

Nov. 14, 1939.

H. R. BUTLER

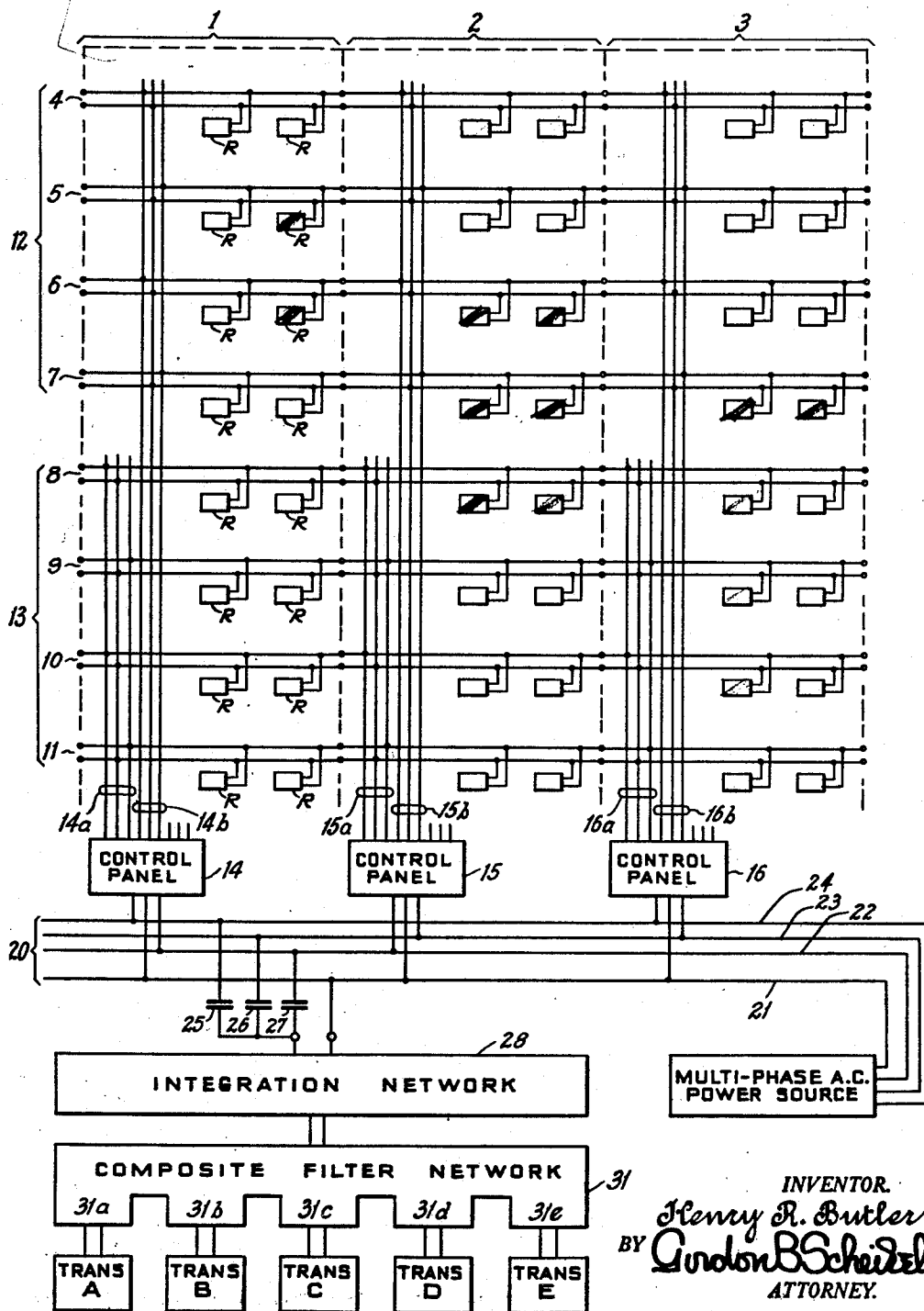
2,179,612

WIRED RADIO SERVICE SYSTEM

Filed Aug. 28, 1937

4 Sheets-Sheet 1

Fig. 1



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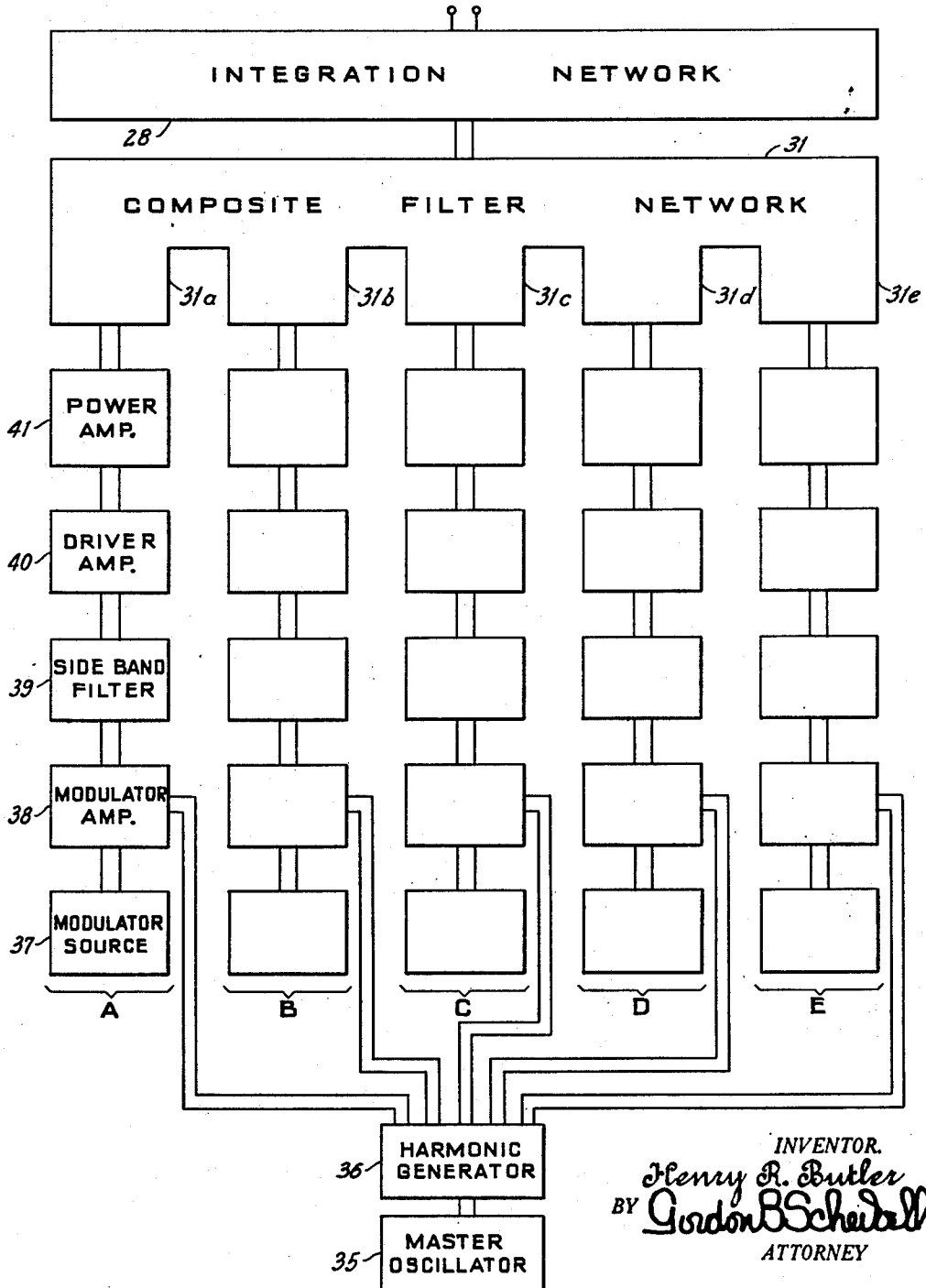
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WIRED RADIO SERVICE SYSTEM

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4 Sheets-Sheet 2

FIG. 2



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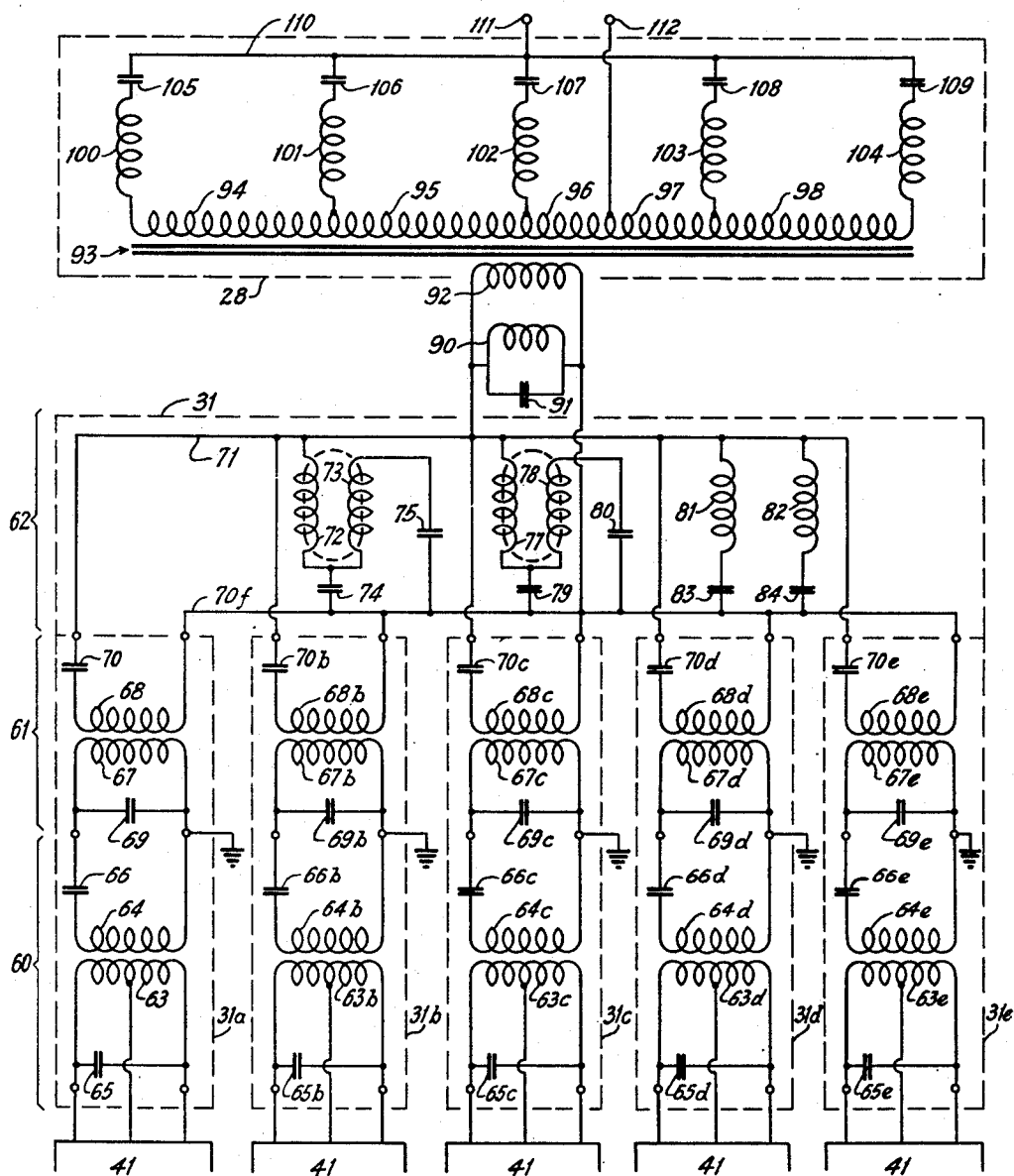
2,179,612

WIRED RADIO SERVICE SYSTEM

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4 Sheets-Sheet 3

FIG. 3



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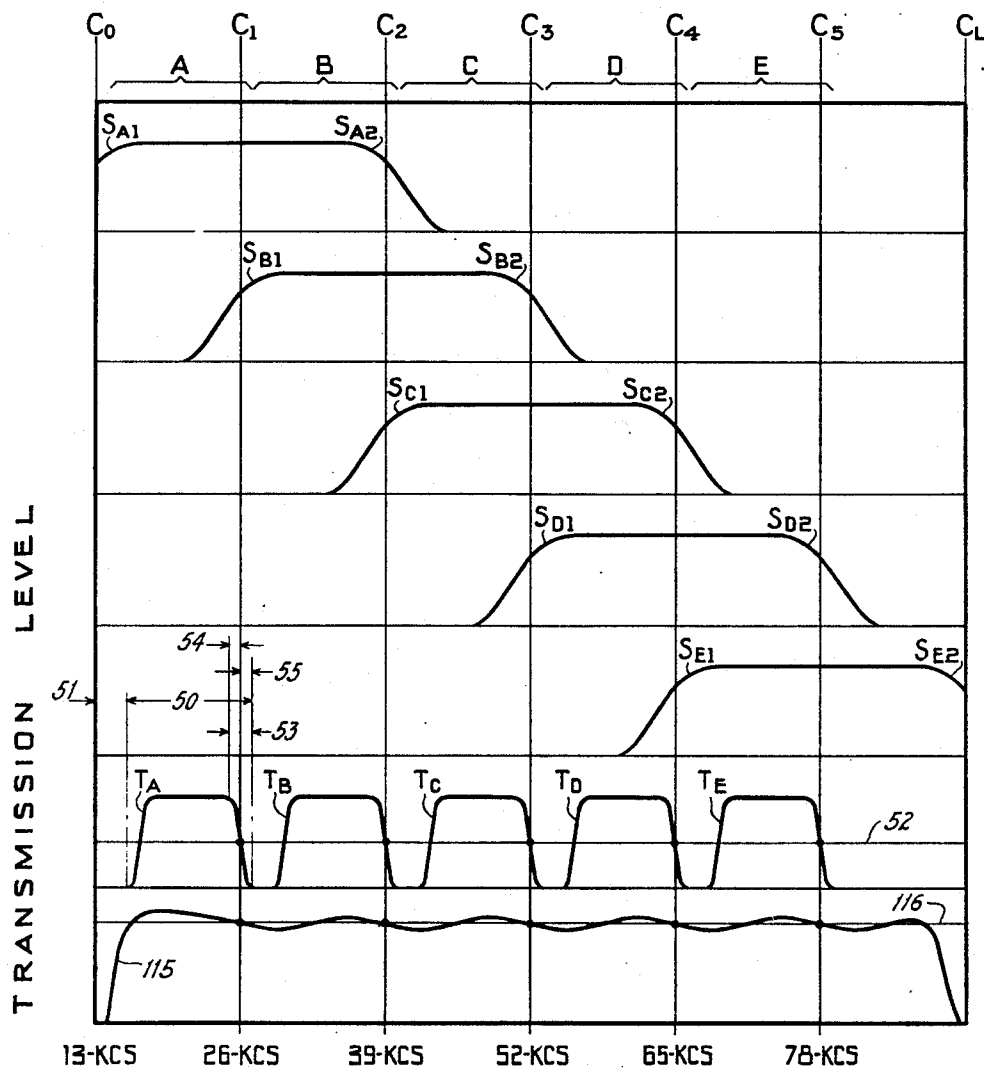
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WIRED RADIO SERVICE SYSTEM

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4 Sheets-Sheet 4

FIG. 4



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UNITED STATES PATENT OFFICE

2,179,612

WIRED RADIO SERVICE SYSTEM

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Application August 28, 1937, Serial No. 161,389

12 Claims. (Cl. 179—2.5)

This invention pertains in general to signal distribution systems and specifically relates to a system of wired radio distribution.

The principal object of the invention consists in providing a distribution system for hotels, apartment houses and the like, as well as other restricted and localized areas involving special distribution problems.

A further object of the invention consists in producing a multiple program-channel distribution system for simultaneously transmitting over a common transmission medium a plurality of programs at discrete frequencies and within a condensed frequency range.

A further object of the invention consists in providing a multiple channel program distribution system having composite networks common to all of the channels for integrating the transmission characteristics of all of the channels with respect to a common transmission medium for effecting constant transmission conditions.

A still further object of the invention comprises providing a wired radio service system embracing a multiplicity of service group networks each including a plurality of service sections, together with an arrangement for integrating the characteristics of the groups and sections to provide uniform transmission.

These and other objects will be apparent from the following, reference being had to the accompanying drawings which form a part of this specification and in which like reference numerals designate corresponding parts throughout, and in which:

Fig. 1 is a schematic representation of one embodiment of a wired radio service system in accordance with the invention;

Fig. 2 is a schematic representation of the transmission equipment employed in the system of Fig. 1;

Fig. 3 is a diagrammatic representation of a composite network employed in the system depicted in Fig. 1; and

Fig. 4 is a graphical representation of certain transmission characteristics of parts of the system of the invention.

The system of the invention contemplates the provision of plural channel selective program service for a multiplicity of subscribers or consumers centrally located in a hotel, an apartment house, or a community, and involving diverse conditions of electrical transmission. In such a transmission area, involving variant electrical conditions including the use of many forms of power consuming apparatus, changing loads, and

many other adverse conditions, it has been found extremely difficult to effectively and efficiently transmit carrier frequency energy to a multiplicity of receivers in the area so that all of the subscribers or consumers at different points of reception will have the benefit of a program of uniform quality and strength. This is true for a single program of a moderate range of audio frequencies, and a problem of much greater proportions arises when it is desired to simultaneously transmit many programs each of high fidelity characteristics embracing a wide range of audio frequencies.

According to the invention, a portion of the carrier frequency spectrum is utilized in which carrier frequency may be transmitted most efficiently, and the plurality of program channels are electrically "condensed" so that they can all be accommodated within this favorable range. Further than this, applicant utilizes composite networks for integrating the effects of the electrical characteristics of the plural channels against the common transmission medium, so as to bring about an effective transmission of plural program channels of wide range audio frequency characteristics to a great number of reception points, and with uniform signal strength and quality at these many reception points.

The transmission network

The invention will be described in connection with a hotel structure, although it will be recognized that the inventive concept is applicable to effect program transmission in other situations involving similar difficulties and problems. Referring to the drawings, the schematically represented hotel structure is divided into a plurality of vertical distribution sections 1, 2, and 3. These sections extend vertically through the building and include a partial area of each floor, the floor areas over one another being aligned. Each floor is provided with wire lines 4—11 which are electrically isolated in accordance with the vertical sections 1, 2, and 3. The floors are further divided into groups 12 and 13, the group 12 including floors 4—7 and the group 13 including floors 8—11.

At a suitable location, such as in the service basement of the building, control panels 14, 15 and 16 are provided to serve commercial power and wired radio signals to the vertical sections 1, 2 and 3. These control panels each comprise suitable equipment such as switches, fuses, etc., for exercising supervisory control over the composite energy distributed to the vertical sections.

Composite bus system 20 supplies both commercial power and signalling energy to the control panels 14, 15 and 16. The bus system 20 comprises a neutral line 21, power voltage phase lines 22, 23, and 24. The lines 22-24 are connected to capacitors 25, 26 and 27 and thence to a terminal of a composite integration network 28, the other terminal of this distribution network being connected to the neutral line 21. The bus system is also connected with a multi-phase alternating current power source 30 which supplies three-phase alternating current to the bus system, the phase lines 22, 23, and 24 each carrying 110 volt alternating current with respect to the neutral line 21.

From control panel 14, riser cables 14a and 14b serve the groups 13 and 12 of section 1. Similarly, riser cables 15a and 15b originate at control panel 15 and energize groups 12 and 13 of section 2, and riser cables 16a and 16b serve groups 12 and 13 of vertical section 3. These riser cables each comprise three lines in which, as shown in Fig. 1, the central line is neutral and the side lines are at 110 volts potential for commercial alternating current, with respect to the neutral line. It will be noted that each of the floors in a group served by riser cables are connected in sequence to different ones of the 110 volt lines, the neutral line of the cable being commonly connected with all of the floor circuits in the group.

The transmitter equipment

The integration network 28 is connected through the composite filter network 31 having branches 31a, 31b, 31c, 31d, and 31e which are respectively connected with transmitters A-E. The transmitters A-E produce modulated high frequency energy corresponding to five different programs comprising the five different program channels transmitted in accordance with the invention.

Referring to Fig. 2, a master oscillator 35 produces waves of a base frequency which, in the present embodiment of the invention, is 13 kilocycles. A harmonic generator 36 is driven by the master oscillator 35, and produces electrical waves which are amplified harmonics of the base frequency of the master oscillator 35. These harmonics are separately fed to modulator amplifiers 38 of the respective transmitters A-E. The frequencies of the oscillation waves delivered to these modulator amplifiers are, in the present instance, 26, 39, 52, 65, and 78 kilocycles, respectively. The modulator amplifiers 38 respectively amplify these various frequencies and, at the same time, modulate the same with the modulation frequencies derived from the various modulation sources 37 of the transmitters A-E. The outputs of the modulator amplifiers 38 are delivered through side band filters 39 which limit the output frequencies in a definite and predetermined manner as will be pointed out hereinafter in more detail.

The modulators 38 are of the variable carrier type, the carrier frequency varying in amplitude in accordance with the impressed modulation frequencies. In another arrangement, the modulators may be of the fixed carrier type. Again, and to obtain certain other desired objectives, the modulators 38 may be of the suppressed carrier type wherein the carrier itself is suppressed, and only the frequencies in a side band adjacent the carrier frequencies are transmitted, as, for instance, disclosed in Patent No. 2,151,464, issued March 21, 1939. The details of

a transmitter system for transmitting with fixed, variable, or suppressed carrier are disclosed in an application of Edmund A. Laport, Serial No. 50,491, filed November 19, 1935, now Patent 2,089,561, issued August 10, 1937.

The side band filters 39 respectively feed into intermediate driver amplifiers 40 which control the output power amplifiers 41 of the transmitters A-E. The power output, comprising modulated high frequency energy within definite frequency limitations, is fed by the power amplifiers 41 into respective branches 31a to 31e of the composite filter network 31. The composite filter network 31 and the integration network 28 co-operate and interact between the transmitters A-E and the transmission medium to effect a level controlled and segregated distribution of the frequencies of the different channels simultaneously transmitted by the transmitters A-E.

Transmission frequency characteristics

Fig. 4 graphically represents the transmission frequency conditions of the system of the invention. The harmonic generator 36 (Fig. 2) produces carrier frequencies C_1 to C_5 inclusive, these carrier frequencies being harmonically related to the base frequency, C_0 produced by the master oscillator 35. The modulated audio frequencies supplied to the various transmitters from the various different program sources 37 A-E are each for an extensive range of audio frequencies. In the present instance, a range of 8,000 cycles per second is used, although wider ranges can be utilized within the scope of the invention.

Such audio frequencies acting upon the carrier frequencies will produce upper and lower side bands. For example, the audio frequencies acting upon the carrier frequency C_1 of transmitter A will produce upper and lower side bands represented by curve SA_1 and SA_2 extending respectively upon opposite sides of the carrier frequency C_1 . Similarly, the other carrier frequencies C_2 to C_5 may be modulated to produce upper and lower side bands represented by curves designated by the letter "S" with corresponding subscripts.

Referring to Fig. 4, it will be seen that the carrier frequencies are all spaced within a relatively narrow range C_0 to C_5 , found by experiment to be the most effective part of the carrier frequency range for transmission over networks carrying other forms of electrical energy. The spacing of the carrier frequencies C_1 to C_5 on the frequency spectrum is by increments of the base frequency, which is 13 kilocycles. Thus the separation between any two of the carrier frequencies is 13 kilocycles. Since, by comparison, any one of the side bands is quite wide in extent, it will be seen that there is considerable overlapping between the upper side band of one channel and the lower side band of the next channel above on the frequency spectrum. Thus the side band SA_2 overlaps the side band SB_1 for approximately 20 kilocycles.

According to applicant's invention, all the channels are "condensed" so that only the lower side bands SA_1 , SB_1 , etc. are utilized. Therefore, frequencies substantially from only the lower side bands SA_1 to SE_1 are impressed upon the electrical circuits common to all the channels. The process of "frequency condensing" is effected by the filters 39 of the transmitters and the other common networks of the system.

The frequency transmissions of the filters 39 in combination with the network 31 are repre-

5 sented by the curves T_A — T_E . The transmission characteristics of these filters definitely determine the extent and position of the pass band of frequencies so that width 50 is substantially less than the frequency range of one of the channels extending between any two of the carrier frequencies, there being, in addition, a guard frequency range 51 between each of the curves T_A — T_E . The right hand slopes of the curves T_A — T_E as shown in Fig. 4 are centered on the carrier frequencies C_1 — C_5 , the points all being along the level indicated by the line 52. The line 52 represents substantially one-half of the total transmission level represented by the height of the curves T_A — T_E . It will be seen therefore that within the range 53, both the upper and lower side bands are transmitted, but with compensating decrements so that the effective level in this range is substantially the same as the level for the remainder of the single side band of frequencies transmitted. It will be seen that the two ranges 54 and 55 comprising the halves of the range 53 are of equal extent on opposite sides of the carrier frequency. Such a condition is true for each of the frequency channels, it being noted that the frequency channels A—E do not coincide precisely with the ranges defined by the frequencies C_1 — C_5 .

30 Composite filter and integration networks

Referring to Figs. 1 and 2, it will be seen that the transmitters A—E and the distribution network are inter-connected by the integration network 28 and the composite filter network 31, connected in tandem, and represented in detail in Fig. 3. Referring to Fig. 3, the branches 31a—31e comprise a part of the filter network. These filter networks have a plurality of filter sections 60, 61 and 62. It will be seen that the first two sections, 60 and 61, of the filter are included in the branches 31a—31e, whereas the last section of each of the filters is included in the network 62, which is common to all of the various filters associated with the channels A—E. That is, each channel operates through a filter comprising a plurality of sections, and one section of each filter is represented by a network common to all of the filters.

The section 60 includes coupled inductances 63 and 64 and capacitors 65 and 66 connected as shown. The section 61 comprises the coupled inductances 67 and 68, and the capacitors 69 and 70 connected as shown. All of the sections 60 and 61 of the filter branches 31a and 31e have similar components, indicated with corresponding subscripts, the value of the parameters of these components being designed in accordance with the frequencies peculiar to the respective program channels associated with the various filters.

The section 62 comprises parallel lines 70f and 71. Coupled inductances 72 and 73, and capacitors 74 and 75 are connected between the lines 70f and 71, as shown. Coupled inductances 77, 78 and capacitors 79 and 80, are also connected between the lines 70f and 71, as shown. Uncoupled inductances 81, 82 are respectively connected in series with capacitors 83, 84, as shown.

The output circuit of composite filter 31 includes a circuit comprising the inductance 90 and capacitor 91 connected as shown. This output circuit is shunted by a primary winding 92 of a transformer 93 having secondary windings 94, 95, 96—97, and 98. These secondary windings are coupled by inductances 100, 101, 102, 103, 104 and

capacitors 105, 106, 107, 108, 109 to line 110 connected to output terminal 111. The output terminal 112 is connected at a point between the secondary windings 96 and 97.

It will be noted that the inductances 63 have a midpoint connection to the power amplifiers 41. The latter are of push-pull type and the midpoint connection is to the balance point of the circuit interconnecting the push-pull tubes of the amplifiers. In this arrangement the anode supply of the push-pull amplifiers 41 traverses the inductances 63, these inductances therefore forming part of the anode circuits of the push-pull amplifiers.

Certain features of the filter networks and transmitter apparatus disclosed herein are claimed in divisional applications Ser. No. 212,472 and Ser. No. 212,473, filed June 8, 1938.

The integration network 28 includes reactive components having parameters calculated to give a general transmission characteristic for the general frequency range C_0 — C_L as represented by the curve 115 in Fig. 4. This curve has definite level points of equal magnitude along the line 116 intersecting the carrier frequencies C_1 — C_5 , and is arrived at by solving five simultaneous equations involving the output impedance from terminals 111 and 112 looking into the transmission medium, the equations being solved for the five carrier frequencies for desired conductance and zero susceptance of the primary input of the transformer.

The curve 115 represents the effective transmission levels of the pass range of the integration network 28. It will be seen that all of the curves T_A — T_E will be accommodated by the curve 115, with appropriate level control for all of the frequencies with respect to the level control mean line 116.

The networks 28 and 31 in tandem cooperate by virtue of the segregated circuit components and the common circuit components, and interact between the transmission medium and the transmitters A—E to produce a uniform distribution of carrier frequency signals as before set forth, so that each of the multiplicity of receivers R may receive any one of the simultaneously transmitted program channels with high fidelity and uniform reception among the channels with respect to a particular receiver, and with uniform reception with respect to all of the receivers located at the various points.

The values for the parameters of the components of networks 28 and 31 are as follows:

TABLE OF CIRCUIT PARAMETERS
Inductances in millihenries

Part Nos.	Value	Part Nos.	Value
63.....	28.82	63b.....	10.97
64.....	9.21	64b.....	4.60
67.....	0.755	67b.....	0.157
68.....	2.98	68b.....	2.85
63c.....	5.72	63d.....	3.71
64c.....	7.73	64d.....	4.67
67c.....	0.1427	67d.....	0.0523
68c.....	2.84	68d.....	2.87
63e.....	2.57	72.....	2.39
64e.....	6.32	73.....	23.45
67e.....	0.051	77.....	0.435
68e.....	2.80	78.....	10.33
		81.....	14.00
		82.....	10.34
		90.....	.2155
		100.....	0.46
		101.....	0.95
		102.....	0.524
		103.....	3.46
		104.....	2.01

Capacities in microfarads

65.....	.001975	65b.....	.001935
66.....	.007500	66b.....	.005000
68.....	.074912	68b.....	.134960
70.....	.020816	70b.....	.007726
65c.....	.001942	65d.....	.001837
66c.....	.001500	66d.....	.001500
69c.....	.077890	69d.....	.130270
70c.....	.003986	70d.....	.002389
10 65e.....	.001808	74.....	.069246
66e.....	.000750	75.....	.001428
69e.....	.081100	79.....	.006890
70e.....	.001571	80.....	.000850
		83.....	.001051
		84.....	.000532
		91.....	.0389
		105.....	.00905
		106.....	.0395
		107.....	.01817
		108.....	.004815
		109.....	.002985

The relations of the transformer ratios for the input transformer of the integration network are as follows:

TABLE OF TRANSFORMER TURN RATIOS

Parts Nos.	Ratios
92:96	::1:0.792
92:96+95	::1:0.875
92:96+95+94	::1:1.04
92:97	::1:0.5
92:97+98	::1:1.085

Although a preferred form of wired radio service system has been disclosed in connection with particular circuit arrangements and components and specific parameter values for such components, it will be recognized that various changes, modifications, and equivalent arrangements can be made without departing from the intended scope of the invention. Therefore, no limitation is intended except as pointed out by the appended claims.

What is claimed as new and original to be secured by Letters Patent of the United States is:

1. The method of simultaneously transmitting a plurality of programs over a power distribution network through a common integration network, comprising, generating a plurality of carrier frequencies spaced in a selected portion of the frequency spectrum, generating a plurality of different ranges of audio frequency currents, separately modulating each of said carrier frequencies with one of said ranges of audio frequency currents, thereby producing modulated high frequency energy in the form of carriers having overlapping side bands, eliminating all of the frequencies adjacent each carrier except those within a limited range preponderantly in a single side band, impressing all of said restricted frequency bands on said common integration network and simultaneously modifying the levels thereof in accordance with the respective impedances presented by said power distribution network so as to produce corresponding uniform level points in all of said bands, and impressing said integrated leveled bands simultaneously upon said power distribution network, and impressing said restricted integrated frequencies simultaneously upon said distribution network.

2. The method of simultaneously transmitting a plurality of programs over a power distribution network through a common integration network, comprising, generating a plurality of discrete carrier frequencies spaced in a predetermined range in the frequency spectrum, the spacing between adjacent carrier frequencies including the range of a single side band of modulation frequencies to be transmitted and in addition a

separation guard range, producing a plurality of ranges of modulation frequencies, restricting said modulation frequencies in definite bands combined with said carrier frequencies so that each band has a sloping cut-off near its carrier frequency with substantially one-half amplitude at the carrier frequency, impressing all of said bands on said common integration network and modifying the levels thereof in accordance with the respective impedances presented by said power distribution network so as to produce corresponding uniform level points in all of said bands, and impressing said frequency restricted level-controlled plurality of bands simultaneously on said power distribution network.

3. A transmission system comprising, a master oscillator producing a base frequency, means for generating from said base frequency a plurality of carrier frequencies spaced in a selected portion of the frequency spectrum, means for producing a plurality of ranges of modulation frequencies, means for individually combining said carrier frequencies and said modulation frequency ranges, means for individually modifying each of the combined carrier and modulation frequencies, a filter network having parts individual to said means and other parts in common for combining all of said carriers and modulation frequencies in a general frequency range, and a common integration network for controlling the levels of all of said bands so as to have a plurality of uniform level points in said general frequency range with at least one of said points in each band, and a common distribution network for all of said frequencies traversing said last mentioned network, said distribution network supplying signalling energy and commercial power to a plurality of receivers coupled therewith.

4. A system for supplying combined signalling energy and commercial power to a multiplicity of separated receivers all requiring commercial power and signalling energy for reproducing programs comprising, a plurality of modulation sources for simultaneously producing modulation current corresponding to a plurality of programs, means for producing a plurality of harmonically related carrier frequencies spaced within a selected portion of a frequency spectrum, means for combining said modulation frequencies individually with said carrier frequencies to position said modulation frequency ranges in discrete parts of said selected portion of the frequency spectrum, a plurality of filters each comprising a chain of filter sections, the last section of all of said filters being included in a common network, connections between all of said transmitters and said filters to individually supply thereto said modulated high frequency energy, a level controlling integration network common to all of said frequencies and connected with said common filter network to control the levels of said frequencies to produce similar level points in all of said frequency ranges, and a commercial power distribution network coupled with a plurality of wired radio receivers and connected with said integration network, said distribution network acting to distribute to said receivers simultaneously all of said program frequencies for individual reception at levels controlled from said integration network.

5. In a system of wired radio distribution, the combination with a commercial power distribution network of a wired radio transmission system comprising, means for producing a plurality of carrier frequencies within a limited portion of

a frequency spectrum and at which said network transmits carrier frequencies most effectively, means for simultaneously producing a plurality of ranges of audio frequencies, the total extent of said ranges being much greater than the total frequency ranges embraced by said carrier frequencies on the frequency spectrum, a plurality of modulators individually adapted to combine said ranges of audio frequencies with the respective carrier frequencies, means for restricting the frequency output of all of said modulators so that the output of each modulator falls within a frequency range substantially less than the frequency range between two adjacent ones of the carrier frequencies, a common integration network for controlling the levels of all of said restricted frequency ranges so as to have a plurality of uniform level points in said selected portion of the frequency spectrum with at least one of said points in each restricted frequency range, and coupling means between said last mentioned means and said distribution network for impressing said integrated and controlled frequencies on said network.

6. A transmission system comprising means for generating a plurality of modulated carriers within a restricted frequency range, means for removing overlapping portions of the modulation side bands to leave each carrier with substantially only one side band and for combining the same in a common output circuit; a distribution network having different impedance for the various frequencies within said restricted frequency range, and an integration network coupling the common output circuit to the distribution network, said integration network in conjunction with the distribution network giving a plurality of uniform level points in said restricted frequency range, with at least one of said points in each side band.

7. The method for coupling a source of individually modulated carriers to a given power distribution network through a tapped transformer having reactive components connected to the respective taps, said carriers being discretely spaced in a restricted frequency range, which method comprises separately modifying the resistance presented by said network for each carrier by selecting a tap ratio therefor so as to present to said source a uniform resistance for all said carriers, and balancing the reactance of said network against all said reactive components simultaneously at several points in said frequency range to obtain zero susceptance at each point, at least one of said points being in the frequency range of each carrier, said balancing including the effect of each said reactive component upon the others as modified by said selected tap ratios.

8. A transmission system comprising, means for generating modulated carrier spaced within a restricted frequency range, means for combining said modulated carriers in a common output circuit, a distribution network having different impedance for the various frequencies within said restricted frequency range, and means coupling the common output circuit to selected points in said distribution network, said coupling means comprising a tapped transformer and reactive circuits which, in combination with the distribution network, present to said common output circuit a substantially uniform resistance for all the carriers, the reactive components of said cir-

cuits being simultaneously balanced against each other to give at least one point of zero susceptance in the frequency range of each modulated carrier.

9. A signal transmission system comprising, means for producing a base frequency, means for generating a plurality of different carrier frequencies from said base frequency, a plurality of modulation sources, a plurality of modulators each connected with one of said modulation sources and controlled by a particular one of said carrier frequencies for producing modulated high frequency energy corresponding to a plurality of program channels, a plurality of side-band filters each connected with the output of one of said modulators and having a transmission curve corresponding substantially to a single side-band with the carrier frequency of the side-band intersecting the side slope thereof, a composite filter connected with said side-band filters and having parts individual to the different side-band filters and parts in common with all of said side-band filters for preventing interaction between the different channels and for combining all of said channels within a general frequency range, and a common integration network coupling said composite filter to an existing distribution network, said integration network acting in conjunction with the distribution network to give a plurality of uniform level points in said general frequency range with at least one of said points in each side band.

10. The system in accordance with claim 9 including a plurality of receivers connected with said distribution network for utilizing commercial power and a selected section of said general frequency range to reproduce a program, and means for transmitting commercial power over said distribution network to said receivers concomitantly with the transmission of said general frequency range.

11. A signal distribution system comprising, a network in a building connected with a source of commercial alternating current, means for producing program modulated carrier frequencies and including a plurality of connections to differently located points of said network for simultaneously impressing said modulated carriers at said plurality of points, and a common integration network interposed between said carrier frequency means and said plurality of connections, said integration network acting in conjunction with said building network to give uniform power levels for at least one frequency in the range of each modulated carrier.

12. The system in accordance with claim 11 in which said carrier frequency producing means includes an arrangement for simultaneously generating a plurality of relatively wide band modulation frequency ranges, and means for condensing said ranges by the elimination of certain of the frequencies so as to occupy a general transmission frequency range substantially less than the total frequency range of the originally developed modulation side band frequencies, said transmitted modulation frequencies comprising a plurality of side bands in which the curves representing the transmission levels thereof relative to frequency intersect the corresponding carrier frequencies at mean points of the side slopes of the curves.

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Little	1 801 870	250-17
Fetter	1 735 742	178-44
Duncan	1 839 301	" " -2
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Rives	1 962 910	" " "
Wurst	2 026 114	179-2.5 P.D.
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Ceffel	1 554 189	179-15 x

CERTIFICATE OF CORRECTION.

Patent No. 2,179,612.

November 14, 1939.

HENRY R. BUTLER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, lines 64, 65 and 66, claim 1, strike out the comma and words ", and impressing said restricted integrated frequencies simultaneously upon said distribution network"; 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 16th day of January, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

51
179-2.5

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(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.