacent radio centrals.

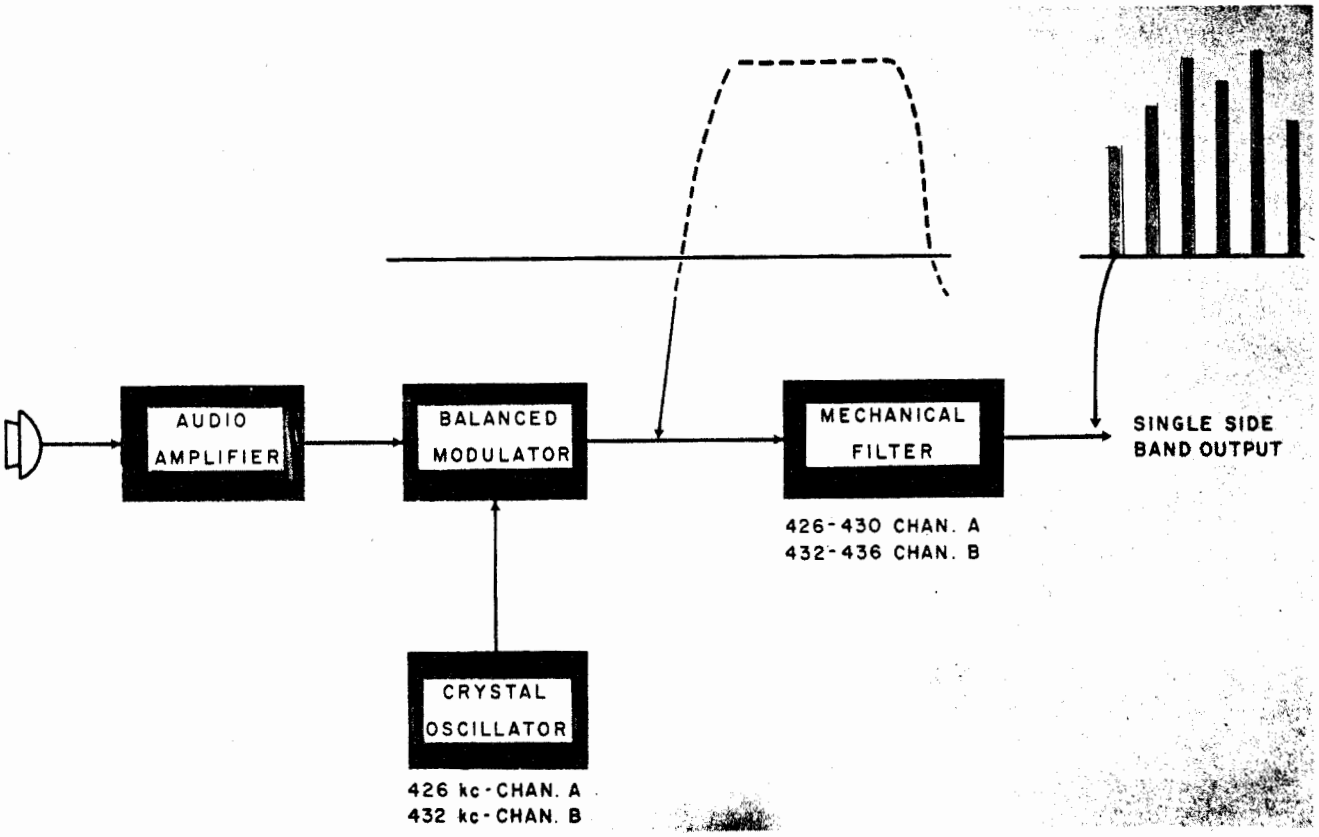


Figure 10. Single-sideband generator.

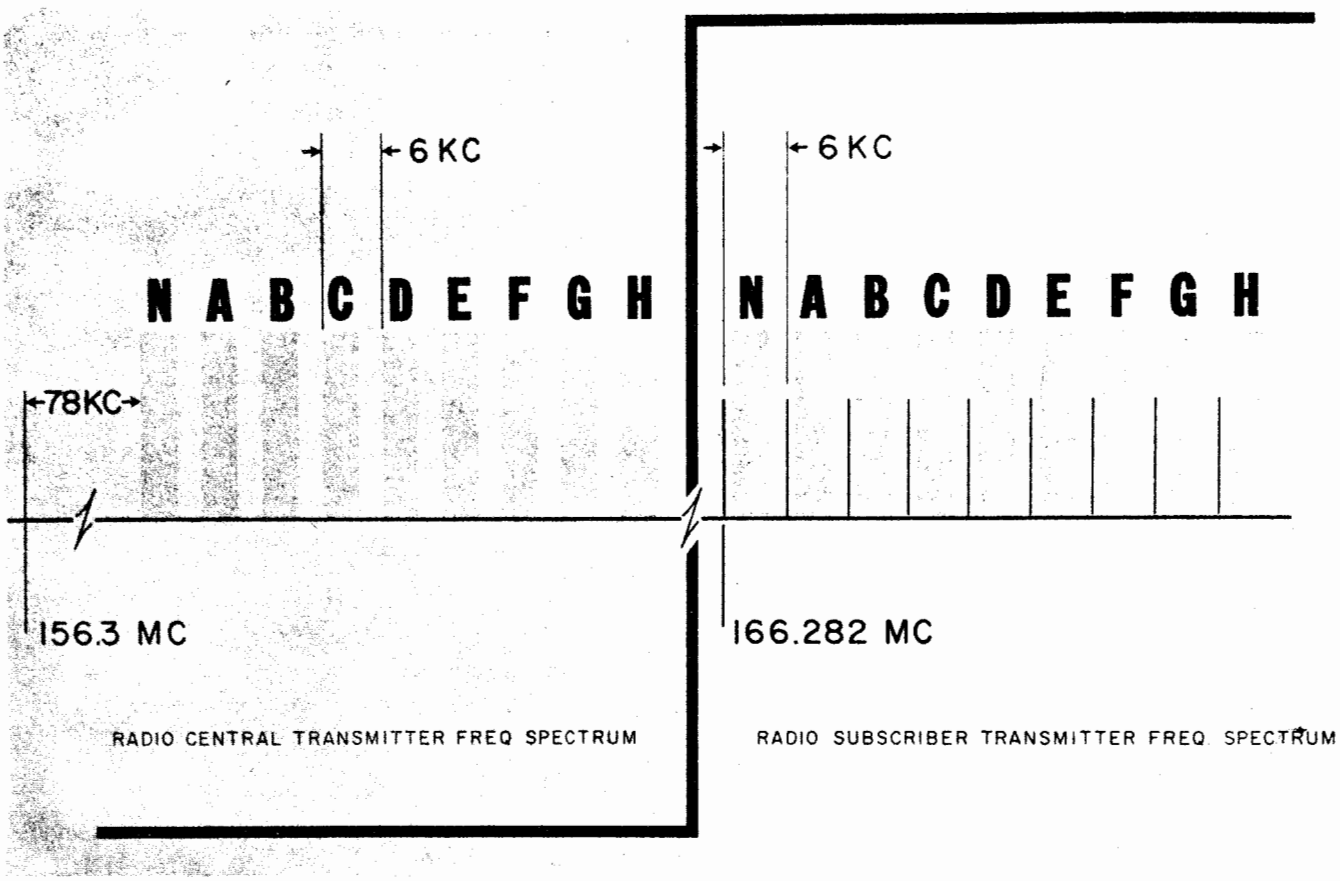


Figure 11. Radio central frequency spectrum.

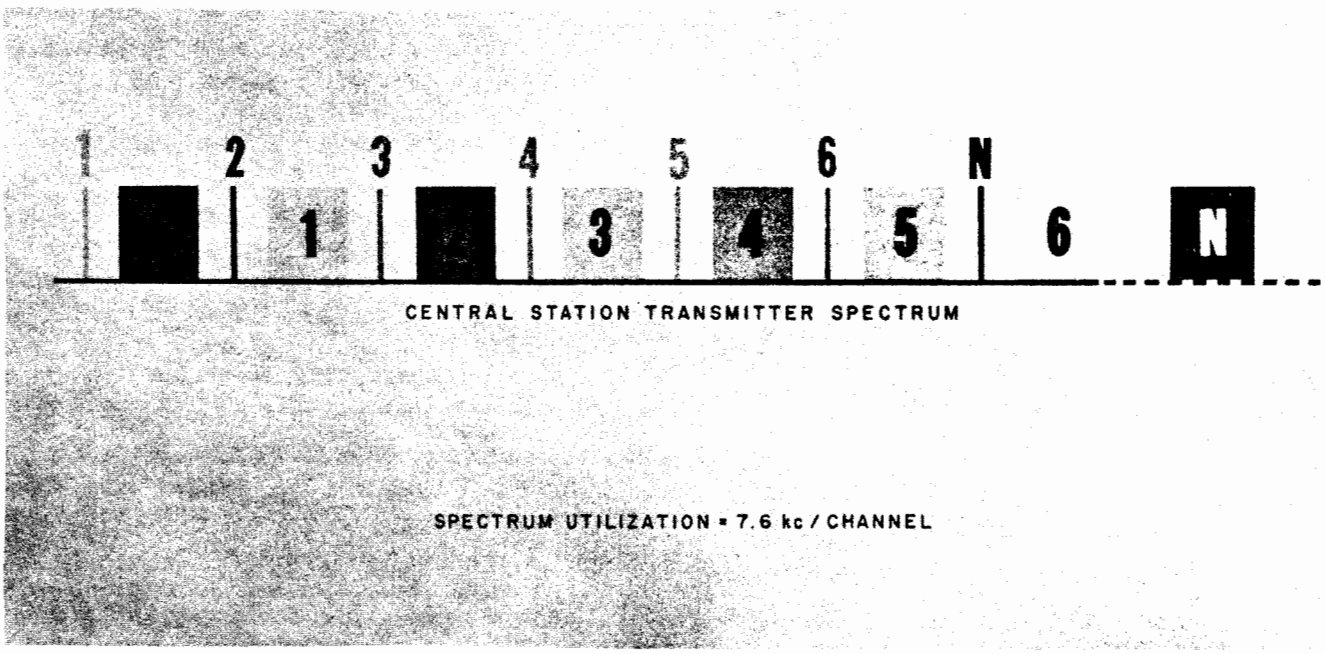


Figure 12. Proposed frequency assignment radio central system.

If the total frequency is divided by the number of communications channels, a spectrum utilization figure of 7.6 kc per channel including guard bands is obtained. If a radio central system were made up of existing military FM equipment, this figure would be at least 7 or 8 times greater.

The complete details on how to generate and receive the radio frequency spectra shown in figures 11 and 12 are lengthy and complex and will not be covered completely in this article. However, there are a few details of the system which might be of special interest.

Through experimentation it has been learned that if telephone-like quality is to be achieved in a single-sideband system, the error between the original carrier and the reinserted carrier must be held within 20 cycles per second (cps). Intelligence can be obtained with frequency errors up to 150 cps, but distortion becomes objectionable when the error exceeds 20 cps.

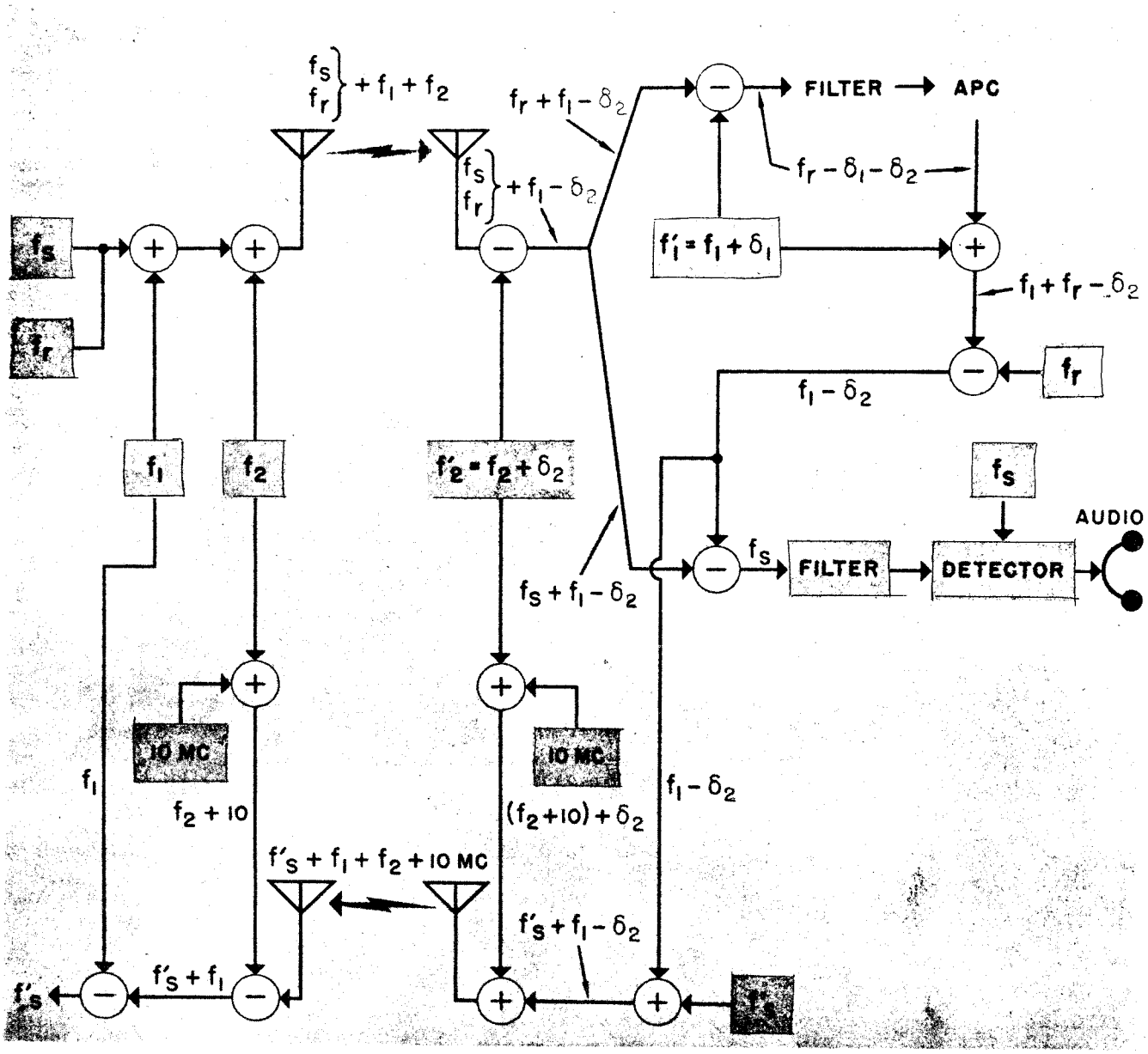


Figure 13. Frequency error correction system.

The present state-of-the-art for stability in small mobile radio equipment allows us to achieve an oscillator drift tolerance of ±5 parts per million per month. If we look at this tolerance in terms of the operating frequencies (150 mc) it could mean ±750 cps at the transmitter and ±750 cps at the receiver, or a possible ±1,500 cps between the reinserted carrier and the originating carrier. These facts made it necessary to use some sort of automatic frequency control in a mobile SSB system operating in the 150-170 mc range.

The error correction system (fig. 13) shows the method by which significant errors are cancelled in the VHF single-sideband system.

One of the functions of the reference signal transmitted by the central station was to control the power output of the subscriber's transmitter. This is necessary due to the following situation. The system gain of the radio central is approximately 150 db. Assume that subscriber No. 1 and subscriber No. 2 are located 500 feet from the central. The attenuation between each subscriber and the central station is approximately 60 db. Subscriber No. 3 is located 5 miles from the central station. The attenuation between his antenna and the central will be approximately 130 db. Therefore, subscriber No. 3 will be competing with signals which are 70 db stronger than his own. If subscribers No. 1 and 2 generate intermodulation products in the base receiver which are only 40 db down and which fall on subscriber No. 3's channel, these products will be 30 db higher than subscriber No. 3's signal. This situation does not make the system completely unworkable, but it means that a certain percentage of the time, if two or more subscribers were operating close to the central station, could cause serious interference with another subscriber operating at 5 or more miles away. It was felt that the occurrence of this type of interference might be frequent enough to cause serious annoyance. Therefore, an Automatic Output Control (AOC) was incorporated into the system.

The AOC operates as follows:

A voltage is derived in the subscriber's receiver from the reference frequency. The mag-

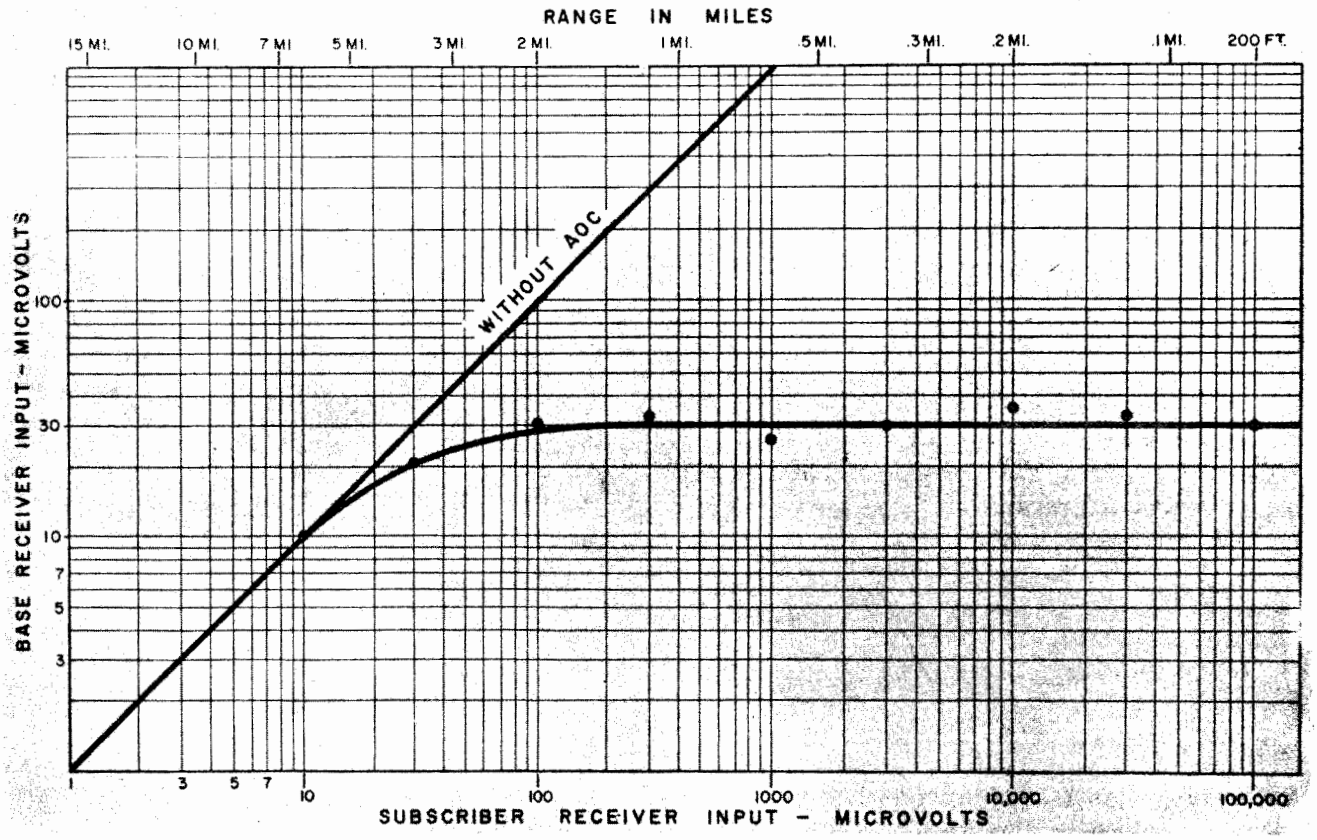


Figure 14. Subscriber AOC operation.

nitude of this voltage is a function of the distance between the subscriber and the central station. This voltage is applied as gain control to the cascaded driver stages of the subscriber's transmitter. As a result, the output of the transmitter varies as a function of its distance to the central station. The output of the transmitter is reduced to 60 db below full output when the subscriber is close to the central station. This automatic power control reduces the probability of near-subscriber interference to a figure that can be considered negligible.

Figure 14 shows a plot of microvolts appearing across the terminals of the central receiver as a function of microvolts appearing across the terminals of the subscriber's receiver. At the top of the figure the microvolts are converted to miles. This conversion assumes theoretical propagation losses over smooth earth. The solid curve is the desired characteristic and the points are the measured characteristics. The figure shows that the input to the central receiver rises to 30 microvolts and remains approximately constant even when the subscriber approaches within 200 feet of the central.

CONCLUSION

By using a coordinated multiplex single-sideband radio central, the system requirements have been fulfilled.

A spectrum utilization factor of 7.6 kc per channel, with guard bands included, has been achieved. This is approximately 1/8 of the spectrum that would be necessary to accomodate a radio central made up with existing equipment. The successful use of SSB and VHF mobile operation has been demonstrated. In addition, through use of a pilot carrier, a system has been developed which can be shifted upward in frequency without having to consider Doppler frequency shift or oscillator stability.

CONARC observed and participated in field tests of the radio central concept at USAEPG. After completion of the tests, CONARC indicated the desirability of incorporating certain technical and operational changes to better fulfill military characteristic requirements.

Details of these changes have received final authorization and the newly developed front-line radio central system AN/MRC-66 has passed its service test and is now in production. Field deliveries are expected in 1961.

The system will provide switched radio telephone service to battle areas. The central office is mounted in a weapons carrier or a three-quarter-ton truck, and subscriber stations are installed in jeeps or armored personnel carriers. The latter stations all work through the central-station board, where incoming calls are switched to other subscriber stations, to long-distance radio relays, or to wire circuits. A single-sideband is used, and voice, facsimile, and teletypewriter traffic is handled. Other features include full-duplex operation, in-channel net, and emergency conventional netting should the central station become inoperable.

Section XIX. Electronic Telephone Central Office AN/TTC-14

A NEW ELECTRONIC SWITCHBOARD

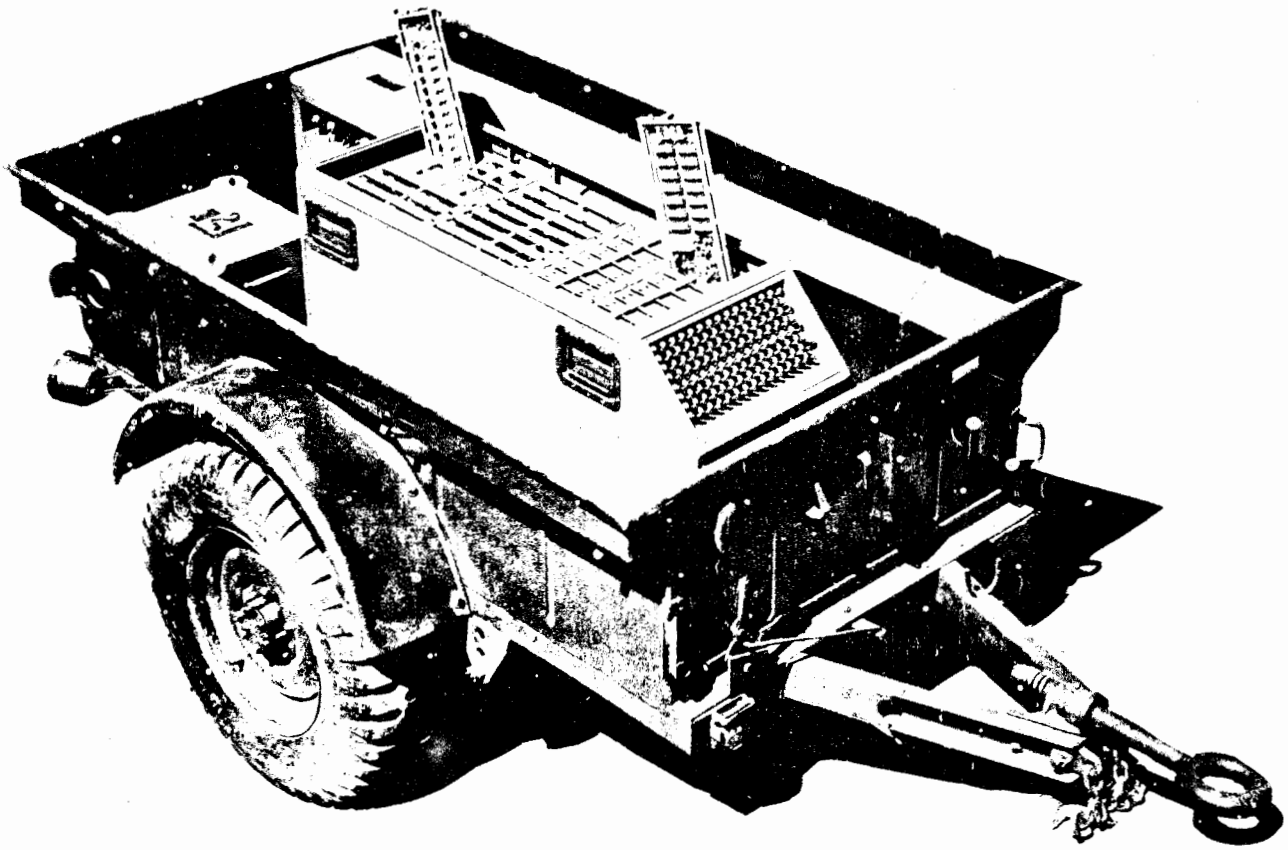
Electronic Telephone Central Office AN/TTC-14 (LEAS) was designed by Kellogg expressly for the Signal Corps to provide improved communications to front line or field units. This lightweight, transistorized equipment meets the requirements for mobile, highly efficient, high speed switching.

The circuitry incorporates the advantages of both space and time division techniques; space division in the voice paths and predominately time division in the control circuitry.

Through a four-wire system, this automatic switchboard permits uninterrupted transmission and reception. By the use of special converters developed by Kellogg, the equipment will accept calls from all military or commercial dial or manual central offices. By the use of other converters developed by Kellogg, connections can be made between telephone users connected to the switchboard to other telephones mounted in mobile units.

A transistorized telephone, with a key, eliminates the need for direct current dial pulses. When a number on the telephone key set is pressed, tone frequencies are sent from the telephone and stored in a memory device at the switchboard. When the call sequence has been completed, the stored information is released and an instantaneous connection is accomplished through the link circuits.

The switchboard will operate on standard vehicular batteries, and functions smoothly under conditions ranging from minus 40 degrees to 125 degrees Fahrenheit.



BASIC 20 LINE UNIT MOUNTED IN M100 TRAILER

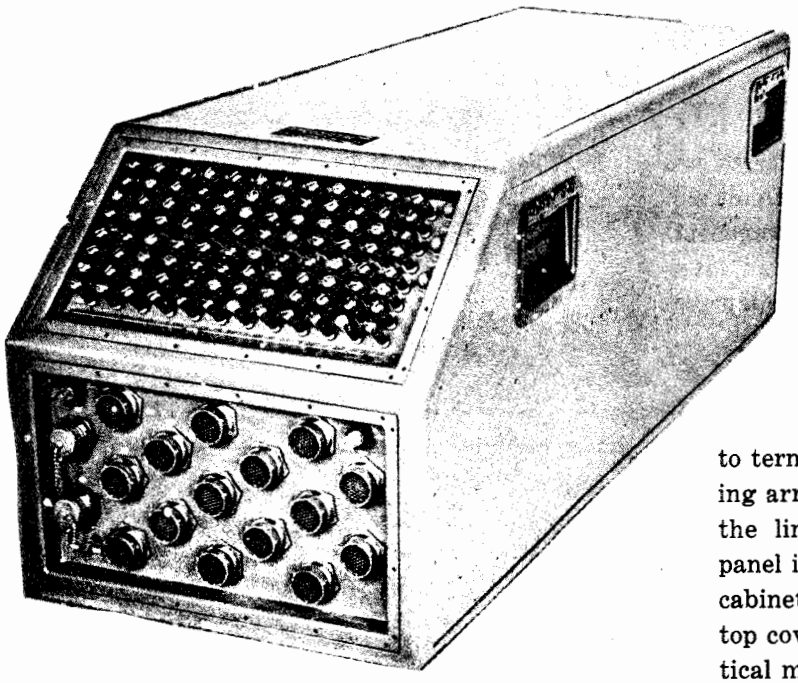
Top removed to show modular insert package units.

The illustration above depicts the smallest possible arrangement for telephone service for 20 lines without the use of an assistant operators position. A 40 line line system (front cover), consists of one "A" unit and one "B" unit with the optional operators position included. A 60-line systems operation can be obtained by interconnecting one "A" unit and two "B" units. The equipment can be mounted either in a horizontal or vertical position thereby being applicable for a variety of mobile or semi-permanent installations.

Components of the equipment which comprise a complete system is illustrated on the pages that follow.

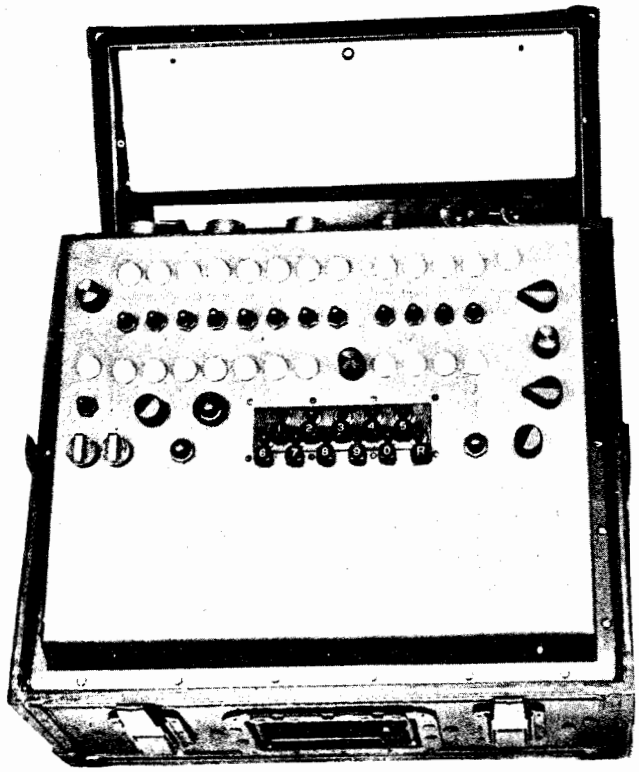
EQUIPMENT DESCRIPTION

BASIC 20 LINE UNIT



The basic units of the Lower Echelon Automatic Switchboard (LEAS) AN/-TTC-14 are the "A" and "B" units. The "A" unit provides service to 20 telephone lines. Each of two additional "B" units connected into the system provides service for an additional 20 lines. The units can be placed as shown or on end in any type of shelter or enclosure. Telephone lines equipped with TA-341-()PT telephone sets or trunk lines for use between switchboards are connected to terminals shown on the sloping panel. Lightening arrestors for each line are located adjacent to the line terminals. Connections on the vertical panel interconnect the A & B units, the operators cabinet, batteries and power supply. A removable top cover enables ready access to a series of identical modules of which a typical module is shown in one of the illustrations.

OPERATORS CABINET (Optional)

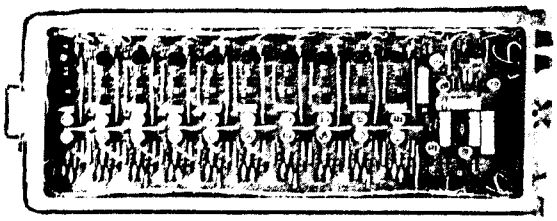


The operators position is a small portable cabinet connected by a 25 ft. cable to the basic unit. It enables an operator to answer any call which comes to him through dialing or a recall and to render assistance to the called or calling party. Calls to the operator may be extended to a trunk circuit or completed to a line. If more than one call is routed to the operator and he is busy, the call is held and connected as soon as he is idle. Waiting recalls are given priority over new calls.

EQUIPMENT DESCRIPTION

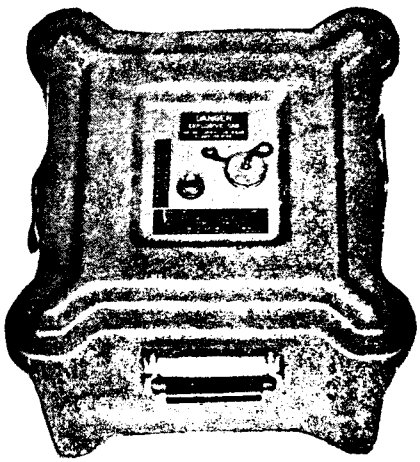
TYPICAL MODULE

A typical module of the "A"and "B" units consists of a rugged cast frame, a printed circuit wiring board, and transistorized circuit components as shown. Modules of the same type are interchangeable in "A" and "B" units. All equipment is transistorized



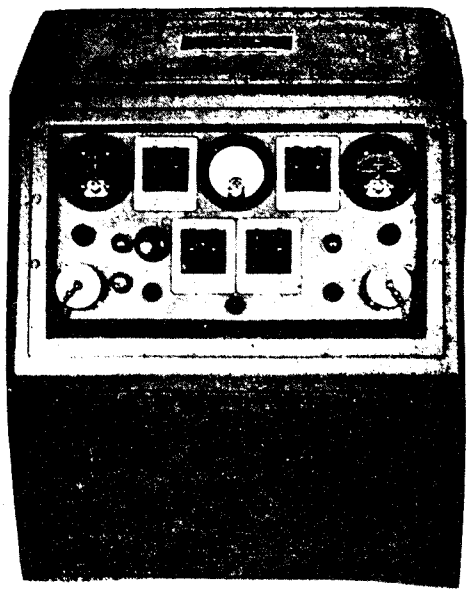
BATTERY CASE

The battery case mounts two 12V 2HN-12 Signal Corps standard batteries for supplying the equipment with positive and negative 12V to ground.



POWER SUPPLY & BATTERY CHARGER

The unit is capable of operating the lower echelon switchboard directly or in conjunction with batteries for continued operation in the event of AC power failure. It operates from nominal 115V single phase supply and provides both positive and negative 12V to the equipment.



SYSTEMS SPECIFICATIONS

I. USED WITH:

Additional AN/TCC-14 switchboards or compatible switchboard equipments.

Telephone Signal Converters TA-375()/TTC and TA-376()/TTC for connection to commercial dial or manual offices.

Telephone Signal Converters CV-639()/TTC and CV-640()/TTC in conjunction with AN VRC 12 Transceivers for connection of switchboard lines to mobile telephone sets.

Telephone Sets TA-341/PT, connected to switchboard with WF-16U field wire or equivalent.

Radio, microwave, and carrier equipments.

II. OPERATIONAL SPECIFICATIONS:

Signaling and Supervision Tone:

Dial Tone	600 cps steady
Ring Signal and Ring Back	600 cps interrupted 1 second on, 2 seconds off, modulated at 20 cps
Busy Tone	600 pps, ¼ second on, ¼ second off,
Seize Tone	1700 cps
Digit Tones	1,900 cps to 2,900 (two tones per digit)

Type of Switching:	4 wire
Transmission Bandwidth:	250 to 25 kc, ± 1 db
Insertion Loss:	1.3 db ± 0.2 db with respect to 1000 cps
Line Input Impedance:	600 ohms ± 10%
Power Required:	230V or 115V ac single phase 50-60 cycles, or + 12 volt and — 12 volt battery source

III. ENVIRONMENTAL CONDITIONS:

Temperature:

Operating	— 40° to 125° F
Storage	— 80° to 160° F

Altitudes:

Operating	To 10,000 ft.
Storage	To 25,000 ft.
Humidity:	95% (All units weather proofed)

Section XX. "The Mite"

This machine is submersion proof, shock resistant, with a field-type carrying case, and is in every respect a true telegraph page printer completely compatible with existing teleprinter equipment and is also equally useful as a computer read-in, read-out device. It is different only in that it is far smaller and far lighter than conventional equipment and has certain design features which make it a far more desirable and versatile piece of equipment. The entire Model 104V unit consists of the receiving and printing unit, the keyboard transmitter, and a case, which may be lightweight fibreglass for field use, or aluminum for fixed plant or mobile use.

Recent tests conducted in the field have demonstrated a lack of mechanical failures as compared to conventional larger machines, thereby reducing operation and repair problems considerably.

While the new features are numerous, some of the more noteworthy are: the keyboard transmitter that requires only two adjustments for perfect square-wave signals; a self-contained electrical system which requires only connection to an appropriate primary power source to ready the equipment for operating; and operation in any position, which lends itself to mobile or aircraft application. The "Mite" (Miniaturized Integrated Telegraph Equipment) with its compactness and light weight is ideally suited to the helicopter concept of highly mobile forces. In addition to its miniature size, it has proven itself easily installed and sturdy despite the rough treatment of vehicular and helicopter employment.

From the standpoint of the operator, the facts that the machine is easily transportable in its double-duty field case, can be carried by one man like a portable typewriter, and can be set up and its operation commenced in less than a minute, are highly desirable features.

When it is considered that all parts are readily accessible to inspection, lubrication, or servicing, its improvements become even more commendable. All these features, of course, are in addition to its obviously outstanding characteristic - reduced size and weight. The MITE is aptly named for it typifies miniaturization. It is small in size, light in weight, and can operate from a variety of primary power sources such as 26 volts d-c; 110 volts a-c; 30 cycles, 60 cycles, or 400 cycles, and in ambient temperatures ranging down to below -55 degrees C. This latter feature makes it extremely valuable for use in polar operations.

END

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