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Nov. 20, 1945. W. S. HALSTEAD 2,389,257

CARRIER WAVE SIGNALING SYSTEM

Filed Dec. 13, 1943 7 Sheets-Sheet 1

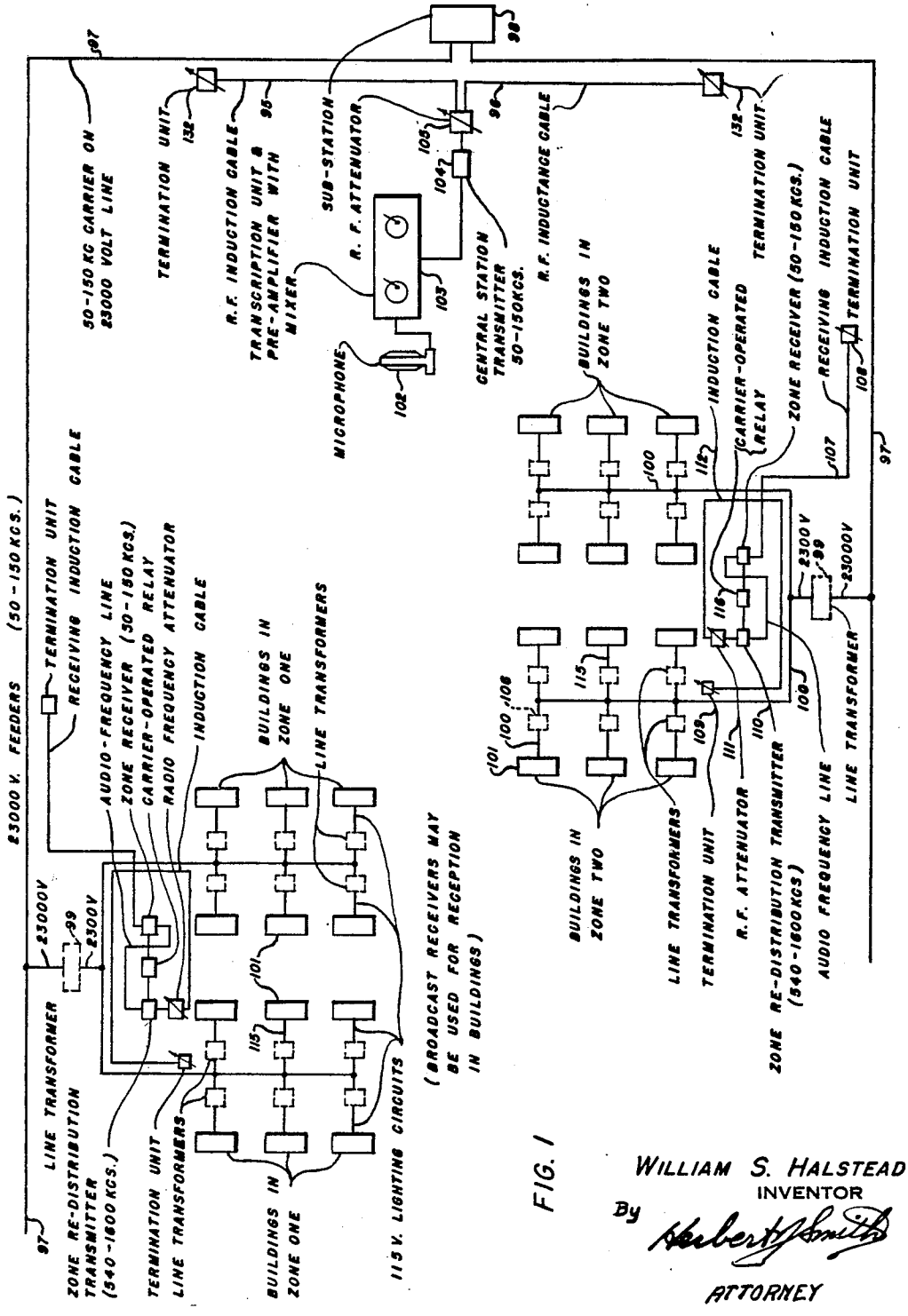


FIG. 1

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CARRIER WAVE SIGNALING SYSTEM

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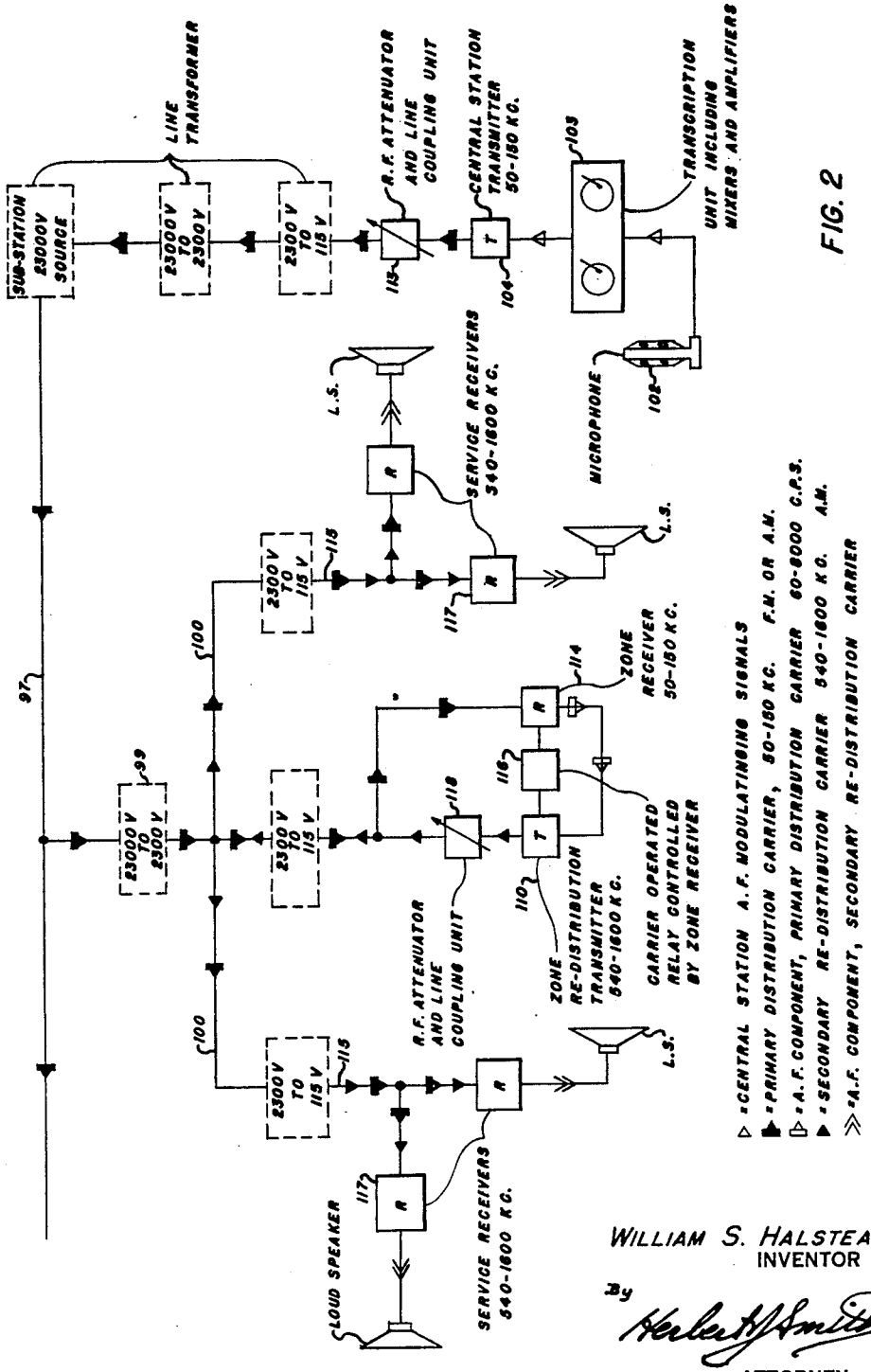


FIG. 2

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CARRIER WAVE SIGNALING SYSTEM

Filed Dec. 13, 1943 7 Sheets-Sheet 3

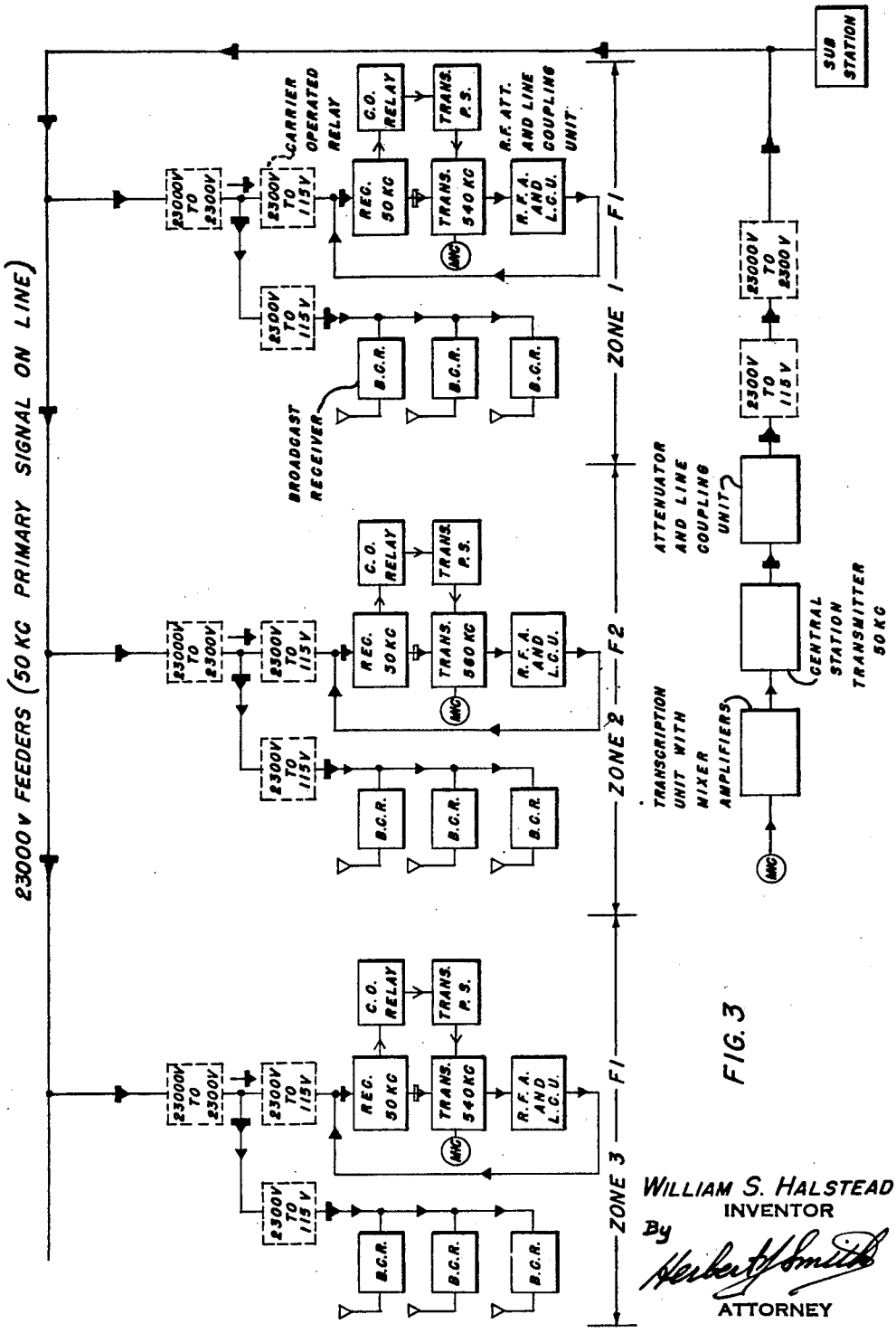


FIG. 3

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CARRIER WAVE SIGNALING SYSTEM

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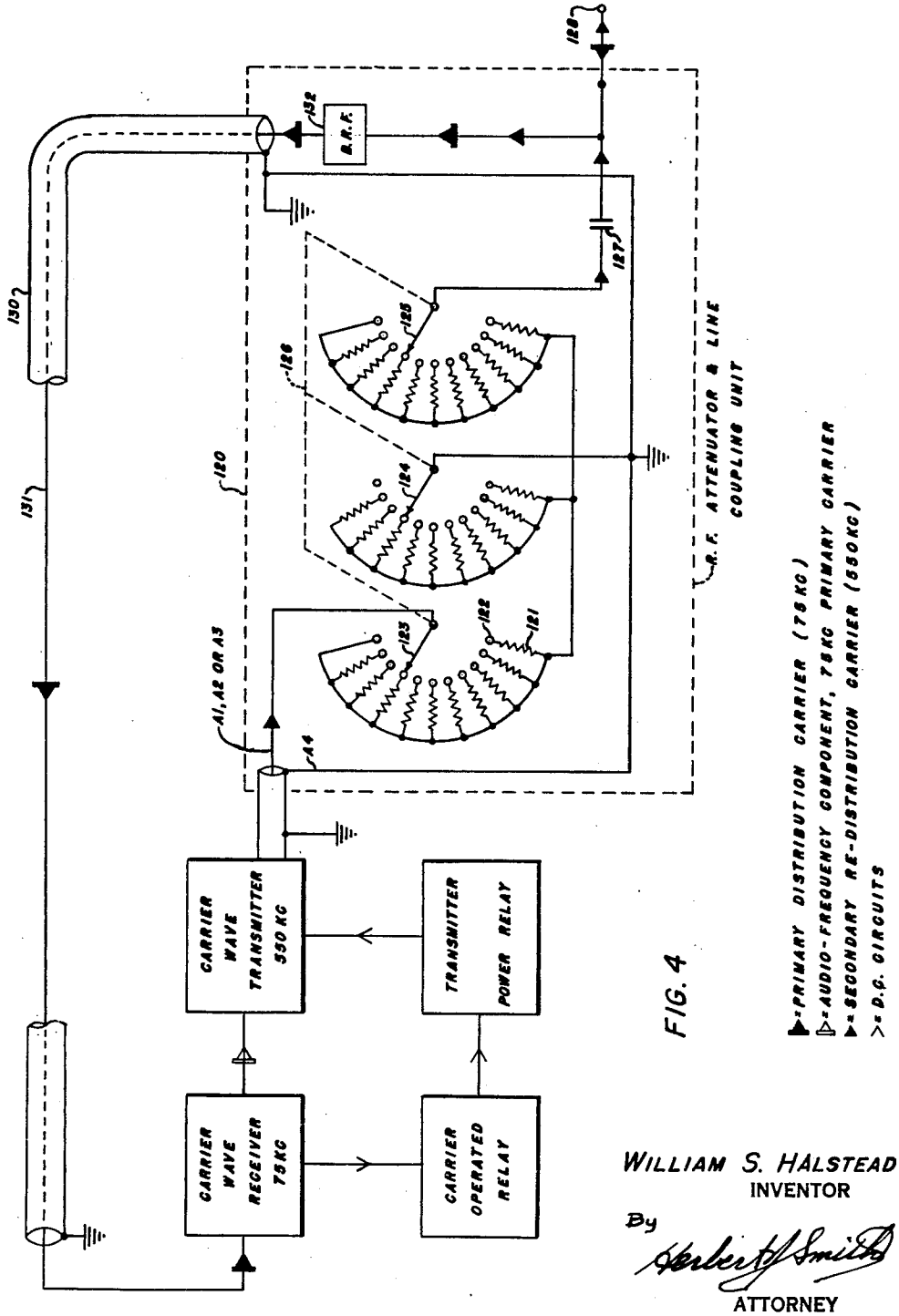


FIG. 4

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CARRIER WAVE SIGNALING SYSTEM

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STEP NO	ATT. IN DB
1	0
2	2
3	4
4	6
5	8
6	10
7	12
8	14
9	16
10	18
11	20

FIG. 6

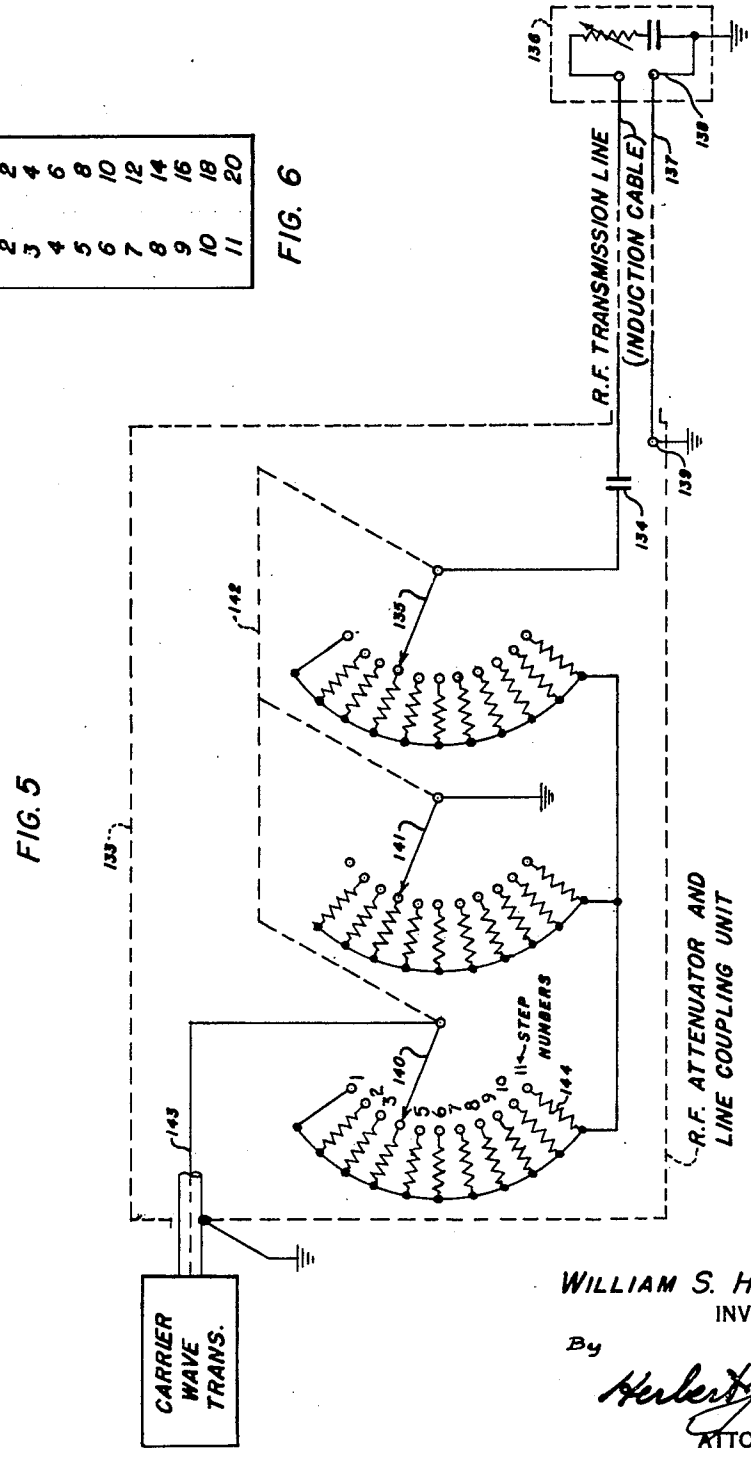


FIG. 5

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CARRIER WAVE SIGNALING SYSTEM

Filed Dec. 13, 1943 7 Sheets-Sheet 6

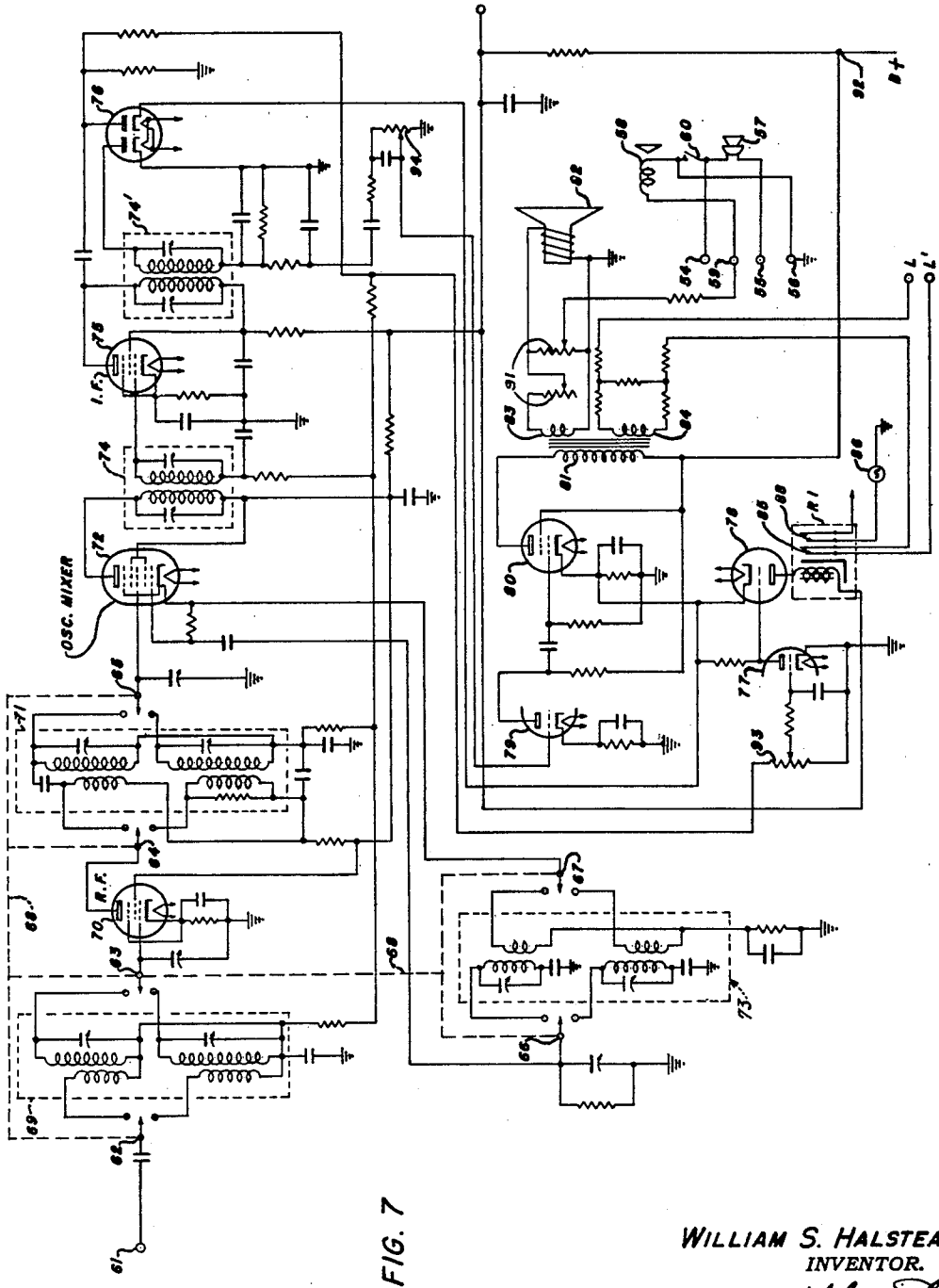


FIG. 7

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CARRIER WAVE SIGNALING SYSTEM

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FIG. 8

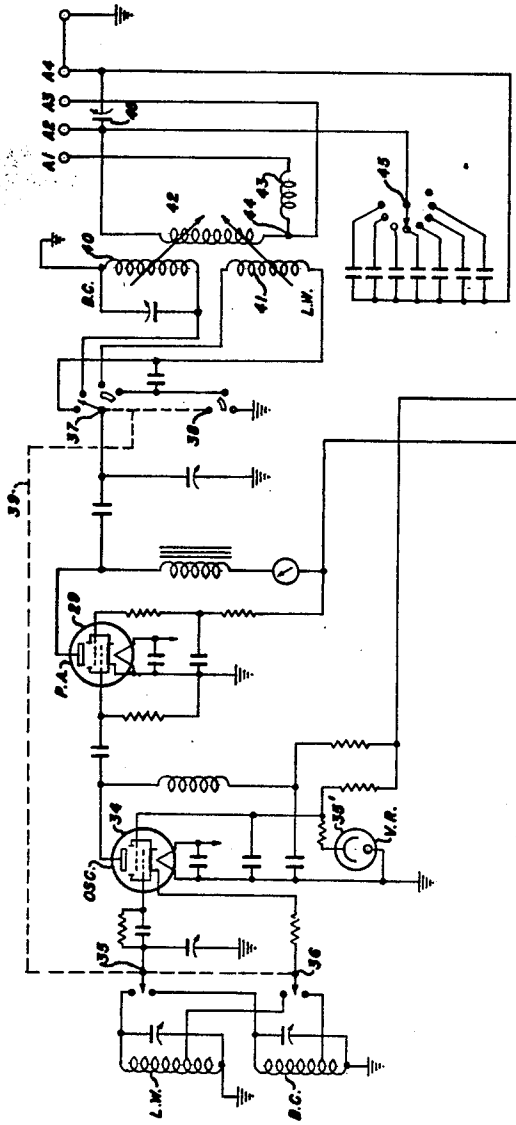
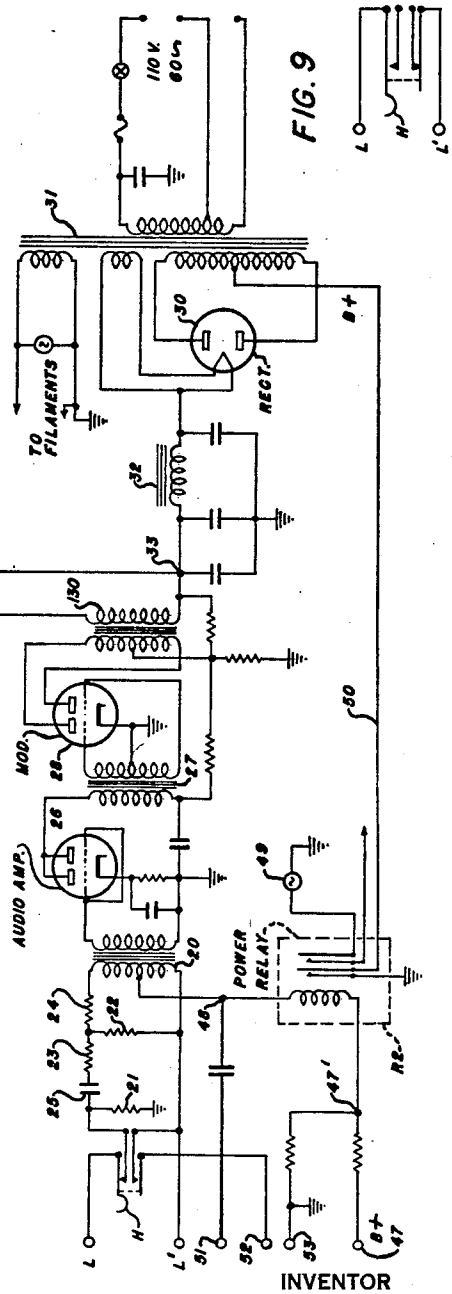


FIG. 9



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Patented Nov. 20, 1945

2,389,257

UNITED STATES PATENT OFFICE

2,389,257

CARRIER WAVE SIGNALING SYSTEM

William S. Halstead, Huntington, N. Y., assignor, by mesne assignments, to Farnsworth Television & Radio Corporation, Fort Wayne, Ind., a corporation of Delaware

Application December 13, 1943, Serial No. 514,095

10 Claims. (Cl. 179—2.5)

This invention relates in general to carrier wave communications systems and more particularly to a communications system in which carrier wave energy is distributed over relatively large areas by means of public utility lines or other conductors.

The system of the invention is especially useful in distributing carrier-wave signals throughout various zones within a relatively large area by means of carrier-wave signals impressed on public utility power circuits or other conductors extending throughout the area, the amplitude of the carrier-wave signals being controlled in each zone in such manner that excessive space radiation of radio wave energy is not caused.

The system also provides means for distributing carrier-wave signals from a central station or studio on power lines extending throughout a large area, and subsequent re-distribution of the carrier signals throughout various zones within the area, the secondary distribution within each zone being adaptable to meet varying attenuating conditions in different portions of power line circuits for the purpose of over-riding electrical noise peculiar to various localized sections of power networks.

In prior applications of carrier-wave signal distribution methods, particularly in providing local broadcasting services by means of R. F. carrier signals impressed on power lines extending throughout a given area, many attempts have been made to obtain coverage of the complete area at broadcast frequencies, in order to permit the use of existing broadcast receivers in home and other buildings. Results obtained with such systems have been considered unsatisfactory because of the varying attenuating characteristics of different portions of the electric-power distribution network, particularly in transformers, in BX or conduit, and in underground circuits, while serious interference has commonly been caused by electric motors, gaseous-discharge lighting appliances, and other sources of objectionable electric noise at various localized points. The result has been that in outlying sections of areas of substantial size, the ampltiude of carrier-wave signals transmitted from a remote central point is so low that the satisfactory reception of amplitude-modulated signals, as transmitted at broadcast frequencies from a central station, is made impossible at many receiving points because of high electrical noise levels. In various attempts to overcome such interference, transmitters of increased power have been employed at the central station in some instance, variable phasing arrangements have been used in other cases to effect in-phase or out-of-phase relationship of carrier-wave energy on different conductors of power-line circuits, or as in some university broadcasting systems, repeater stations supplied with audio-frequency energy transmitted by telephone line connection between the central station and the repeater transmitters, have been utilized. In the first instance, the use of high-power transmitters at broadcast frequencies causes excessive space radiation of wave energy with subsequent possibility of serious interference with distant broadcast stations on the same or adjoining frequencies. In the second case, matching and phasing networks with high-voltage coupling units are required to minimize radiation, while in the third case, extension telephone-line installations are required.

In the system of the invention, which is particularly adaptable for use in distributing musical programs or other information to all zones within a large area, all signal distribution is effected on existing power lines or other wire circuits extending throughout the area. Carrier wave energy of relatively low frequency, which is attenuated by a comparatively small amount in passing through power circuits, is employed by the central station, or primary, transmitter in distributing amplitude-modulated or frequency-modulated primary signals throughout the entire area, while in each local zone of the area, where signals need reinforcement, or where local noise conditions are excessive, automatic, carrier-operated conversion, or secondary, transmitters, the output of which may be regulated by definite steps to enable each secondary transmitter to effectively serve its zone without causing objectionable space radiation of wave energy, redistribute the signals throughout each zone on broadcast frequencies.

In this manner, all portions of large residential or industrial areas may be reached with effective carrier-wave signals having an amplitude sufficient to over-ride local noise conditions. In addition, by the use of frequency-modulation circuits in the central station transmitter, and in each of the receivers associated with the zone, or secondary, transmitters, primary signal distribution may be effected with a minimum of interference despite electric noise levels of extremely high amplitude. In this instance, secondary distribution may be effected either by amplitude-modulated secondary transmitters in order that conventional amplitude-modulated broadcast receivers may be employed within the various zones,

or by secondary frequency-modulated transmitters, the signals from which may be received by available frequency-modulation receivers in homes or at other points within each zone.

The system of the invention also incorporates induction signaling technique by which in each primary and secondary zone a localized radio-induction field, extending laterally for a distance of several hundred feet from roadside electric power lines throughout a given area, may be used in reaching operators of motor vehicles, locomotives, or other mobile units equipped with suitable receiving apparatus for radio traffic control or mobile communications services. Further, though the use of pocket-size receivers, hearing-aid type earphones and associated carrying belt with built-in horizontal-loop antenna, as disclosed in co-pending application Serial No. 514,094, filed Dec. 13, 1943, key plant personnel, patrolmen, or other persons moving on foot in various parts of large industrial areas, where loudspeakers cannot or should not be employed, can be reached effectively despite high ambient noise levels.

The system may also be utilized in operating facsimile or teleprinter apparatus in various portions of a given signal distribution network, such graphic-record transmission service being handled on power-line networks concurrently with aural intelligence without mutual interference between the different services. In this manner, broadcasting stations may extend their scope of operation and provide new mass-communicating facilities without the injecton of the serious frequency allocation problem which would be involved in normal space-radio transmission of the same signals.

It is a primary object of this invention to provide means for distributing signal intelligence throughout large areas or within localized zones within these areas, through the use of carrier-wave signals of different frequency ranges impressed on electric power line or other conducting circuits extending through out these areas, said distribution being effected with a minimum of space radiation of wave energy.

It is another object of the invention to provide means for distributing carrier wave signals throughout all zones within a given area with an effective carrier wave signal having an amplitude sufficient to provide useful broadcast service and to over-ride ambient line noise peculiar to each zone, distribution of signals in the various zones being effected by means of a converter and/or repeater transmitter, individual to each localized zone, with a central station, or primary distribution, transmitter controlling the overall operation of the entire system.

It is an additional object of this invention to provide means whereby carrier-wave signals from a central station transmitter may be distributed by electric power lines or other conductors throughout a given area, and means whereby the primary signals from the central station transmitter are received and re-distributed on a secondary carrier frequency in various zones throughout said area, the zone transmitters being placed in operative condition automatically during periods in which carrier-wave energy from the central station trandsmitter is received at the zone transmitting points.

It is a further object of this invention to provide means whereby carrier-wave signals from a central station transmitter may be impressed on power line circuits in such manner that the amplitude of said carrier-wave signals is regulated in definite predetermined steps without affecting the tuning or loading circuits of the transmitter, and means whereby the carrier-wave energy from the central station is received and re-transmitted within each zone of said area on a secondary frequency, the amplitude of said secondary signals also being regulated in definite predetermined steps, without affecting the tuning or loading adjustments of the zone transmitter, in accordance with the signal-level requirements within each zone.

It is another object of this invention to provide an intelligence disseminating system in which primary carrier-wave signals are distributed from a central station by means of carrier-wave signals of relatively low frequency impressed on power lines or other conductors extending throughout a given area, said primary signals being received and re-transmitted on a secondary power line or other wire circuits extending throughout each zone, and means whereby each of the zone transmitters may be utilized in effecting selective coverage of each zone from a local control point without interference from said primary signals or without interfering with carrier-wave signals from zone transmitters in adjoining zones.

It is another object of this invention to provide means for establishing a plurality of localized induction-radio signaling zones adjoining public utility lines or other metallic conductors extending within each zone, the lateral extension of each of said signaling zones being regulated in definite predetermined steps by signal attenuating means associated with carrier-wave transmitters individual to each zone, each of said transmitters being controlled by carrier-wave energy transmitted from a central station transmitter electrically connected with the public utility network or other metallic circuits extending throughout the area in which each of said zones form a part.

In the drawings:

Fig. 1 is a block diagram of the system of the invention showing the carrier wave distribution network employing a central station, or primary transmitter and a plurality of zone, or secondary, transmitters for re-transmission of intelligence within localized signaling zones of a given primary distribution area.

Fig. 2 is a block diagram of the system pictorially disclosing the frequency conversions and transmission paths followed by carrier-wave signals during distribution on primary circuits from a central transmitting point and in secondary distribution throughout various zones within a given area.

Fig. 3 is a block diagram of the signaling system wherein three localized signaling zones, each adjoining the other, are established by re-distribution of primary signals by three secondary transmitters, the operating frequencies of the secondary transmitters being such that no mutual interference is caused between the zone transmitters.

Fig. 4 is a combination schematic and block diagram showing one form of R. F. attenuator employed in the invention to regulate the amplitude carrier-wave signal energy, impressed on wire conductors, in definite predetermined steps.

Fig. 5 is a schematic representation of one form of R. F. attenuator and line coupling unit employed in the system of the invention, a two-wire R. F. transmission line employed in induc-

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ing carrier signal energy on high-voltage feeders, and a termination unit for minimizing space radiation of wave energy from the line.

Fig. 6 is a chart showing the attenuation of signal energy, expressed in decibels, in relation to the various steps of the attenuator.

Fig. 7 is a wiring diagram of one form of carrier-wave receiver showing the carrier-wave relay connected to be operable by received carrier signal energy.

Fig. 8 is a wiring diagram of the transmitter showing the power relay connected to be controlled by the carrier-operated relay of the receiver shown in Fig. 7.

Fig. 9 is a positional modification of the hook switch H, shown in Fig. 7.

In the block diagram of Fig. 1, Fig. 1 showing a representative arrangement of a power distribution system upon which is superimposed R. F. energy from the central station and zone transmitters of the system of the invention, the elective power sub-station **98** is connected with primary feeders, such as **97**, to supply power or secondary, distributing feeders **100** in both zone **1** and zone **2** are connected with line transformers, which are clearly identified by legend on the drawings, Fig. 1. Buildings **101** in both zones **1** and **2**, served by secondary power circuits, as identified by legend on the drawings, are representative of any building or construction, wherein 115 volt 60 cycle A. C. is provided.

R. F. transmission lines, or induction cable, **95** and **96** are designated as "R. F. induction cable" by legend on the drawings, and are installed in proximity to high-voltage feeders of the elective power system for the purpose of inducing R. F. signal voltage on the various parallel conductors of the feeder systems without the requirement of high voltage coupling condensers or L/C matching networks.

The induction cable is disposed in spaced relation and parallel with the power feeders, and may be placed at either side of the sub-station **98** in order to induce R. F. signal energy in each branch of the feeder circuit.

At the central station transmitter **104**, the mircrophone **102** is connected to a transcription unit **103** with suitable mixer-amplifiers. The output of the transcription unit and mixer-amplifier is connected to the input circuit of transmitter **104**. The output of the central station transmitter **104** is connected to an R. F. attenuator **105**, the output circuit of which is connected to the R. F. transmission line or induction cables **95** and **96**. The extreme ends of the R. F. induction cables are connected with variable termination units **132** so that the R. F. induction line may be terminated in its characteristic impedance, thereby inhibiting the formation of standing waves on the R. F. induction cable, and minimizing space radiation of radio wave energy. Under these conditions, the field surrounding the induction cables and within the distance

$$\frac{157{,}000}{kc.} \text{ ft. } (\lambda/2\pi)$$

is principally of an inductive nature, with field intensity decaying rapidly with distance, approximately, in some instances a rate of decay varying as the cube of the distance, laterally, form the induction cables. Inasmuch as the R. F. induction field of high intensity exists in the immediate vicinity of the R. F. induction cables, and as this concentrated field extends longitudinally for the length of the induction cable without the existence of effective standing waves to inject pronounced induction cables without the existence of effective standing waves to inject pronounced peak voltage and nodal points along the cables, R. F. signal energy of the order of several thousand milli-volts may be impressed on the electric power circuits without excessive space radiation of radio wave energy at distances substantially in excess of $\lambda/2\pi$.

To pick up the signal in zones **1** and **2**, a receiving induction cable **107** is shown in spaced relation to the feeder **97**, in the vicinity of line transformers **106**. Termination unit **108** is connected to the extreme end of the receiving induction cables **107**, to provide optimum matching for the end of the line while the opposite end of cable **107** is connected to the input circuit of the zone receiver. The received-signal is then retransmitted through the zone re-distribution transmitter **110**, as indicated schematically in the diagram. An R. F. attenuator **111** is connected across the output circuit of the zone transmitter **110**, while induction cable **112**, connected to the output of R. F. attenuator **111** is disposed in proximity to the elective power feeders **100**. It will, therefore, be seen that the carrier signals transmitted over the power network to zones **1** and **2** are picked up by induction cable **107** and subsequently re-transmitted over induction cable **112**, thereby eliminating the excessive loss in signal energy caused by transmission of R. F. carrier signal energy through line transformers, such as **99**, which also are responsible for much of the electrical noise in carrier circuits.

In order to distribute primary signals on public utility wire circuits without excessive attenuation a relatively low frequency is employed by the central station transmitter low. This frequency is normally in the range of 50 to 150 kilocycles. The signal is picked up in each zone re-distribution point by the zone receivers and impressed upon the associated zone re-distribution transmitters, which operate on various zone frequencies, such as those in the range of about 540 to 1600 kilocycles. Thus, by a primary distribution frequency in the 50–150 kilocycle band wire signal attenuation on electric power or other wire networks is relatively low and subsequent redistribution in localized zones at frequencies in the 550–1600 kc. band existing broadcast receivers may be used in the buildings in zones **1** and **2**. The result is that signals from the central station may be picked up on conventional broadcast radios in zones **1** and **2** without the attendant loss in signal strength that would be present if broadcast frequencies were employed by the central station transmitter.

The signal distribution systems in zones **1** and **2** are fundamentally the same inasfar as components are concerned. The carrier-operated relay of each zone receiver automatically applies plate voltage to the zone re-distribution transmitter as long as carrier-wave energy is being received from the central station transmitter.

The block diagram of Fig. 2 indicates the various distribution frequencies and paths of primary and secondary signals in the system. The symbols on the diagram are explained by footnote on the drawings. Central station microphone **102** is connected to the transcription unit **103** including mixers and amplifiers. The central station transmitter **104** and R. F. attenuator and line coupling unit **113**, are connected so that a signal may be impressed upon the main power feeder **97** through capacity coupling between a

secondary feeder 115 carrying 115 volts A. C. and R. F. attenuator and line coupling unit 113. The secondary feeder selected for this function preferably should be in proximity to the sub-station from which main feeders 97 extend toward the various zones of the power network. The zone receiver 114 will pick up the carrier-wave signals transmitted from the central station in the 50 to 150 kilocycle band and the signals will be retransmitted over the zone re-distribution transmitter 110 in the 540 to 1600 kc. band. The carrier-operated relay 116 of receiver 114 applies power to operate the zone transmitter when the relay is closed during reception of carrier wave energy from the central station transmitter. The R. F. attenuator and line coupling unit 118 are connected to the output of the transmitter 110. Service receivers in each secondary circuit are identified in the drawings, as are loudspeakers, represented by conventional symbol and the legend "LS."

The audio-frequency modulating signals are impressed on the central station transmitter 104, and the primary distribution carrier-signal at a frequency in the 50 to 150 kc. band, is impressed upon the main feeders through secondary power circuits coupled to R. F. attenuator and line coupling unit 113. The carrier wave energy on the secondary power feeders in the local zone is impressed upon the input circuit of the zone receiver through power line connection with the secondary circuit. The output signal of the zone receiver, representing the audio frequency component of the primary distribution carrier, is impressed upon the signal input circuit of the zone transmitter 110. The secondary re-distribution carrier at a frequency in the 540 to 1600 kc. range, is impressed upon the same secondary power circuits that serve to carry the primary distribution signals to the input circuit of the local zone receivers, interference between the two signals being prevented through use of different frequency bands and the choice of carrier frequencies not in harmonic relationship.

In the block diagram of Fig. 3, wherein the general arrangement of central station transmitter and the zone receivers with re-distribution transmitters are substantially the same as the disclosure in Fig. 2, a plurality of adjacent localized zones is shown. In such a re-distribution system, in which the zone signaling fields overlap each other it is desirable to use at least two secondary distribution frequencies in the system. By this means signals in adjacent zones would not cause mutual interference. However, it is pointed out that the same frequency may be used by two or more different zone transmitters, providing that there is not sufficient overlapping of the effective signaling fields to cause objectionable heterodyne effects. In Fig. 3, zones 1 and 3 are spaced sufficiently to prevent interzone interference, while in the intervening zone 2, a different frequency is employed. Therefore, by using power lines with the energy of the carrier wave signals conducted thereon, and providing that there is no effective space radiation of carrier wave energy, a series of receivers in the various signaling zones may be used to pick up the primary distribution carrier and re-distribute the signal energy over localized zone transmitting systems in a frequency band different than that employed in primary distribution, while the same secondary carrier frequency may be utilized by zone transmitters in different zones, or different zone frequencies may be employed dependent upon local power distribution networks. It is pointed out that the carrier amplitude of secondary signals in each zone distribution system may be controlled in definite steps by means of the R. F. attenuators, thus minimizing interference between secondary signals in different zones separated by line transformers which further tend to reduce interzone interference as long as no direct space radiation exists.

It will be seen in Fig. 3 that the central station equipment operating on a frequency of 50 kilocycles and the attenuator and line coupling unit are similar to that already described in Fig. 2. The line coupling unit is used, as will be described hereinafter, where there is a direct capacitive connection to secondary power line circuits, in contradistinction to the induction method of coupling, as set forth in relation to Fig. 1.

In zones 1, 2 and 3 of Fig. 3, the legend "C O relay" represents the carrier-operated relay. The legend "Trans PS" represents the transmitter power supply. The legend "R. F. A. and L. C. U." represents the R. F. attenuator and line coupling unit. The legend "Trans 540 KC" represents the transmitter operating on 540 kilocycles. The legend "Rec 50 KC" represents the zone receiver operating on a frequency of 50 kc., which is the frequency of the central station transmiter. The legend "BCR" represents a conventional broadcast receiver. Zones 1 and 3 have the transmitter legend marked at 540 kilocycles, while zone 2 has the transmitter marked at 560 kilocycles. The transmitters in zones 1 and 3 operate on a frequency F1, while the transmitter of zone 2 operates on a frequency F2.

The arrow symbols, showing the transmission paths and frequencies of signal energy impressed on the various portions of the circuit, are similar to those symbols referred to in relation to Fig. 2.

The combination block diagram and schematic diagram of Fig. 4 shows the R. F. attenuator 120 having a plurality of resistors, such as 121, connectable to the contacts, such as 122. The switches 123, 124 and 125 connect the resistor 121 in T-pad connection, and are all on the same shaft 126. The switch shaft 126 is operable so that the resistors, such as 121, of predetermined value may be selected to provide the proper attenuation of signal energy while maintaining the input and output circuits of the attenuator at a substantially constant value, thereby presenting a substantially constant load to the transmitter at all times.

A condenser 127 is in series with switch 125 and the terminal 128, which terminal is the ungrounded side of the 115 volt 60 cycle A. C. secondary power circuit. A concentric or co-axial cable with outer sheath 130 and an inner metallic conductor 131, is connected to the carrier wave receiver as indicated. The opposite end of the cable is connected, as shown, to a band-rejection filter 132 for the purpose of rejecting carrier wave energy from the local zone transmitter, represented as operating on 550 kilocycles. The carrier-operated relay of the zone receiver and the power relay of the zone transmitter are shown, symbolically, connected so that carrier wave energy received by the zone receiver will cause the carrier-operated relay to actuate, in turn applying plate power to the zone transmitter, as described in more detail in the portions of the specifications relating to Figs. 7 and 8.

The symbols showing the transmission paths and frequencies of the signals are described by legend in Fig. 4.

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The R. F. attenuator and line coupling unit in Fig. 4 is utilized when direct coupling to the power line is desired. The band-rejection filter 132, shown by legend "BRF," may be of any type that will adequately reject the carrier with its side bands of the local zone transmitter and prevent the signal of the local transmitter from returning to the input of the receiver.

Referring to the schematic diagram of Fig. 5, the R. F. attenuator and line coupling unit 133 is substantially similar to the disclosure in Fig. 4. A power line coupling condenser 134 is connected between switch 135 and the R. F. transmission line. A termination unit, 136, is shown as of variable type and is connected between the end of the R. F. induction cable and the ground wire, which may be the ground wire of a parallel power line system, or a separate parallel ground wire individual to the signaling system. A conductor 137 is shown connected between terminals 138 and 139. While a specific metallic conductor is shown between terminals 138 and 139, it will be observed that both terminals are connected to ground. The metallic conductor 137 may or may not be used, as the installation may require. Switches 140, 141 and 135 are connected on the same shaft 142 and are operated simultaneously. The carrier wave transmitter is connected by a shielded conductor 143 to the switch 140 of attenuator 133. The sheath of the conductor 143 is grounded, as shown by symbol. Each of the switches 140, 141 and 135 are connected with resistors, such as 144, of predetermined value, and arranged in T-pad connection so that the attenuator may be adjusted in definite steps from 1 to 11, while the input and output impedances of the unit are substantially constant for all attenuation settings.

Fig. 6 is a chart showing the attenuator step numbers and the attenuation in decibels. By legend, the attenuation in decibels in Fig. 6 is shown as "Att. in DB." The various resistors in the T-pad attenuator are of such value that the attenuation in decibels varies two decibels per step for each step of the attenuator in the range from zero to 20 decibels.

While only the carrier wave transmitter is shown in Fig. 5, it is to be understood that the receiver, carrier-operated relay, and transmitter power relay are used in the same manner as shown in the other drawings of the case.

Fig. 7 is a wiring diagram of one form of zone receiver employed in the system of the invention. Terminal 61 is the antenna connecting terminal which connects a condenser to switch 62. Switches 62, 63, 64, 65, 66 and 67 are all connected to a single shaft 68. The antenna coil 69 is connectable through switch 63 to the R. F. tube 70. The R. F. coil 71 is connectable through switch 65 to the oscillator-mixer tube 72. The oscillator coil 73 is connectable to the oscillator tube 72 by means of switches 66 and 67. The plate of the oscillator-mixer tube 72 is connected to the first I. F. transformer 74, and then to the I. F. tube 75. The second I. F. transformer 74' is connected with the I. F. tube 75 and the duo-diode tube 76. The first half of the duo-diode tube is a detector, while the second half provides voltage for the automatic volume control which is also fed to the relay amplifier tube portion 77, which in turn provides voltage to operate the relay 78. The first audio portion 79 is in the same envelope with the amplifier relay tube portion 77. The plate of the first audio portion 79 is connected to the audio output tube 80, the plate of said tube 80 being fed to primary winding of transformer 81. The loudspeaker 82 is connected across one of the secondary windings 83, while a second secondary winding 84 is connected through contacts 85 of relay R1 to the terminals L—L'. A pilot light 86 is connected through contact set 88 of relay R1 so that the pilot light 86 is illuminated when relay R1 is energized. Plate voltage is provided at terminal 92, while all filaments are connected from a suitable source. The power supply is conventional and therefore, is not shown. A gain control 93 and an audio frequency volume control 91 are both provided in the circuit. It will, therefore, be seen that a portion of the received signal will energize the monitor loudspeaker 82, while a portion of the energy component in winding 84 is impressed on terminals L—L'. When the received-signal causes the relay tube 78 to operate, the relay R1 will become energized, thereby closing contacts of said relay and impressing the signal component from the winding 84 across terminals L—L' of the receiver, which terminals in turn are connected to terminals L—L' of the transmitter in Fig. 8. The pilot light 86 is energized when the relay is closed to serve as a visual indication of proper operation.

Referring to Fig. 7, when the relay R1 is operated so that contacts 85 are closed, it will be seen that the audio component from the winding 84 of the receiver is being fed to terminals L—L'. Terminals L—L' of Fig. 7 connect to terminals L—L', respectively, of Fig. 8. When the microphone is on the hook H, the winding 20 of the input transformer of the transmitter (Fig. 8) is connected to the terminals L—L' of the transmitter through the upper contact of the hook switch H, thus permitting the audio component of the receiver to be impressed upon the input of the transmitter to modulate same.

The D. C. supply voltage used to energize the power relay and microphone is fed from terminal 47, through the winding of the power relay R2, then through the microphone portion of the winding 20 of the input transformer back to terminal L', and then through the contact set 85 (Fig. 7), through the winding 84 (Fig. 7) back to the opposite side of the line to terminal L, through the upper contacts of hook switch H, through the resistor 21 to ground. The power relay R2 will then be operated and the power supply for the transmitter will be completed through the relay contacts by way of conductor 50 (Fig. 8), to the ground, so that the transmitter is in operation.

When it becomes desirable to operate the transmitter independently by the local transmitter microphone instead of having the transmitter modulated by the output of the receiver, the removal of the microphone from the hook switch H will cause the transmitter hook to be moved to an upper position thereby opening the upper contact and closing the lower contact of said hook switch, as shown in Fig. 9. The power supply from the terminal 47 in Fig. 8 will be connected through the winding of the power relay R2, then through the microphone portion of the winding 20 of the input transformer, through the lower contacts of the hook switch H, to the terminal 52, which terminal is connected to terminal 55 (Fig. 7), through the microphone 57, then through the press-to-talk switch 60 to the ground terminal 56. The microphone and the relay winding of power relay R2 are in series.

The transmitter wiring diagram, shown in Fig. 8, has the input terminals L—L' which are connected to the output terminals L—L' of the receiver, shown in Fig. 7. The input terminals L—L' of Fig. 8 are connected to the input transformer 20 by audio-frequency attenuator including resistors 21, 22, 23 and 24 in addition to the condenser 25. The output winding of the signal input transformer 20 is connected to the audio amplifier tube 26, which tube is in turn connected to the driver transformer 27, and the modulating tube 28. Plate voltage is fed through the modulation transformer 130 to modulate the plate and screen of the R. F. power amplifier tube 29. The rectifier tube 30 and the transformer 31 have a conventional filter network 32. Plate voltage is fed from terminal 33 to the master oscillator tube 34. A voltage regulator tube 35', shown by legend "VR," regulates the screen voltage of the master oscillator tube 34 to insure frequency stability under varying power line voltage. The master oscillator coil has a long wave, or low frequency, section designated as LW, and a broadcast frequency section designated as BC. These coils are connected through switches 35 and 36 to the master oscillator tube 34. The master oscillator is connected to the power amplifier tube 29 in a conventional manner. The output of the power amplifier tube 29 is connected to switch 37. Switches 35, 36, 37 and 38 are all controllable from a single shaft 39. The broadcast frequency plate tank-coil 40, and the low frequency, or long-wave, plate tank coil 41 cooperate in conjunction with the coupling coil 42. The loading coil 43 is connected between terminals 44 and A1. Terminals A1, A2, A3 and A4 are provided for connecting to the line to obtain the desired loading. A switch 45 is connected to a plurality of condensers so that rotation of the switch will connect the various condensers in the circuit as required. One side of the line is always connected to a terminal A4, which in turn is connected to ground. The other side of the line will be connected to one of the terminals A1, A2 or A3. The position of switch 45 in conjunction with the proper terminal will provide definite loading. Switch 45 is an adjustment for the R. F. impressed on the power line and has steps of large increment, while a small variable condenser 46 is connected between terminals A2 and A4 so that fine tuning may be obtained as required. The manipulations of switch 45 and condenser 46 permit suitable impedance matching with the various transmission lines, or power lines. The relay R2 is connected between terminals 47' and 48 with terminal 48 being connected to a mid-tap on the primary side of the input transformer 20. When relay R2 operates, a pilot light 49 will be energized to show that the relay is energized. The closure of relay R2 will complete the plate supply circuit from conductor 50 to ground, thereby connecting plate voltage to the transmitter. It will, therefore, be seen that, when a received signal from the receiver is impressed on the transmitter across terminals L—L', relay R2 will be energized to apply transmitter plate voltage and thereby put the transmitter in full operation.

Terminals 51, 52 and 53 of Fig. 8 are connectable to terminals 54, 55 and 56, respectively, of the receiver shown in Fig. 7. The microphone button 57 is connected across terminals 54 and 55, while a receiver 58 is connected across terminals 59 and 56 with a push-button 60 connected between the receiver and microphone, as shown in Fig. 7.

In the diagrams, such as Figs. 1, 2 and 3, a single conductor is shown upon which is impressed or superimposed the radio frequency signals from the central transmitter and zone transmitters. It is to be understood that in all cases any suitable electrically conducting line may be used, such as a power line which may have several conductors, telegraph or telephone lines, if they are found to be suitable for a particular installation, or any other conductors may be used provided they are adequate to carry out the purpose of the invention. In the various views, a coupling means is shown as either capacitative or inductive. However, it is to be understood that either or both coupling methods may be used on the system depending upon the circumstances.

While certain specific illustrations of the invention are shown, it is to be understood that they are merely illustrative of the invention and that many other modifications may be employed without departing from the spirit of the invention as defined by the subjoined claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a restricted zone signaling system, means for generating modulated radio frequency signals, means for coupling said modulated radio frequency signals to an electrically conducting line, a receiver, means for coupling said electrically conducting line to said receiver, a second transmitter operating on a frequency different than said first transmitter, coupling means for re-impressing the received intelligence of said radio frequency signals on said second transmitter, means for coupling said second transmitter signal to an electrically conducting line for establishing a restricted range signaling zone, a second receiver disposed within the restricted signaling zone established by the second transmitter and adjusted to said second frequency, and means connected to the output of said last receiver for translating the intelligence of said second frequency.

2. In a restricted zone signaling system, means for generating modulated radio frequency signals, means for coupling, superimposing, and adjusting the modulated radio frequency signals to a predetermined level on an electric transmission line, a receiver, means for coupling said transmission line to said receiver located at a remote point, a second transmitter operating on a frequency different than said first transmitter, coupling means for re-impressing the received intelligence of said radio frequency signals on a second transmitter, means for coupling, superimposing and adjusting to a predetermined level the second frequency on an electric transmission line for establishing a restricted range signaling zone, a second receiver disposed within the restricted signaling zone established by the second transmitter and adjusted to said second frequency, and means connected to the output of said last receiver for translating the intelligence of said second frequency.

3. In a restricted zone signaling system, means for generating modulated radio frequency signals, means for coupling, superimposing, and adjusting the modulated radio frequency signals to a predetermined level on an electric transmission line, a receiver, means for coupling said transmission line to said receiver located at a remote point, a second transmitter operating on a frequency different than said first transmitter, coupling means for re-impressing the received intelligence of said radio frequency signals on a sec-

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ond transmitter, the frequency between said second transmitter and said first transmitter being such as to eliminate interaction therebetween, means for coupling, superimposing and adjusting to a predetermined level the second frequency on an electric transmission line for establishing a restricted range signaling zone, a second receiver disposed within the restricted signaling zone established by the second transmitter and adjusted to said second frequency, and means connected to the output of said last receiver for translating the intelligence of said second frequency.

4. In a restricted zone signaling system, means for generating modulated radio frequency signals, means for coupling, superimposing, and adjusting the modulated radio frequency signals to a predetermined level on an electric transmission line, said radio frequency being of such a value as to pass through line transformers with substantially minimum attenuation, a receiver, means for coupling said transmission line to a receiver located at a remote point, a second transmitter operating on a frequency different than said first transmitter, coupling means for re-impressing the received intelligence of said radio frequency signals on said second transmitter, the frequency difference between said second transmitter and said first transmitter being such as to restrict interaction therebetween, means for coupling, superimposing and adjusting to a predetermined level the second frequency on an electric transmission line for establishing a restricted range signaling zone, a second receiver disposed within the restricted signaling zone established by the second transmitter and adjusted to said second frequency, and means connected to the output of said last receiver for translating the intelligence of said second frequency.

5. In a restricted zone signaling system, means for generating modulated radio frequency signals, means for inductively coupling said modulated radio frequency signals to an electrically conducting line, a termination unit connected to said last means to restrict the formation of standing waves thereon, means for inductively coupling said electrically conducting line to a receiver, coupling means for re-impressing the received radio frequency signals on a second transmitter, a second transmitter operating on a frequency different than said first transmitter, means for inductively coupling the second frequency signals to an electrically conducting line, a termination means connected to said last means to restrict the formation of standing waves thereon, a receiver disposed within the restricted signaling zone established by the second transmitter and adjusted to said second frequency, and means connected to the output of the receiver for translating the intelligence of said second frequency.

6. In a restricted zone transmitting signaling system having at least one electrically conducting line, a transmitter for transmitting modulated radio frequency signals, means for coupling said modulated radio frequency signals to an electrically conducting line of said system, a plurality of receivers, means for coupling said electrically conducting line of said system to said plurality of receivers, a plurality of transmitters, coupling means for re-impressing the received radio frequency signals on said plurality of transmitters, one of said plurality of transmitters being complemental to one of said plurality of receivers, each of said plurality of transmitters operating on a frequency different than said first transmitter, and means for coupling each of said complemental transmitters to an electrically conducting line of said system.

7. In a centrally controlled communications distribution system having at least one electrically conducting line, a central station transmitter, means for modulating said central station transmitter, a radio frequency attenuator and line coupling unit connected to the output of said transmitter, the output of said radio frequency attenuator and line coupling unit being connected to said electrically conducting line, a secondary communications distributing system including a zone receiver and a zone transmitter coupled to said electrically conducting line, means for automatically initiating operation of the zone transmitter when the carrier from the zone receiver is impressed upon said zone transmitter, and a zone radio frequency attenuator and line coupling unit connected to the output of said zone transmitter, the output of said zone radio frequency attenuator and line coupling unit being connected to said electrically conducting line to establish a localized signaling zone.

8. In a restricted zone transmitting signaling system having at least one electrically conducting line, a central station transmitter for transmitting modulated radio frequency signals, means for coupling said modulated radio frequency signals to an electrically conducting line of said system, a plurality of zone receivers, means for coupling said electrically conducting line of said system to said plurality of receivers, a plurality of zone transmitters, coupling means for re-impressing the received radio frequency signals on said plurality of zone transmitters, one of said plurality of zone transmitters being complemental to one of said plurality of receivers, each of said zone transmitters in adjacent zones operating on different frequencies, all of said zone transmitters operating on a frequency different than said central station transmitter, and means for coupling each of said complemental transmitters to an electrically conducting line of said system.

9. In a restricted zone transmitting signaling system having at least one electrically conducting line, a central station transmitter for transmitting modulated radio frequency signals, means for inductively coupling said modulated radio frequency signals to an electrically conducting line of said system, termination means connected to the coupling means to restrict the formation of standing waves on said coupling means, a plurality of zone receivers, means for coupling said electrically conducting line of said system to said plurality of receivers, a plurality of zone transmitters, coupling means for re-impressing the received radio frequency signals on said plurality of zone transmitters, one of said plurality of zone transmitters being complemental to one of said plurality of receivers, each of said zone transmitters in adjacent zones operating on different frequencies, all of said zone transmitters operating on a frequency different than said central station transmitter, means for inductively coupling each of said complemental transmitters to an electrically conducting line of said system, and termination means connected to each of last said coupling means to restrict the formation of standing waves on each of last said coupling means.

10. In a centrally controlled communications distribution system having at least one electrically conducting line, a central station transmitter, means for modulating said central station transmitter, a radio frequency attenuator and

line coupling unit connected to the output of said transmitter, the output of said radio frequency attenuator and line coupling unit being connected to said electrically conducting line, a secondary communications distributing system including a zone receiver and a zone transmitter, means for automatically initiating operation of the zone transmitter when the carrier from the zone receiver is impressed upon said zone transmitter, said automatic initiating means including a carrier-operated relay responsive to operation of said zone receiver, and a power supply relay responsive to operation of the carrier-operated relay to supply plate voltage for said zone transmitter, and a zone radio frequency attenuator and line coupling unit connected to the output of said zone transmitter, the output of said zone radio frequency attenuator and line coupling unit being connected to said electrically conducting line to establish a localized signaling zone.

WILLIAM S. HALSTEAD.

CERTIFICATE OF CORRECTION.

Patent No. 2,389,257. November 20, 1945.

WILLIAM S. HALSTEAD.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, line 50, before "zones" insert --signaling--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 5th day of February, A. D. 1946.

Leslie Frazer

(Seal) First Assistant Commissioner of Patents.