A Portable Telephone Set for Military Use

L. J. COBB *Apparatus Development*

A new military telephone set illustrates how civilian developments can be adapted to meet the needs of national defense. After the introduction of the 500-type telephone set into the Bell System, Bell Laboratories modified this basic design to develop a versatile and efficient telephone set for use by the armed forces. Without sacrifice in performance, the set operates under extreme conditions of climate and rough handling.

Most people are familiar with the improvements in the performance and appearance of the customer's telephone brought about by the introduction of the 500-type telephone set into the Bell System. But it is not so widely known that since World War II the Signal Corps' field telephone set has been similarly improved.

Under a development-production contract with the Signal Corps, the Laboratories has developed, and the Indianapolis Plant of the Western Electric Company is now producing, a new field telephone set, the military nomenclature for which is Telephone Set TA-43/PT. As in the case of almost all military equipment, the necessity for the highest degree of reliability, even under the most rigorous and unfavorable service conditions, imposed many difficult problems for its designers to solve.

The new field telephone set, in addition to retaining the sensitivity and excellent transmission performance of the best civilian sets, meets all of the military reliability and ruggedness requirements. The set is ready for instant use even though it might have been submerged in the surf during an amphibious landing operation, delivered by parachute drop, hurriedly tossed into a jeep or truck and transported without protection over miles of roadless, rough terrain, and even dropped on a rock in unloading. It will also withstand without damage, the terrific acoustic blasts from large guns operating nearby. The telephone set will operate satisfactorily under arctic conditions where mercury thermometers freeze and become useless, or in the broiling heat of a desert sun. In addition it is light in weight (9 pounds), convenient to carry and easy to use.

As shown in Figures 1 and 2, all of the component parts of the telephone set, except the handset, are mounted in a two-piece, die-cast, immersion-proof aluminum housing. The electrical terminals, switches, and controls are brought out on a panel, which also provides a mounting for the handset. A hinged and gasketed door on this panel covers the battery compartment. A canvas carrying case, closed with a zipper, encloses the set except for openings for the audible signal (ringer) and the hand-ringing generator. The telephone set may be used in any position. It is suitable for use on a table or desk and can be attached to a wall, tent pole or tree.

The handset, which is also immersion proof, is made of a phenolic molding compound containing rubber. In addition to a transmitter and a receiver

Fig. 1 — The author (left) and W. G. Turnbull with new military field telephone set.

unit, the handset includes a push-to-talk switch, a click-reducing varistor, and a jacketed seven-conductor retractile cord. The handset can be held comfortably and securely with or without arctic gloves. A de-icing membrane protects the transmitter against ice accumulation from breath moisture at sub-freezing temperatures. Ice gathering on the membrane is easily wiped off. The thinned-down receiver end of the handset permits it to be inserted under a battle helmet.

The receiver of the military telephone is essentially the Bell System U1 receiver unit * which forms a part of the 500-type telephone set. However, gaskets have been added in the military unit to make it watertight. The click-reduction varistor has been removed from the back of the receiver unit and located in the transmitter end of the handset. Also, the terminal plate has been modified to reduce the thickness of the unit.

Although the transmitter in the military handset has the general appearance of the T1 unit * used in the 500-type telephone, several important internal differences were required by the severe conditions of military service. The new carbon transmitter unit is designed for efficient and stable operation in both local and common battery circuits. In common battery circuits the transmitter current is supplied over the telephone line from a battery at the switchboard. The magnitude of this current is determined primarily by the resistance of the circuit rather than by that of the transmitter. On the other hand, in local battery circuits the transmitter current is supplied from a battery associated with the telephone set, and since the resistance of the local circuit is usually quite low, the transmitter resistance plays a larger role in controlling the transmitter current.

It is unusual for a telephone transmitter to be designed for interchangeable use in both types of circuits, as was done in this case. Ordinarily, a transmitter for common battery operation is designed with its diaphragm cone directed toward the electrodes, as shown in Figure 3. This is done so that the inward thermal expansion of the diaphragm, which occurs when the current is first turned on, operates to limit the resistance of the transmitter to desirably low values. In this way, excessive voltages across the transmitter which might produce objectionable carbon noise or "burning" are avoided.

For local battery operation, where the battery supply is only three volts or so, burning is seldom a problem. However, to avoid an inward motion of the diaphragm as the current is turned on in local battery circuits (which could result in a very low transmitter resistance and an undesirably high current drain) the diaphragm cone is normally directed away from the electrodes.

The dual operation problem for the new military telephone was solved by designing the transmitter as though it were intended for use only in common battery circuits, and then modifying the design for use in local battery circuits.

Design of the new set was further complicated by the need for the transmitter to operate properly during, or soon after, a large change in ambient tem-

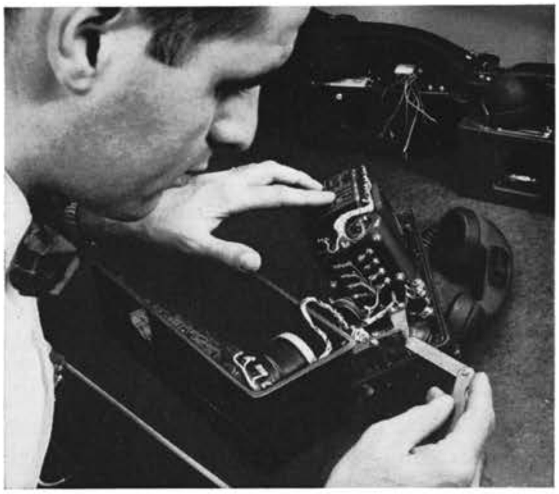

Fig. 2 — R. T. Ferri checks line switch spacing on a Signal Corps military field telephone set.

* RECORD, *August, 1952, page* 317.

perature. The magnitude of the problem will be better appreciated if it is realized that thermomechanical displacements of the electrodes of the order of the wavelength of light, 0.00002 inch, are often sufficient to produce decidedly undesirable effects. The required degree of thermal stability was achieved by carefully shaping the various transmitter parts, and by the judicious use of brass, Zamak (a zinc-base die-casting alloy), and Nilvar (a nickel-steel alloy having a high degree of dimensional stability with temperature). These three metals differ by about thirty to one in their temperature coefficients of linear expansion. In the military transmitter unit they have been combined in such a way that the dimensional change of one part with temperature is compensated by the change in an associated part, thereby maintaining the desired relative position of the two electrodes.

In addition to aiding in the solution of the thermal stability problem, the use of Nilvar in the diaphragm reduces the possibility of gun-blast damage because of its relatively high strength. Additional strength is obtained by forming long radial ribs in the conical surface of the diaphragm. A fixed stop, located just behind and very close to the diaphragm, is provided for further protection against gun-blast damage.

A push-to-talk switch, which can be operated readily even when the user is wearing arctic gloves, forms a part of the handset. It has two electrically independent sets of contacts, one to close the local battery current circuit to the transmitter, and the other for remote control of a radio set. To reduce fatigue when the switch is held in the operated position for extended periods, the holding force has been made less than the operating force. A boot made of a special rubber compound, suitable for use at low temperatures, seals the switch in the handle and prevents ice or dirt from interfering with its operation. The push-to-talk switch feature of the system is not used when the telephone set is employed in common battery systems.

For maximum flexibility the new telephone set is equipped with a three-position circuit-selector switch. This provides a choice of circuits for three types of service: common battery talking and signaling, local battery talking with hand-ringing generator signaling, and local battery talking with common battery signaling. Two flashlight batteries within the set provide transmission power for the two local battery talking conditions. If no battery supply is available, emergency transmission can be obtained over distances up to about four miles by using the receiver of the handset as a sound powered transmitter.

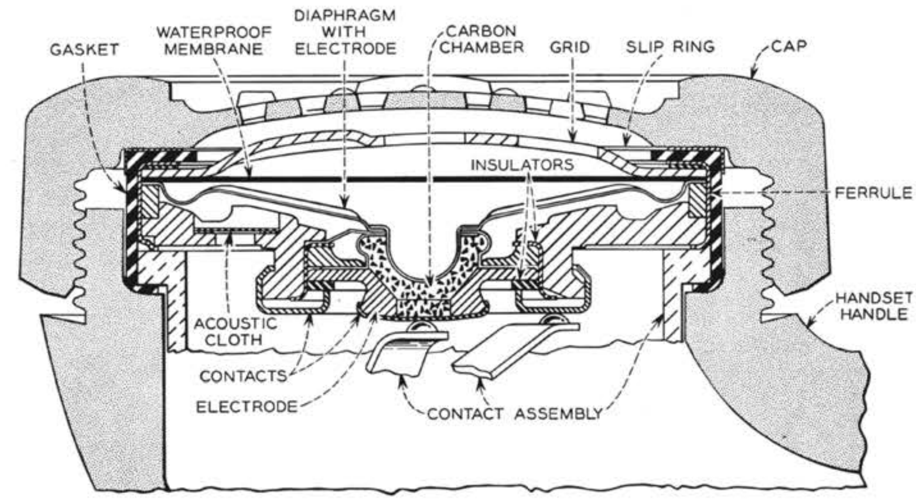

Fig. 3 — Cross-section of military handset transmitter unit.

As in the case of the Bell System 500-type telephone set, equalization in the common battery circuit is provided by two silicon carbide varistors, which decrease in resistance as the voltage across their terminals increases. This non-linear characteristic of the varistors makes the transmitting and receiving performance in common battery circuits less dependent on loop length, reduces crosstalk, and provides protection against high voltage surges. The varistors also limit the transmitter current, thereby reducing transmitter noise and increasing the life of the transmitter. The circuit keeps the sidetone (speaker's voice heard in his receiver) at desirably low levels over the range of loops and trunks that are likely to be encountered in service. The demodulation of radio signals by the non-linear varistors in the new telephone set is reduced to a negligible amount by capacitors shunting the varistors. Also, a small capacitor is bridged across the transmitter unit to prevent it from demodulating radio signals and to bypass radio-frequency transients which otherwise would cause the carbon granules to cohere and impair the efficiency of the transmitter.

The local battery circuit is designed so that current to the transmitter is supplied through a coil shunting the transmitter when the push-to-talk switch in the handset is operated. This coil has a low dc resistance and a high impedance at voice frequencies. In this arrangement, the batteries are not in the voice-frequency output circuit of the transmitter, and thus provide better transmission performance over the useful life of the batteries.

Provision is made in the local battery circuit for push-to-talk operation of remote-control equipment associated with a radio set. This is accomplished by connecting another coil across a portion of the telephone set circuit when the handset push-to-talk switch is depressed. In this way, a dc path for telephone line current is provided from an auxiliary source to operate a relay at the radio set. This relay switches the radio set between transmitting and receiving conditions in synchronism with the operation of the push-to-talk switch. The coil also serves as a holding coil in the local-battery-talking, common-battery-signaling circuit. All of the principal circuit elements — including the induction coil, local-battery feed coil, hold coil, equalizing varistors, capacitors and resistors — are combined in one hermetically sealed unit known as the network.

The audible signal of the new field telephone set is unique, and was developed to meet the need for a signaling device to form a part of a waterproof telephone set. In the new signal, designated by the Signal Corps as a buzzer, the clapper strikes the bottom of a formed cup set into the wall of the telephone set thereby radiating the acoustic energy directly to the outside (see Figure 4). To obtain the best signal, the clapper strikes the bottom of the cup off center. Further, to increase the loudness of the signal, the cup acts as a resonator so proportioned as to reinforce its fundamental frequency of approximately 2,700 cps. With this arrangement, practically all of the sound is concentrated in a 1,000-cycle band centered about the resonant frequency. The clapper of the new signal is actuated by a highly efficient magnetic structure to insure that the signal will operate satisfactorily over telephone lines

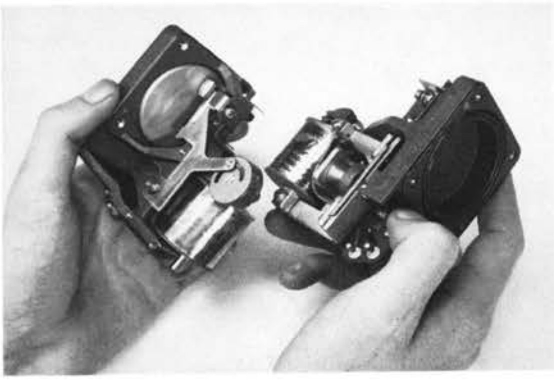

Fig. 4 — Front and back views of audible signaling device for the new waterproof telephone set.

at least as long as those which the improved transmission of the new field set now makes usable.

Because of the character of the sound produced, this signaling device has been dubbed the "woodpecker." Outdoor tests in the presence of background noise show that this type of sound has excellent carrying power and attention-attracting qualities. It is superior to the usual gong signal in the certainty with which it can be heard under marginal conditions and also in that its perception is much less dependent on the listener's high-frequency hearing acuity. Thus, the new signal should be more readily heard by men suffering from battle fatigue than the conventional form of signal.

The loudness of the signal may be adjusted from a gentle buzz to a noise-piercing "woodpecker" tone by controlling the stroke of the clapper with a cam-adjusted stop. The rotatable shaft associated with the cam is brought through a water-tight gland in the panel of the telephone set and terminated in a suitable knob. A friction device built into the volume-adjusting mechanism prevents accidental changes in the setting of the loudness control.

The hand-ringing generator is a newly designed, small yet powerful unit manufactured by Holtzer-Cabot. At a crank speed of 200 revolutions per minute, the generator is capable of delivering 1¾ watts at 20 cycles per second to a matched load. A centrifugally operated transfer-contact switch built into the generator connects the output voltage to the line when the crank is turned at about 140 revolutions per minute or higher. This switch also opens the circuit to the signaling unit in the telephone set to prevent its operation on an outgoing call, and to remove its shunting effect.

As previously stated, the telephone set housing and the handset in which all of the components are mounted are watertight. It is essential, however, that both of them be vented to equalize internal and ambient pressure differences resulting from barometric pressure changes, temperature changes, or transportation or use at high altitudes. Failure to do so could result in improper operation of several of the components or even in permanent damage to the delicate parts of the receiver and transmitter units. Breather valves are used to provide the required pressure equalization. These valves are made of porous ceramic material which is coated with pyrolytic carbon because of its non-wetting properties. When water comes in contact with the carbon treated surface, it does not pass through the porous valve but, because of surface tension, acts as though separated from it by an invisible membrane. The valves will withstand a pressure equivalent to submersion in several feet of water without leakage.

Throughout the design of Telephone Set TA-43/PT, the material most suited for each part was selected by the engineers working on the project. In making these selections, many factors were considered in addition to those dealing solely with the physical characteristics ordinarily required of such a part. Availability in time of war, machinability, long life under conditions conducive to corrosion, light weight, resistance to mechanical damage, long life at both low and high temperatures, immunity to the effects of fungi, and dimensional stability are a few of the many such factors. As the result of these considerations, well over one hundred different metals or metallic alloys, plastic materials, rubber compounds, cements, waxes, papers, paints, and other miscellaneous materials are used in the manufacture of the new field telephone set. In many instances, alternate materials are specified in order to facilitate procurement.

The development of Telephone Set TA-43/PT by the Laboratories and its production by the Western Electric Company soon after the introduction of the 500-type telephone set is another example of the Bell System's ability and willingness to make its technical advances in the field of communications available to our military forces.

THE AUTHOR

LEONARD J. COBB joined Bell Telephone Laboratories in 1922, and received a degree in Electrical Engineering, cum laude, from the Polytechnic Institute of Brooklyn, in 1933. During his early experience at the Laboratories, Mr. Cobb was assigned the job of developing testing procedures for shop inspection of telephone transmitters and receivers, and in this connection he later designed and built specialized measuring facilities for laboratory use. In 1949, he took over additional responsibilities, being placed in charge of a group developing telephone instruments. Mr. Cobb is presently continuing in this work, and in April of 1956 was appointed Apparatus Development Engineer at the Indianapolis Laboratories.

R. A. Heising Receives Founders Award from I.R.E.

Dr. Raymond A. Heising, Laboratories Patent Engineer prior to his retirement in 1953, has been named to receive the Founders Award by the Institute of Radio Engineers.

The award, which is given only on special occasions to an outstanding leader in the radio industry, was granted to Dr. Heising "for his leadership in Institute affairs, for his contributions to the establishment of the permanent I.R.E. Headquarters, and for originating the Professional Group System." Presentation of this award will be made at the annual I.R.E. banquet to be held at the Waldorf-Astoria Hotel, New York, on March 20, 1957 during the Institute's national convention.

Dr. Heising played a major role in the original development of transoceanic and ship-to-shore radio telephone systems for the Bell System and contributed many firsts in this field. He conducted and supervised research work on ultra-short waves, electronics and piezoelectric crystal devices that underlie modern radio.

He is a Fellow and Life Member of the Institute of Radio Engineers and a Fellow of the American Institute of Electrical Engineers and American Physical Society. He received the I.R.E. Morris Liebmann Memorial Prize in 1921, and the Modern Pioneer Award from the National Association of Manufacturers in 1940.