RADIO ENGINEERING

MOBILE RADIO

ENGINEERING AND IMPLEMENTATION METHOD SYSTEM FOR 150-MEGAHERTZ BELLBOY®

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1. GENERAL

1.01 This section provides overall engineering information and other considerations for the 150-MHz BELLBOY personal signaling system. The system permits a customer to be selectively called, while he is away from his own telephone, by means of a small pocket-carried radio receiver.

A. System Operation

1.02 The overall system employs direct customer dialing and FM radio transmission. Two radio frequency assignments, 152.84 and 158.10 MHz, have been authorized by the Federal Communications Commission (FCC) for exclusive one-way signaling by wire-line common carriers. One radio frequency is required per system with a maximum of two per serving area.

1.03 Figure 1 illustrates a typical setup for a BELLBOY call. The BELLBOY customer carries a pocket receiver which is assigned a seven-digit telephone number. A person desiring to contact the customer dials the BELLBOY number from any telephone. From the local office the call is routed over a tandem or direct trunk to the central office serving the BELLBOY control terminal. The control terminal translates the dialed number into a three-frequency signaling code which is transmitted over wire-line facilities to frequency modulate one or more transmitters.

1.04 A complete call consists of sending the signaling code three times at intervals of approximately 30 seconds. During the 30-second intervals calls to other customers may also be transmitted. A distinctive "tinkle tone" and a

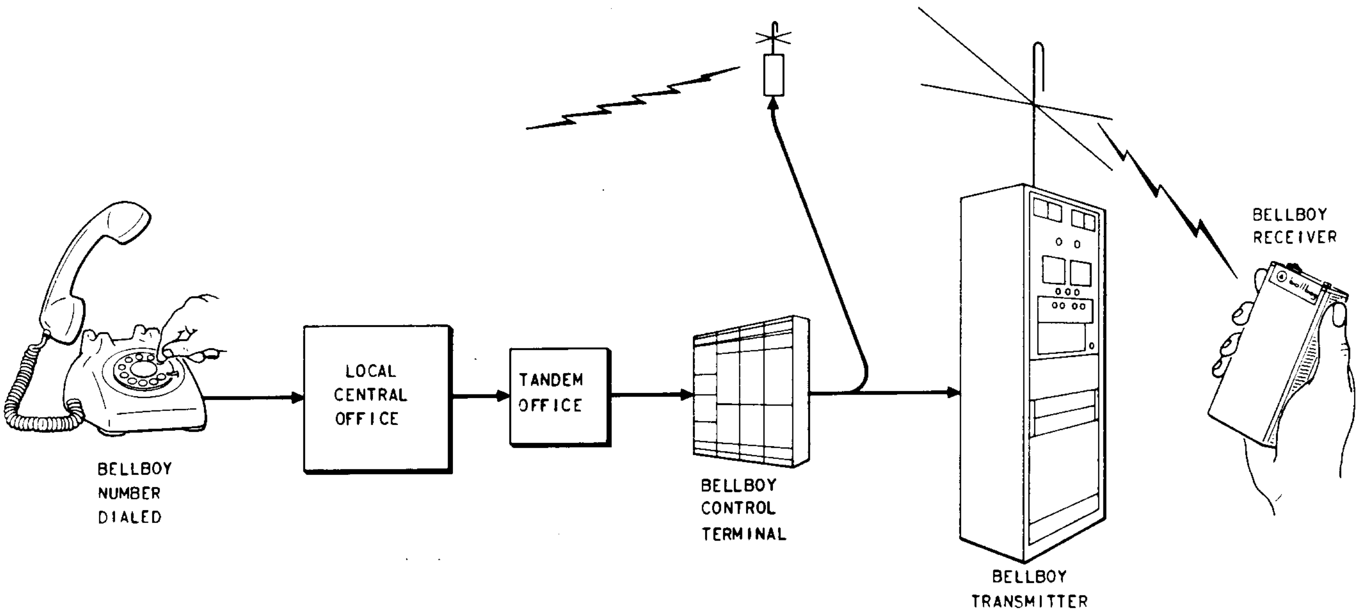

Fig. 1—Typical Setup for a BELLBOY Call

voice announcement stating that the call will be transmitted is returned to the caller. If the number is not a working one, the call is transferred to intercept where an appropriate report is given the calling party. When the signal reaches the BELLBOY receiver, it causes the set to emit an alerting tone indicating that the customer should take some prearranged action such as call his office or his home. Depressing a small reset button on the receiver silences the tone and conditions the receiver for the next call. The alerting tone will automatically silence in about 15 seconds if the reset button is not operated.

B. System Features

1.05 The system consists principally of a central office control terminal, 1 to 20 radio transmitters, and up to 3200 BELLBOY receivers.

1.06 Principal operating features of the system include call storage, number-to-tone translation, simultaneous signaling, functional voice announcements, and multitransmitter operation.

1.07 The first three digits of the telephone number direct the call to the control terminal. The last four digits are pulsed into the terminal where they are processed and stored during the three transmissions of the call. These digits are translated into a three-frequency signaling code in the audio-frequency range of 500 to 1000 Hz. The three frequencies of the code are transmitted simultaneously by the radio transmitters. The three tones which modulate the transmitted carriers will signal only the receiver responsive to that particular code. There are 3200 usable signaling codes derived from 32 audio-frequency tones.

1.08 To discourage use of BELLBOY units in other BELLBOY systems outside the customer's home area, a series of tone-versus-telephone-number translation plans have been devised. Thus, different tones are assigned to a particular BELLBOY number (last 4 digits) in various systems. Changing the order in which the tone generators are plugged into the control terminal provides a convenient means of establishing different translation plans. Eight such plans, A through H, are discussed in Section 407-207-100 and are assigned on a random nationwide basis with a separation of 100 to 200 miles between like plans on the same radio frequency.

1.09 In addition to voice announcements for call completion, provision is made for a trouble announcement and periodic station identification. Normally, a reorder tone is returned to the subscriber when the control terminal is in trouble. However, a key operation inserts the trouble announcement when trouble is sufficient to put the system out of service for an extended period. Periodic station identification using International Morse Code is accomplished by means of a timing circuit. The timing interval begins at the first transmission and inserts the station identification after 30 minutes elapsed time or as soon thereafter as the radio transmitters become idle.

2. SYSTEM COMPONENTS

A. Radio Transmitter

2.01 The KS-20429 Radio Transmitter, shown in Fig. 2, employs frequency modulation, and has an output power variable from 50 to 150 watts, a precision crystal oscillator, harmonic filters, and monitors to check for the presence of carrier and modulation. Alarms at the control terminal indicate loss of carrier or modulation. Monitoring is necessary inasmuch as a failure on a one-way system might not be detected for an extended period or until a large number of customers had missed calls. Optional features include RF isolators and arrangements for outdoor installation. Each transmitter interfaces with a Western Electric Company trunk terminating unit to provide for interconnection to alarm and control facilities. Sections of the 407-201 Plant Series furnish detailed information on this transmitter.

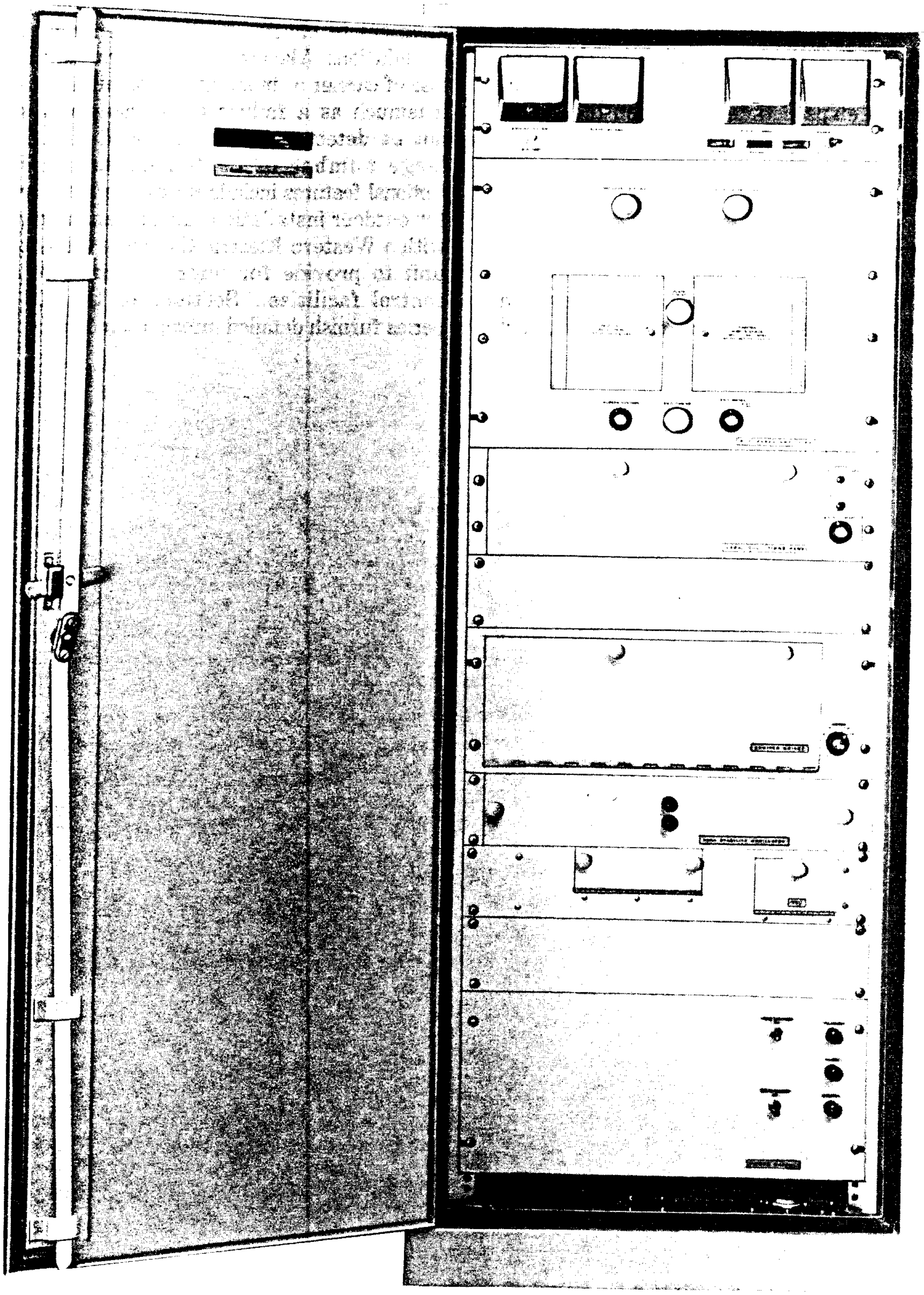

Fig. 2—150-MHz BELLBOY Transmitter

KS-20429 Transmitter Specifications

Manufacturer — Motorola, Inc.
Type acceptance number — CC3058
Frequency stability — ±0.0001 percent per YR
Power output — 50 to 150 W (adjustable)
Weight — 500 lbs
Cabinet size — 5 x 2 x 2 ft
AC power — 117 Vac at 10 A
Frequency range — 150 to 160 MHz
Maximum deviation — ±5 kHz
Maximum input power — no isolator — 280 W
one isolator — 310 W
two isolators — 340 W

KS-20432 Receiver Specifications

Manufacturer — Motorola, Inc.
Sensitivity (8 position body average) — 20 uV/m or —126 dBW
Weight (with battery) — 9.25 oz
Volume — 10.8 cu in
Decoder — contactless reed
Sounder frequency — 2 kHz
Sounder amplitude — 78 dB SPL min at 13 in
Sounder time-out — 15 S
Operating time (on a single charge) — 10 HR
Charging time — 12 HR
Estimated battery life — 1 YR

B. Radio Receiver

2.02 The KS-20432 Radio Receiver, which may be carried in the pocket or clipped to a belt, is shown in Fig. 3. It is a miniaturized, solid-state, single conversion, FM superheterodyne type, which operates in low signal-to-noise environments. It consists of an RF stage, a mixer stage, four 6-kHz IF stages, a detector stage, a decoder, and a source of alerting tone. Nominal receiver sensitivity (8 azimuthal position body average) is 20 uV/m or equivalent to —126 dBW on a quarter-wave whip antenna per Ref(2). Sections of the 407-204 Plant Series furnish detailed information on this receiver.

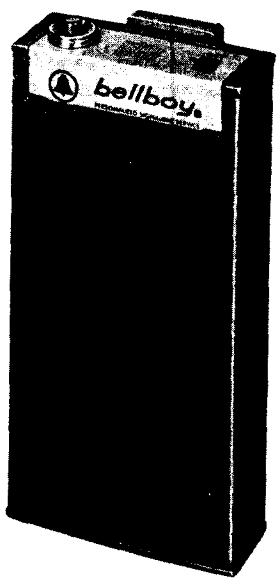

Fig. 3—150-MHz BELLBOY Receiver

C. Control Terminal

2.03 The control terminal translates the last four digits of the dialed BELLBOY number to the signaling code, controls the radio transmitters, verifies that a working number has been dialed, collates and sequences the signals to be transmitted, returns tone and voice announcements to the subscriber, transfers invalid calls to intercept, and makes periodic station identification announcements.

2.04 The control terminal has a maximum capacity of 3200 customers in number blocks 1000 through 1999, 2100 through 2699, 3000 through 3999, and 4100 through 4699. A fully equipped control terminal consists of six equipment bays. Four bays comprised of the transmitter control bay, tone supply bay, common control bay, and announcement bay contain all of the common equipment and are always required. They can serve up to a maximum of 1200 customers. The first and second supplemental bays increase the capacity to 2400 and 3200 customers, respectively. Section 407-200-100 furnishes detailed information on the control terminal.

2.05 Metallic pairs between the control terminal and radio transmitters provide the tone signaling path and two dc paths for transmitter alarms and remote control. Delay equalization is required on these facilities in multitransmitter systems. Loss equalization across the signaling band may also be required.

3. SYSTEM PLANNING

3.01 Planning a BELLBOY system requires conferring with all departments involved with the service in order to arrive at a system design that will satisfy as many of the company requirements as possible for the particular locality involved. The items to be considered should include the following:

(a) ***Marketing:*** Area to be served. Market potential, initial system requirements, customer equipment estimates, growth estimates, promotional programs, and customer education.

(b) ***Rates:*** BELLBOY rates including multiple receivers, extra battery, extra charger, etc.

(c) ***Plant:*** Maintenance of BELLBOY receivers, transmitters, and terminal. Establishing method of handling trouble reports and repair service. Receiver repair can be handled either by (1) Western Electric Company shop, (2) Telephone Company shop, or (3) manufacturer's repair contract. Operation and maintenance instructions.

(d) ***Engineering:*** Estimated equipment requirements and costs. Installation, test, and service dates, FCC matters, Western Electric Company schedules, and Engineering practices.

(e) ***Traffic:*** Estimated traffic loads. Requirements for number of incoming trunk registers (ITR). Storage circuits and number check circuits. BELLBOY number assignments. Intercept arrangements.

A. System Design

3.02 For a user of the BELLBOY service, the only meaningful measure of service is the reliability with which he is signaled. This reliability varies with the location of the user, who may be outdoors in an open area, or in the basement of a concrete and steel building. It is somewhat difficult, in such a service, to define an adequate criterion of service. A system-wide average probability of success is not appropriate where extreme variability can cause some users to have virtually perfect service and others, who work in certain buildings, to have consistently poor service. It is preferable because of these factors to consider the distribution of service grade, that is, the percentage of buildings enjoying better than any given grade of service.

3.03 The overall design objective for engineering BELLBOY service is to provide a reliable alerting signal inside buildings within the prescribed coverage area. Street coverage, which is always assured in the primary service area, will extend well out and beyond that of the primary service area. The percentage of buildings exceeding a given signaling reliability at the boundary of the primary service area may be estimated from the curves in Fig. 4. The following assumptions are made:

> Five classifications of buildings, by size, location, and structure, were used to arrive at a cumulative total percentage. These were intended to typify buildings in which BELLBOY users would be found.
>
> An allowance for the diversity advantage resulting from the use of two transmitters is assumed.
>
> Signaling reliability is computed for the ground floor of the assumed types of buildings.
>
> No increase in reliability is assumed for repeated (3 times) transmission of the paging signal. (Experimental results show either no increase or a small increase in reliability due to the second or third transmission.)

3.04 It is expected that the overall reliability of the BELLBOY system will be of the order of 99 percent within the boundary of coverage. It is important, however, that the reliability experienced by a user in a "worst case" position be adequate. Toward this end the worst case will be defined as the ground floor of a large building on the boundary of coverage. It is desired that a reliability of 80 percent be maintained in 85 percent of these worst case locations. These figures apply to the ground floor of such buildings and substantial improvement can be expected on other floors as the height above street level is increased. Also, higher reliability can be expected in buildings located closer to the transmitters. In addition, some improvement can be expected by the use of three paging transmissions. It is important that building size and building concentration be taken into consideration in connection with the selection of transmitter sites as well as in the determination of spacing between transmitters.

3.05 On the boundary of the primary service area, a margin will exist between the Path Loss* and the Allowable Loss† (L) [Allowable Loss (L) = Path Loss + margin]. Cases in which the total loss to a point within a boundary building exceeds Path Loss by more than this margin will result in a signal below receiver sensitivity, and consequently, a failure to signal. Reliability may now be related to this margin (see Fig. 4), which can only be varied by changing the radius of coverage (assuming that the transmitted effective radiated power (P) and the receiver sensitivity (S) are both fixed). Computing in-building coverage by the use of Fig. 5 will provide the approximate reliability suggested in 3.04 and shown as the 37-dB margin curve of Fig. 4. As noted previously, the use of multiple transmitters is assumed since most BELLBOY systems are of this type. For single transmitter systems 6 dB should be subtracted from the computed allowable loss as determined according to 3.04 before applying to the coverage charts, Fig. 5 and 6.

* Path Loss is the mean loss to points in streets at some distance from the transmitter and has been determined experimentally.

† Allowable loss is the difference between effective radiated power and receiver sensitivity.

3.06 Coverage charts (Fig. 5 and 6) provide a convenient means of estimating in-building and street coverage where transmitter radiated power, antenna height, and type of building environment involved are known. The effective radiated power (ERP) of a transmitting station is expressed in dB with respect to one watt (dBW). Transmitter output power in dBW is 10 LOG. of the power in watts and may be calculated or read directly from Fig. 7. Transmitter output power in dBW, antenna gain, and transmission line losses are added algebraically to obtain the effective radiated power in dBW.

3.07 The method for estimating coverage consists of subtracting the signal strength required (from 2.02) to operate the receiver from the effective radiated power of the transmitting station resulting in an allowable path loss which is applied to the proper category of building environment and antenna height on the charts to determine the coverage range of the transmitter.

3.08 The primary service area and peripheral street coverage area will vary with the types of buildings in the areas and with antenna heights. Three types of building complexes and three antenna heights are shown on the charts. Figure 5 should be used to determine the primary service area coverage in buildings. Street coverage in the primary service area is assumed in all cases. Figure 6 should be used only to determine the street coverage peripheral to the primary service area. Approximate ranges for antenna heights other than those shown on the charts can be obtained by interpolation. The physical height of the antenna above street level should be used. The ranges obtained from the charts will be valid only if the antenna is located in the clear and is above surrounding buildings.

3.09 These calculations should give an adequate estimate of the service area; however, actual service area can only be determined by making field strength measurements or by test operating the receiver in various locations in the proposed service area.

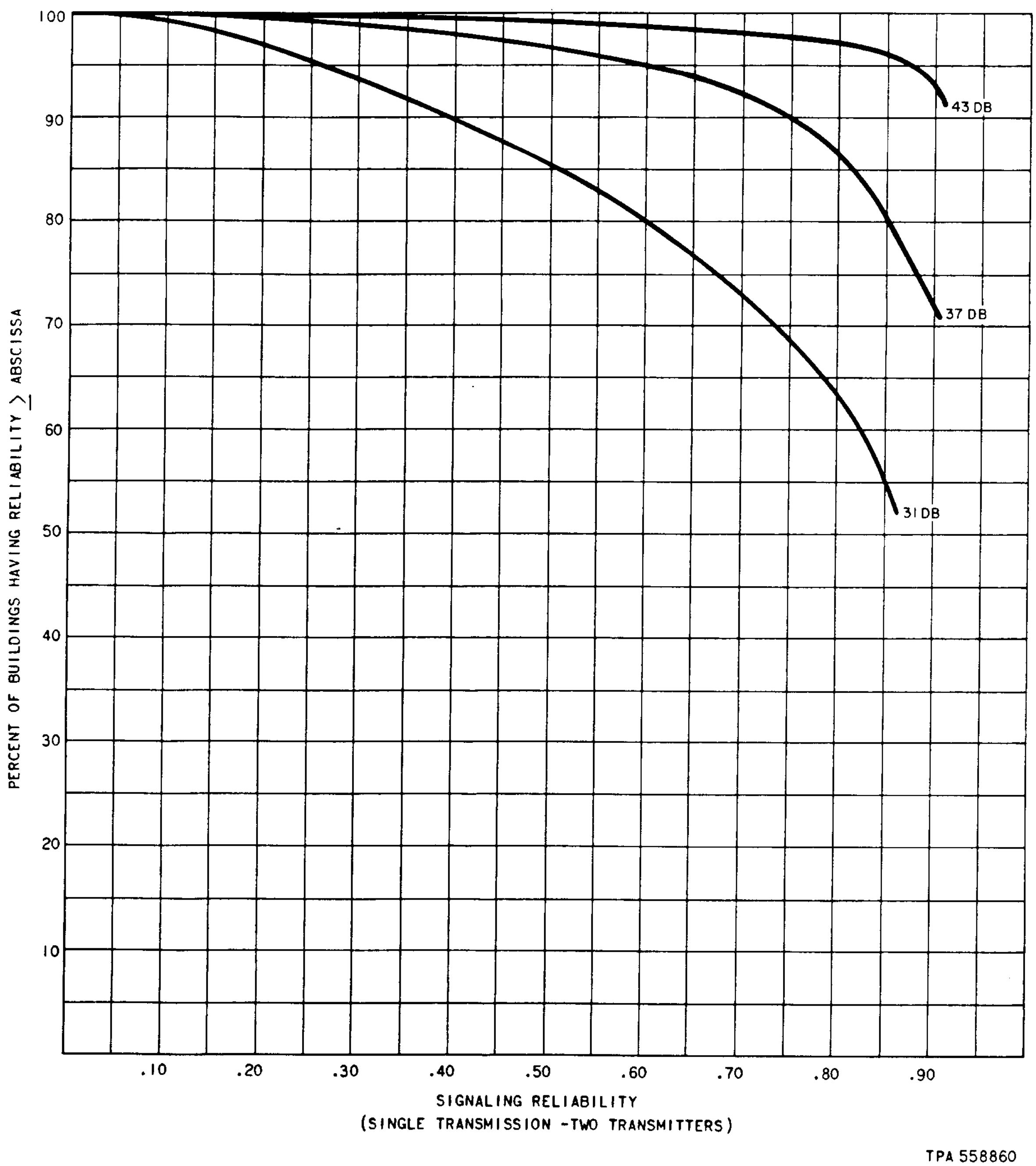

Fig. 4—Signaling Reliability vs Building Loss Design Margin at Boundary of Coverage

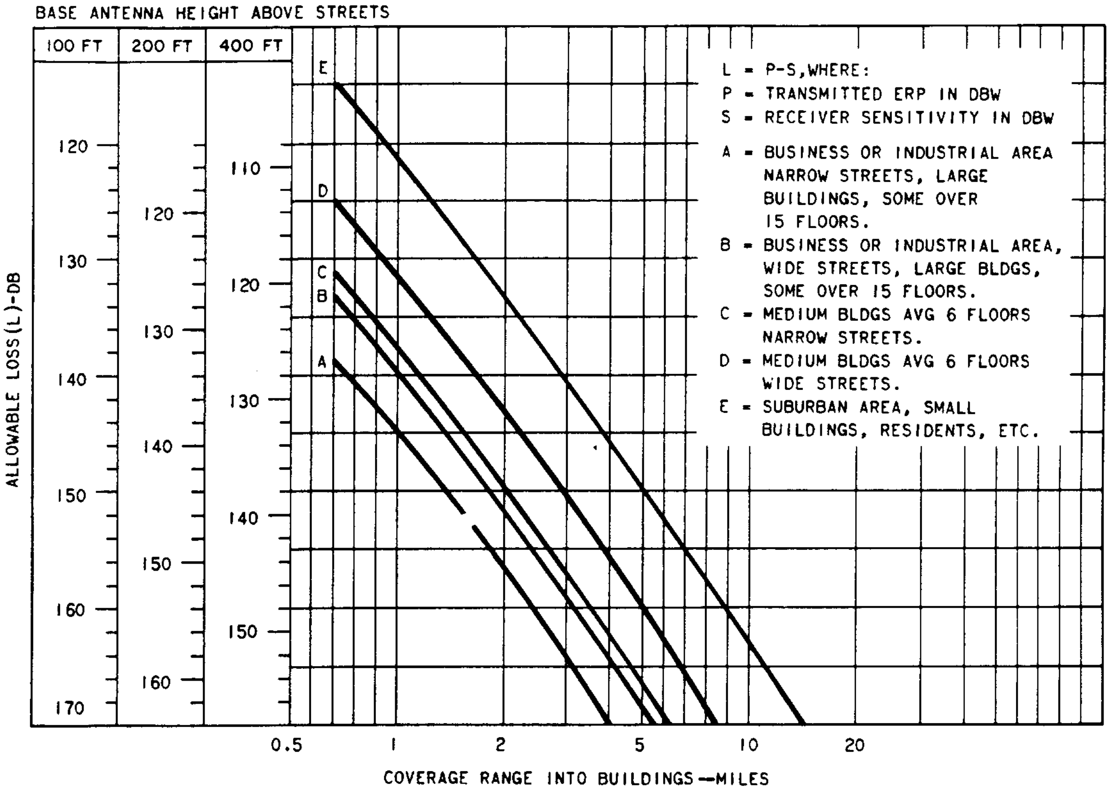

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Fig. 5—Primary Service Area Coverage Within Buildings—150-MHz BELLBOY

Reissued April, 1972 - See Addendum, Issue 1.

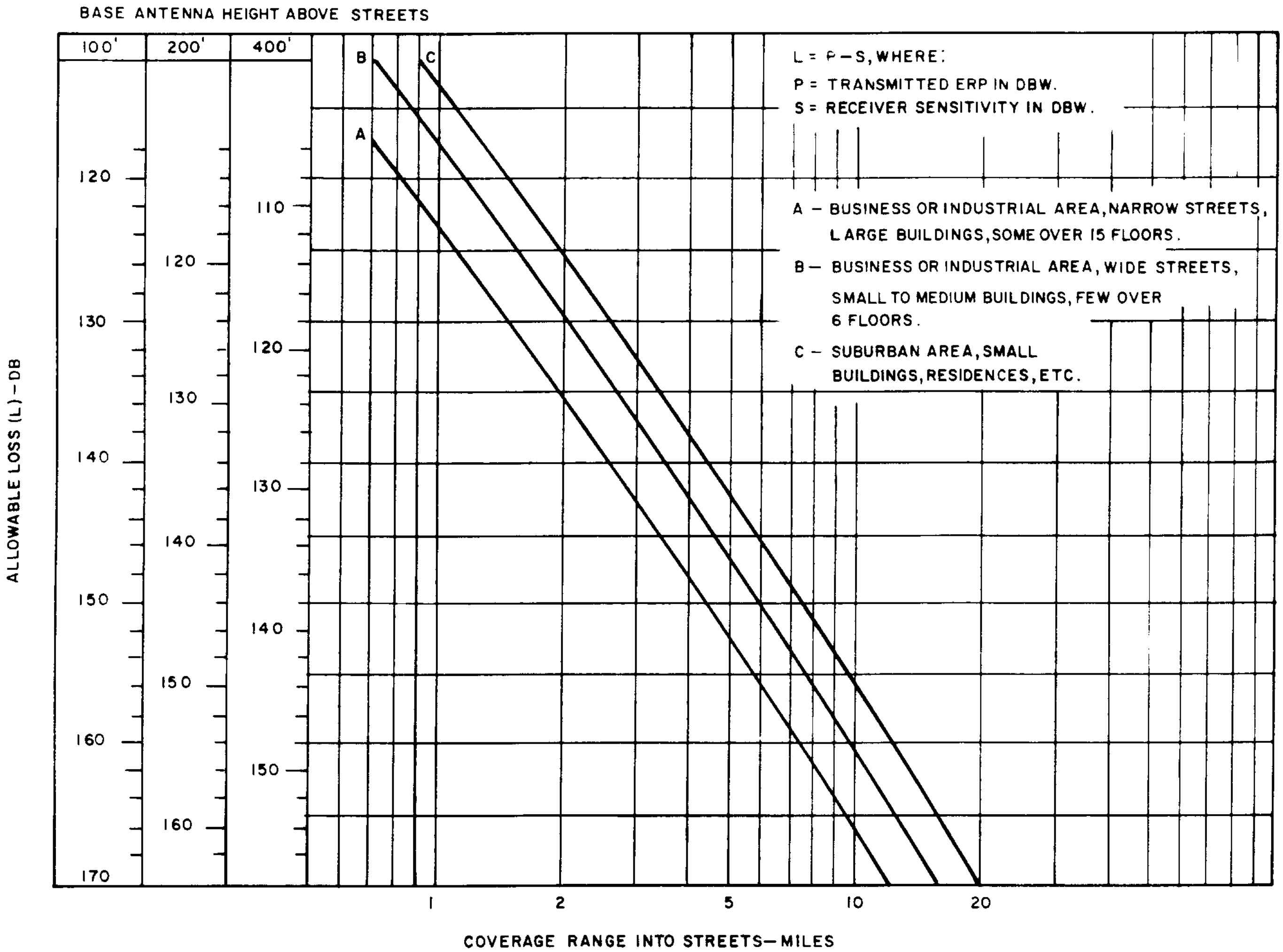

Fig. 6—Peripheral Area Coverage on Streets—150-MHz BELLBOY

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Issue 1

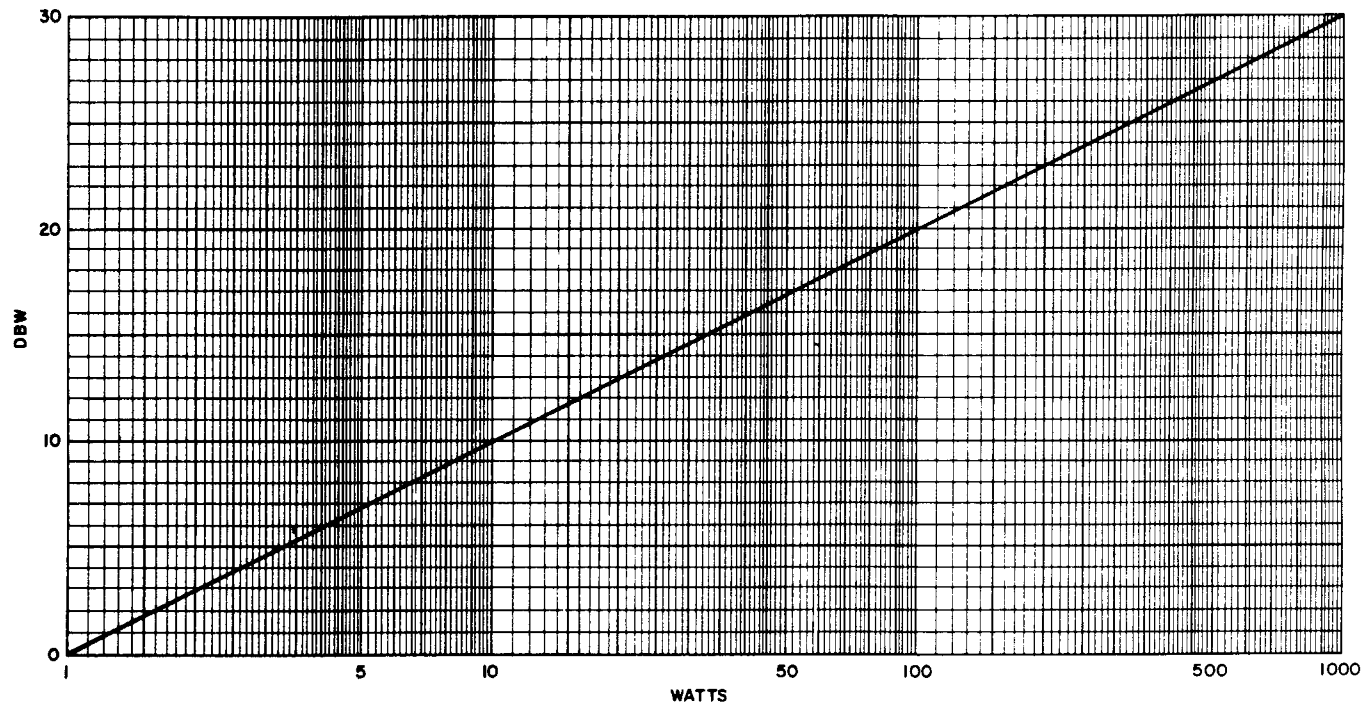

Fig. 7—Power in dBW vs Watts

3.10 ***Typical Example:*** Assume a multitransmitter system in (1) a business or industrial area with small to medium height buildings (few over six floors) on wide streets, (2) a maximum allowable ERP of 500 watts, and (3) an antenna height of 100 feet.

(a) **Computation of primary service area coverage in buildings:**

150 watts transmitter output	= +21.8 dBW
Antenna gain	= + 6.0 dB
Typical transmission line loss	= − 0.8 dB
Effective radiated power (ERP)	+27.0 dBW (500 W)

Using curve D on Fig. 5 for coverage in buildings, allowable loss, L (dB), equals transmitted ERP (dBW) minus receiver sensitivity (dBW).

L = +27 dBW — (−126 dBW) from par. 2.02
= 153 dB

Estimated primary service area coverage on ground floors of buildings is 3.5 miles radius. From Fig. 4, a signaling reliability of 80 percent or better in 85 percent of the buildings at the limit of coverage can be expected.

(b) **Computation of peripheral coverage in streets bounding the primary in-building service area:**

Using allowable loss of 153 dB and curve B on Fig. 6, estimated peripheral street coverage is 7.2 miles radius.

3.11 Usually several transmitters are required to cover a metropolitan area. Use of the maximum allowable ERP is recommended to minimize the number of transmitters required. The requirement for minimum separation between cochannel systems is affected to some extent by multitransmitter systems as described in Part D.

B. Transmitter Site Determination

3.12 With a map prepared to scale showing the desired primary area to be served as determined by Marketing and Rate Department studies, determine the approximate transmitter locations. Using assumed antenna heights, determine the range from the coverage chart, Fig. 5. A more accurate transmitter and coverage determination should then be made by selecting actual transmitter sites using Telephone Company buildings wherever possible and substituting actual antenna heights for assumed heights. The area in which in-building coverage is desired should be divided into subareas which can be typified as building environment classes A to E (see categories listed on Fig. 5). The boundary of coverage of each transmitter may be calculated where the radius of coverage is determined by the type area the boundary passes through. If in a given direction the environment changes from class C to class D before the class C coverage limit is reached, the class D coverage limit will apply on that radial. Since coverage range is a direct function of antenna height, and since shadow losses caused by nearby obstructions reduce the effective coverage area, every effort should be made to select antenna sites as high and as in the clear as possible. RF transmission line losses and installation costs should be given appropriate consideration in these determinations.

3.13 The purpose in selecting a particular transmitter site is to provide the coverage necessary for the service. The judgment of site suitability involves such considerations as antenna height, terrain, cost of site acquisition, construction at the site, and maintenance accessibility. Dependability of the service furnished at a site depends upon the reliability of the primary power and wire-line facilities as well as the BELLBOY equipment. In addition, local zoning ordinances should be checked to see that the antenna structure can be erected where desired, and FCC Rules and Regulations, Part 21, should be consulted for regulations regarding the allowable maximum ERP for the antenna heights being considered.

C. Channel Selection

3.14 The two BELLBOY channel assignments, 152.84 and 158.10 MHz, are adjacent to the assignments of existing mobile radio service assignments. The 152.84-MHz assignment is adjacent to the 152.81-MHz JR channel (base station transmit, mobile station receive). The 158.10-MHz assignment is adjacent to the 158.07-MHz JR channel (base station receive, mobile station transmit). The Special Industrial Radio Service at 152.87 MHz and the Power Radio Service at 158.13 MHz are also adjacent to the respective BELLBOY channels. These private carrier radio systems usually employ the same frequency for both the base station transmitter and the base station receiver. Knowing the geographical location of the adjacent channel services in the proposed BELLBOY area may be helpful in planning transmitter sites to avoid interference. Use of the adjacent channels in the proposed area and potential cochannel operation nearby may make one BELLBOY frequency more attractive than the other in a particular situation.

D. Cochannel Operation

3.15 When a BELLBOY system is to be operated in an area adjacent to another BELLBOY system, geographic separation between the transmitters of cochannel systems must be provided to protect against false signaling of a "home" system receiver by transmission of its code from a "foreign" system assuming that the same codes must be used in both. Use of discrete codes or modulation schemes may permit cochannel operation; however, capture in the overlap area may result in missing some calls. The future potential of cochannel operation should be considered in engineering a system.

3.16 The protection desired determines the transmitter separation to be provided. For any chosen degree of protection, the required separation will vary with the character of the protected area and with antenna heights. An effective radiated power of 500 watts is generally assumed. Figure 8 shows the overall probability of signaling a receiver out-of-doors as a function of distance from a 500 watt (ERP) transmitter for a range of antenna heights and environments. Figures 9 and 10 combine the points taken from Fig. 8 to show directly the required distances between the nearest adjoining transmitters of two systems. Antenna heights for both systems are the same. Environment of interest is that where protection limits of interest fall, not at system cores.

3.17 For example, assuming a 10-percent chance of falsely signaling a receiver situated so far into the fringe of the home area that there is only a 30-percent chance of receiving a desired call, the following estimated separations between cochannel systems (single transmitter) would apply:

(a) In big city streets, 100-foot antenna height, 18.5 miles (Fig. 9)

(b) In big city streets, 450-foot antenna height, 36.0 miles (Fig. 9)

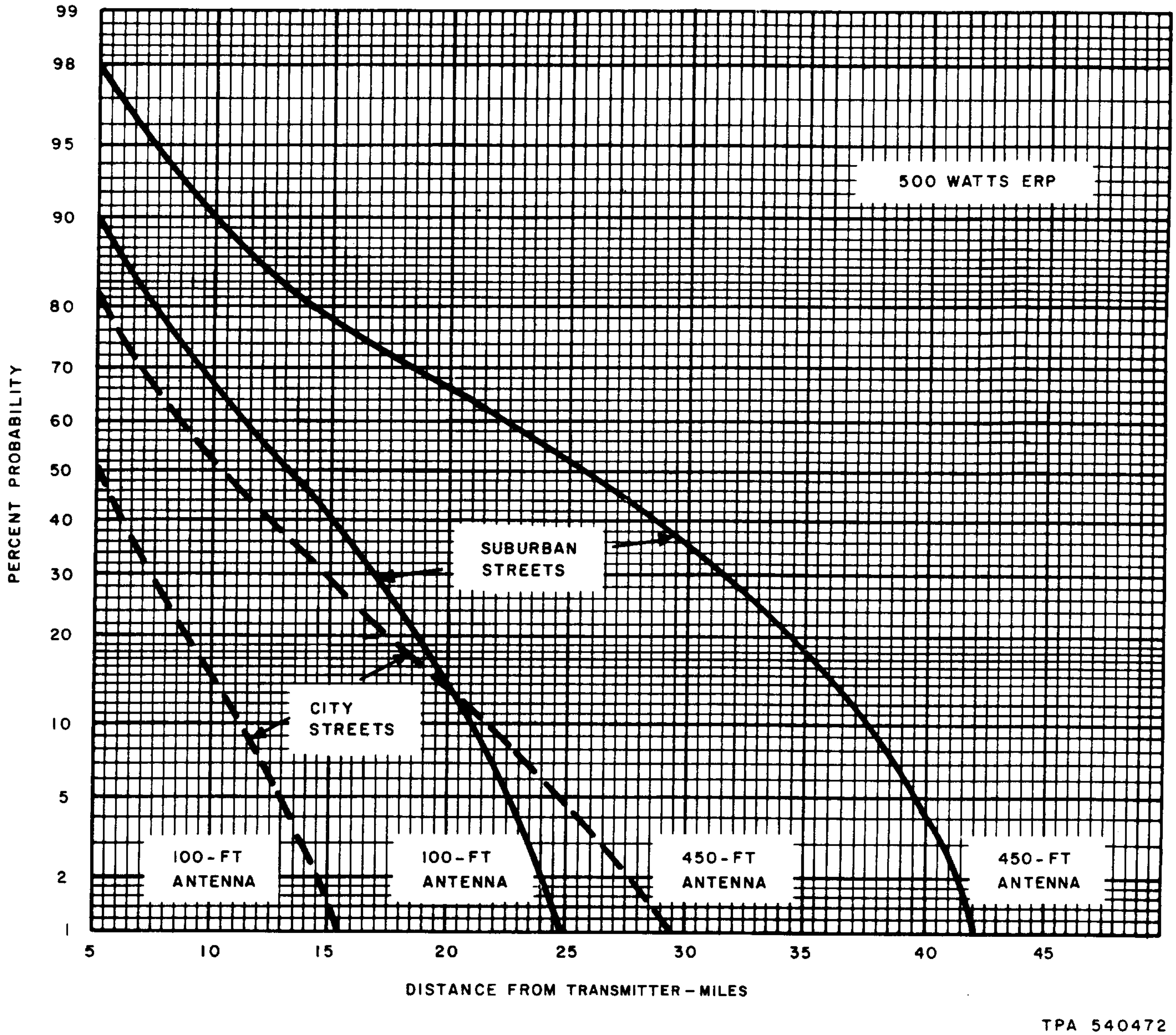

Fig. 8—Probability of Signaling a 150-MHz BELLBOY Receiver in Streets

(c) In suburban streets, 100-foot antenna height, 38.0 miles (Fig. 10)

(d) In suburban streets, 450-foot antenna height, 69.0 miles (Fig. 10).

3.18 Neither the example nor the charts allow for the effects of multiple transmitters in a system. Multitransmitter layouts can be expected to enhance the distant field strength. In such cases the separation between cochannel systems should be increased by an appropriate amount. Also, when receivers are located on upper floors of buildings, less protection than indicated in Fig. 9 may exist. In actual practice the chance of receiving a false call is considerably less since a particular receiver would have to be present in the fringe area when its code is being transmitted in the adjacent area and when the home transmitter is off the air.

E. Radio Interference

3.19 As previously mentioned, the characteristics and location of nearby radio systems operating in the band and within the coverage area of the BELLBOY system should be known.

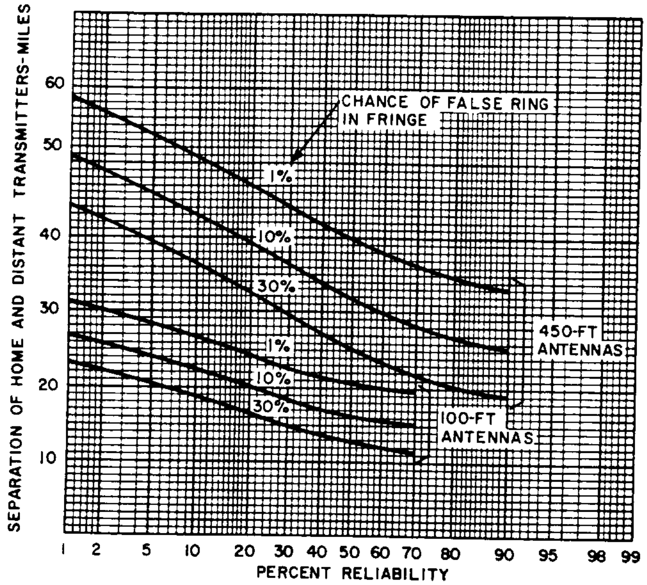

Fig. 9—Reliability of Home Service in Fringe Area—Big City Streets—150-MHz BELLBOY Service

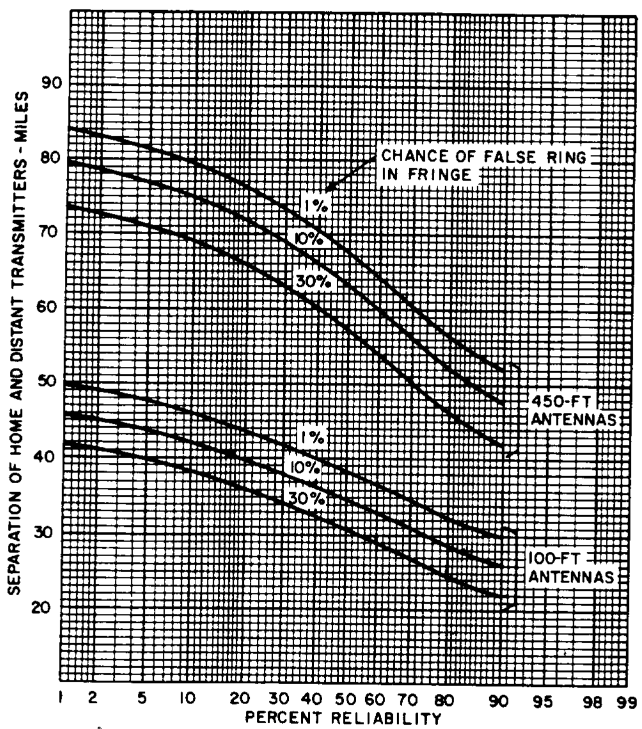

Fig. 10—Reliability of Home Service in Fringe Area—Suburban/Rural Streets—150-MHz BELLBOY Service

3.20 Radio frequency isolators may be required to suppress intermodulation products between transmitters with closely coupled antennas. Each isolator provides a minimum of 25-dB loss to external signals which may result in the generation of intermodulation products in the final amplifier. Isolators may be required where BELLBOY transmitters are co-sited with Public Land Mobile base transmitters.

3.21 Spurious RF radiation can be of serious concern in the immediate area surrounding a transmitter site. Radio transmitters may radiate spurious energy over a considerable portion of the spectrum. A filter is provided in all BELLBOY transmitters to suppress such transmitter noise. Although the spurious RF radiation is of relatively low level compared to the radiated carrier, it may be greater than the modulation energy on adjacent channels in the very near vicinity of the reference transmitter.

3.22 Potential interference to adjacent channel mobile receivers in the area near BELLBOY transmitters can be greatly reduced by using gain antennas and locating the antennas as high above the ground as possible. Omnidirectional gain antennas direct a major portion of the radiated energy in a narrow vertical pattern. Also, by using gain antennas to obtain maximum effective radiated power, fewer transmitters are required for a given service area, thus creating fewer potential interference spots. Co-siting of BELLBOY and mobile base station transmitters is desirable in those cases involving the 152.84-MHz assignment.

3.23 Adjacent channel base station receivers are particularly susceptible to transmitter noise and desensitization since they are usually located at elevated, low-noise sites. Even with the noise suppression provided in the BELLBOY transmitter, transmitter noise can be objectionable to adjacent channel base station receivers within a radius of approximately one mile. A strong signal near the operating frequency of a receiver can cause desensitization of the receiver within a radius of about two miles. Every effort should be made to provide geographic separation of at least one mile between transmitters and adjacent channel base station receivers. Crystal bandpass filters or equivalent remedial measures may be required on adjacent channel base station receivers located within a radius of two miles from BELLBOY transmitters to minimize desensitization effects. Unusual terrain conditions, high noise receiver sites, directional antennas, or lower transmitter powers might alter these criteria and should be taken into consideration.

F. Frequency and Phase Requirements

3.24 The BELLBOY System is designed to utilize up to 20 radio transmitters operating simultaneously. In multitransmitter systems it is necessary to provide (a) precise carrier-frequency control to minimize generation of objectionable beat frequencies and (b) delay equalization on all audio line facilities to minimize degradation due to cancellation of the signal received from two or more transmitters.

3.25 To prevent generation of beat tones in receivers which might interfere with signaling, the carrier frequency of all transmitters is maintained within about 150 Hz per year. Therefore, the highest possible beat note between carriers of adjacent transmitters will not exceed 300 Hz, which is well below the signaling tone range.

3.26 Phase differences exceeding 45 degrees on the audio tones feeding multitransmitter systems will result in impaired service in overlapping coverage areas. Audio-frequency phasing requirements are met by delay equalizing the line facilities between the control terminal and each transmitter. Delay equalization information for this system is covered in Sections 407-200-501, 407-200-508, and AB27.340.1.

3.27 The ability to receive all transmitter carriers from a common location is desirable for both delay and radio frequency measurements. This requires an antenna location capable of receiving signals from all transmitter sites. A preferable location for this central measuring point is the control terminal site since transmitters must be individually keyed to perform these measurements.

G. Interface Considerations

3.28 The transmitter is arranged to interface with the J41643B trunk terminating unit to permit operation with the transmitter trunk originating unit in the control terminal. Individual trunk units are required for each transmitter in the system. The transmitter trunk terminating unit is installed in the transmitter rack. Repeating coils in these units provide appropriate impedance matching and also derive two dc control paths. Circuits in the interface units provide relay and transmission operations to key and modulate the transmitter. Operating condition indicators, test and make-busy arrangements, and alarms provide individual control for each radio transmitter in the system.

3.29 A tone transmission and control trunk is required between the transmitter trunk units of the control terminal and each radio transmitter. Circuit loss of this trunk should not exceed 13 dB at 1000 Hz, and the difference in attenuation for any two frequencies between 500 and 1000 Hz should not exceed 1 dB. The maximum allowable loop resistance is 10,000 ohms. The control terminal output level to the trunk will be −5.0 dBm for each tone.

H. Interconnection Arrangements

3.30 The control terminal is arranged only for dial pulse operation. The terminal can be associated with any switching system which outpulses either three or four digits. Step-by-Step, No. 5 crossbar arranged for line link pulsing, and the No. 1 ESS are suitable systems. The terminal is served by a maximum of ten incoming trunks. The range of the incoming trunk register is the standard range of interoffice dial pulse trunks. Charge or noncharge supervision may be returned to the connecting trunk.

3.31 The numbers assigned to BELLBOY receivers are restricted to the series 1000 through 1999, 2100 through 2699, 3000 through 3999, and 4100 through 4699. Assigning a central office code to the control terminal and treating it as an end office will result in an inefficient use of telephone numbers. Therefore, it is recommended that a suitable method of office code sharing be selected. Shared office code arrangements must overcome the restricted thousands number assignment of the control terminal. The 1 through 4 thousand number blocks may be in use in the existing central office while other number blocks are available. In Step-by-Step systems, through establishment of separate trunk groups for each thousands number block, any available thousands number block may be used with only three digits pulsed to the control terminal. The control terminal will simulate the appropriate thousands digit. This method has the serious defect of decreasing trunk efficiency. When all ten trunks are used as a single trunk group, the traffic load for a full complement of 3200 receivers can be adequately handled and provide a grade of service of P.01. However, when the ten trunks are split into groups of 3, 2, 3, 2, only 860 receivers can be served and maintain the established P.01 grade of service. A better approach is available in the No. 5 crossbar and No. 1 ESS systems. Code conversion arrangement may be used to delete the first four digits of the seven digit receiver number and insert the desired thousands digit. The last four digits may then be outpulsed over a common trunk group to the control terminal.

3.32 Connections to intercept unassigned numbers are established through the control terminal to central office intercept facilities. If the associated central office is not arranged for vacant number intercepting, other arrangements such as the provision of a special BELLBOY intercept announcement set must be made.

3.33 Traffic usage observations should preferably be made in the originating office by using a traffic usage recorder (TUR) on the trunks assigned to the control terminal. If no TUR is available in the originating office, observations may be made in the office containing the control terminal by using leads brought out from the incoming trunk register circuit.

4. LICENSE APPLICATION PROCEDURES

4.01 Section 400-521-100 discusses the general considerations involved in obtaining FCC authorizations for the establishment of common carrier radio stations. The section contains references for the preparation of all applicable forms. Of particular interest is the need for a closely coordinated schedule of FCC processing and construction intervals. Failure to prepare a realistic overall schedule can result in delays in FCC authorizations and/or missing a service date.

5. EQUIPMENT ENGINEERING CONSIDERATIONS

5.01 Equipment engineering information for control terminal equipment is furnished in Section AA295.006. The control terminal may be ordered and equipped in any combination of incoming trunk registers, storage units, and number check units required to satisfy traffic loading in a particular system. The terminal is made up of four, five, or six loop shop-wired and tested bays. These bays should be located adjacent to one another in a single lineup. It is recommended that an initial system be equipped for no less than 600 customers and include at least four incoming trunk registers, three number check circuits, and ten stores. Equipment that is vital to the operation of the terminal is duplicated for system reliability.

5.02 The provision of 36A tone oscillators and crystals for the terminal will depend upon the number translation plan authorized for the terminal and the number groups to be served. Regular and standby oscillators are required for each discrete coding element tone used in the receivers of the system. Dummy load networks are required in all unused tone oscillator positions in the terminal. It may be noted from the number translation plan that it is desirable to assign numbers wholly within certain number series. Tone frequencies corresponding to the third and fourth digits are the same throughout the 1000 through 1999 and 2100 through 2699 series of numbers. Similarly, they are the same throughout the 3000 through 3999 and 4100 through 4699 series. This eases tone generator requirements, simplifies the provision of coding elements for receivers, and enables orderly expansion of the system.

5.03 Intercept trunk units are provided in the control terminal for connection to central office intercept facilities. The intercept trunk units are not required when direct association with a special BELLBOY intercept announcement set is employed.

5.04 Delay equalizers required in transmitter trunks of multitransmitter systems are installed in the control terminal. Attenuation equalizers may be installed in the terminal if space is available or on central office miscellaneous frames.

5.05 The KS-20429 Radio Transmitter may be ordered by various list numbers to meet the requirements of a particular site. A J41643B Transmitter Trunk Terminating Unit is required for each transmitter. Equipment engineering for these units is contained in Sections AA290.020 and AA290.025.

5.06 Antennas and transmission lines of several types and suppliers are available to meet gain and radiation requirements at each transmitter site. Supporting structures and all material required for antenna installation are ordered as specified locally.

5.07 The KS-20432 Radio Receiver is furnished for operation on one of the two BELLBOY frequencies as specified. Customers are normally furnished a receiver equipped with three coding elements and one battery plus a charger. Extra batteries and charging adapters are optional. The receiver may be operated while in the charger; however, the charging rate is about half the normal rate. The receiver, battery, or charger will not be adversely affected should the receiver remain on charge for an indefinite period. See Section AA290.025 for equipment engineering information.

5.08 Coding element requirements for a given customer number block may be determined from the number translation plan authorized for the system. It will be necessary in each case to compute the total number of coding elements required for the numbers to be assigned.

5.09 Customer service receiver maintenance is generally performed on a go/no-go basis by installing new batteries and/or coding elements. If these measures fail, a new receiver with the same coding elements is provided to the customer. Therefore, extra receivers, coding elements, and batteries are required. A complement of 5 percent spares is suggested for receivers, batteries, and each of the discrete coding elements in use in the system.

6. TEST EQUIPMENT

6.01 A general survey of test equipment on hand and that required for a BELLBOY system should be made to avoid unnecessary expense and to insure that specific test equipment is available to perform necessary maintenance. Equipment required for maintenance is described in sections covering tests to be performed. Any item with equivalent ratings can be substituted for those specified. Any substitution should utilize equipment of equal accuracy and stability.

7. SYSTEM ACCEPTANCE TESTS

7.01 Each BELLBOY system must be lined up and thoroughly tested before being placed in service. This includes the following:

(a) Transmission and delay equalization of wire lines.

(b) Tuning, power, frequency, and modulation checks of all transmitters.

(c) Frequency and level checks of 36A oscillators.

(d) Operation and level checks of announcement sets including acknowledgement, trouble, and station identification.

(e) Operation of intercept trunks.

(f) Alarm and control of all transmitters.

(g) Complete operational check of the control terminal.

(h) Verify coverage with test BELLBOY receiver and prepare a coverage map.

(i) Advise FCC and all Telephone Company departments concerned before turning up system for service.

8. REFERENCES

8.01 References mentioned in the foregoing text and others of particular interest are listed below:

Bell System Practices

SECTION	TITLE
AA290.020	Personal Signaling System—Transmitter Trunk Terminating Unit
AA290.025	150 MHz Radio—BELLBOY Personal Signaling System
AA295.006	J1 Control Terminal—BELLBOY Personal Signaling System
AB27.340.1	Mobile Telephone Systems—Delay Equalization of Channels Provided for Multistation Radio Systems
400-521-100	Radio Administration—FCC Regulatory Information

SECTION	TITLE
407-200 Series	Personal Radio Services—150 MHz BELLBOY—Overall System
407-201 Series	Personal Radio Services—150 MHz BELLBOY—Radio Transmitter
407-204 Series	Personal Radio Services—150 MHz BELLBOY—Radio Receiver
407-207 Series	Personal Radio Services—150 MHz BELLBOY—J1 Control Terminal
407-210-100	Personal Radio Services—150 MHz BELLBOY—Auxiliary Equipment
940-230 & 240 Series	Radio Engineering—Mobile Radio

Engineering Letters and Memoranda

E. L. 259—Interconnection Arrangements for One-Way Signaling Systems

E. L. 314—BELLBOY Personal Signaling Services Planning and Engineering 150 MHz BELLBOY Systems (Including price and ordering information)

Engineering Letters and Memoranda

E. M. 1620--Test Equipment Required for Maintaining 150 MHz BELLBOY Personal Signaling Systems

E. M. 1651—Nationwide Tone-Subscriber Number Translation Plan for 150 MHz BELLBOY Systems

Marketing Letter, May 9, 1969—BELLBOY Personal Signaling Service

Rate/Marketing Letter, June 24, 1970 (GL70-06-185)—Illustrative 150-MHz BELLBOY Pricing Approach

Engineering Cost Letter, June 30, 1970 (GL70-06-228)—Illustrative 150-MHz BELLBOY Cost Study

Other References

(1) Mitchell, Doren, and K. G. Van Wynen. A 150 Mc Personal Radio Signaling System, ***Bell System Technical Journal,*** September 1961, pp. 1239-1257.

(2) Rice, L. P. Radio Transmission into Buildings at 35 and 150 Mc, ***Bell System Monograph 3234.***