

PATENT SPECIFICATION

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COMPLETE SPECIFICATION

A Telephone System

We, SUPERIOR CONTINENTAL CORPORATION, formerly known as Superior Cable Corporation, of P.O. Box 489 1928 Main Avenue, S.E., Hickory, North Carolina, United States of America, a corporation organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to telephone communication systems, and more particularly to apparatus for use in combination with existing telephone systems which facilitates the addition of a second subscriber telephone circuit to each cable transmission pair normally providing a single one-party subscriber telephone circuit.

With the rapid growth in population, a problem arise in telephone communication systems of providing for subscriber circuit expansion in areas where the subscriber exchange plant was already congested without the necessity of adding cable reinforcement. In other words, the problem was that of furnishing a second listed telephone for a business or residence. This problem became especially critical in many so-called "dedicated plant" areas where only one cable pair was allotted per residence address in building development areas. A general object of the present invention is to provide a practical, efficient and economical solution to the aforesaid problem.

Another object of our invention is to provide a system that is adaptable for use in combination with and is readily applicable to existing telephone facilities and will supply a second subscriber circuit for a cable pair. Moreover, it is an object of the invention to provide such a system that can be installed and maintained easily by telephone company

personnel with no special skills being required. 45

According to one aspect of the invention, there is provided a telephone system comprising a central office including switching and line finding circuits, a cable transmission pair extending from the central office to a remotely located subscriber station and connected to a first telephone set to form a non-carrier subscriber circuit, a power supply in the central office for supplying power to the transmission pair, and a carrier circuit providing an additional subscriber facility for the same transmission pair, wherein a central office terminal unit having carrier transmitter and receiver sections is connected to the central office and to the transmission pair, a subscriber terminal unit also having carrier transmitter and receiver sections is connected to the transmission pair at the subscriber station, a second telephone set is connected to the subscriber terminal unit, and a rechargeable battery is provided in the subscriber terminal unit for supplying power to operate the subscriber terminal unit sections, the battery being connected to the transmission pair through charging control means for recharging by the power supply of the central office. 50 55 60 65 70

An advantage of the present invention is the provision of a system for supplying a second subscriber circuit for an existing cable pair in a conventional, i.e. non-carrier, telephone system that requires no external adjustments when it is installed. The equipment of our invention may readily take the form of prepackaged units that can be easily installed at the subscriber station and at a central office terminal of the system. There is no common equipment associated with the system of our invention which is required for a plurality of our units. Thus, no economic penalty is involved in applications where only a small number of circuits are required. Consequently, the equipment can be installed 75 80 85

[Price 5s. 0d.]

on a circuit-per-circuit basis as required, on a readily determined fixed cost per circuit basis.

A further advantage of the invention is the provision of a system for supplying a second subscriber circuit to an existing cable transmission pair in a telephone system that utilizes its own battery power for operation. Previous attempts to utilize batteries for subscriber circuits failed because the batteries were not recharged during operation of the equipment. Such systems were not reliable and were thus unsuccessful. This problem has been overcome by the present invention by an arrangement wherein a battery in the subscriber circuit is continually recharged when ever the subscriber telephone of the non-carrier circuit is in the on-hook position. Thus, for our added main line system, no external power source is required for either end of the equipment. The equipment is powered directly from the "talking" battery" means normally supplied by the central office switching equipment to each subscriber circuit and is done in such a way that it does not interfere with the normal utilization of this power for operating the switching relays and providing telephone set transmitter current.

This way of powering the added subscriber circuit also greatly enhances the simplicity of the equipment. The only connections required are to the existing line terminals of the central office equipment for a central office terminal unit and to the transmission cable pair at the subscriber station for a subscriber terminal unit.

According to another aspect of the invention, there is provided a subscriber terminal unit for use in a telephone system to provide service via a carrier derived circuit to an additional telephone set at a subscriber station, which station includes a first telephone set connected by a cable transmission pair to a central office to constitute a non-carrier subscriber circuit, the transmission pair being supplied with power from a power supply in the central office, such subscriber terminal unit comprising carrier transmitter and receiver sections having a first pair of terminals for connection to the transmission pair and a second pair of terminals for connection to the additional telephone set, a rechargeable battery for supplying power to operate the transmitter and receiver sections, and charging control means connected to the battery and adapted to be connected to the transmission pair, whereby the battery is rechargeable from the transmission pair under the control of the charging control means.

According to a further aspect of the invention, there is also provided a central office terminal unit for use in a telephone system to provide service via a carrier derived circuit to an additional telephone set at a subscriber station, which station includes a first telephone set connected by a cable transmis-

sion pair to a central office to constitute a non-carrier subscriber circuit, the transmission pair being supplied with power from a power supply in the central office, such central office terminal unit comprising carrier transmitter and receiver sections having input leads for connection to the central office and output leads for connection to the transmission pair, the transmitter section comprising a voice frequency amplifier connected in series to a low pass filter, a modulator connected to an oscillator operating at a first predetermined frequency, a carrier amplifier and a band-pass filter having a pair of output leads for connection to the transmission pair, the receiver section comprising a voice frequency amplifier connected in series to a voice frequency low pass filter, a detector, a carrier amplifier, a bandpass filter set at a second predetermined frequency and having a pair of input leads for connection to the transmission pair, and automatic gain control means for maintaining a constant voice frequency output, and power regulation and control means for regulating the voltage from the central office power supply to a predetermined level and supplying it to the receiver and transmitter sections.

In order that the invention will be more clearly understood an embodiment thereof will now be described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a block diagram showing the broad concept of a system embodying the principles of the present invention;

Figure 2 is a combined block and circuit diagram showing the central office station for the system of Figure 1;

Figure 3 is a detailed circuit diagram showing a series mode of a power regulating system for the central office terminal unit of Figure 2;

Figure 4 is a detailed circuit diagram showing an alternative parallel mode of a power regulating system for the central office terminal of Figure 2;

Figure 5 is a combined block and circuit diagram showing the subscriber station for the system of Fig. 1; and

Figure 6 is a detailed diagram of the ringing control circuit for the subscriber terminal unit shown in Fig. 5.

In the drawings, Fig. 1 shows diagrammatically a telephone system embodying the present invention, wherein a carrier derived circuit is connected to a single physical subscriber circuit of a conventional, i.e. non-carrier, telephone system, thereby enabling a second single party subscriber to be added to the one normally provided by the single transmission cable pair. Thus, at a residence or business office which is connected by only one cable pair to the telephone central office, an additional one-party subscriber can be

5 shown, the conventional telephone exchange central office equipment, including its switching and line finding circuits, is represented by the block 10. Its connector terminals 12 and 14 for the conventional subscriber's circuit, which shall be referred to as circuit A, are connected to a standard cable pair 16 that extend to the subscriber's station and are connected to a conventional telephone set 18. Another pair of connector terminals 20 and 22 from the central office equipment are connected to a central office terminal unit 24 of the carrier derived circuit, hereinafter referred to as circuit B. On the other side of the central office terminal unit, a pair of leads 26 and 27 are connected to the cable pair 16.

20 At the subscriber station, a subscriber terminal unit 28 is connected on one side by a pair of leads 30 and 31 to the cable pair 16, and by another pair of leads 32 and 33 on the other side to the added subscriber's telephone set 34.

25 The carrier circuit B, including the central office terminal unit 24 and the subscriber terminal unit 28, provide means for deriving and applying to the transmission pair a double sideband amplitude modulated voice frequency signal. The system utilizes different frequencies for the two directions of transmission. In the following description F_1 designates the frequency of the signal transmitted from the central office, while F_2 designates the frequency of the signal transmitted from the subscriber terminal unit 28.

30 At the telephone central office between the equipment terminals 12 and 14 and the junctions 36 of the central office terminal leads 26 and 27 and the cable pair 16, is provided a first voice frequency (VF) low pass filter 38. Similarly, at the subscriber station a second voice frequency low pass filter 40 is connected to the cable pair between the conventional telephone set 18 and the junctions 42 of the cable pair 16 and the leads 30 and 31 to the subscriber terminal unit 28. These filters 38 and 40 provide a means for isolating the non-carrier circuit (circuit A) from the carrier circuitry associated with the carrier derived circuit (circuit B). Thus, since the added carrier circuit operates at the relatively high carrier frequencies F_1 and F_2 , its transmissions are filtered out of the cable pair 16 and are thereby prevented from reaching the conventional telephone receiving equipment at either the central office or the subscriber station.

35 As shown in Fig. 2 the central office terminal unit 24 comprises transmitter and receiver sections 44 and 46, respectively, both of which are connected to a hybrid transformer 48. The transmitter section includes a VF amplifier 50 connected in series to a VF low pass filter 52, a modulator 54 connected to

an oscillator 56 operating at the frequency F_1 , a carrier amplifier 58 and band pass filter 60, the latter having output leads 26 and 27 connected to the cable transmission pair 16. The receiver section 46 of the central office terminal includes a VF amplifier 66 connected in series to a VF low pass filter 68, a detector 70, a carrier amplifier 72 and a band pass filter 74 set for the frequency F_2 and having a pair of input leads 76 and 78 connected to the leads 26 and 27 and thus to the cable transmission pair. An automatic gain control means 80 is utilized in the central office terminal unit to maintain a substantially constant VF output with a wide range of signal power input levels, thereby eliminating the need for external field adjustments.

In an actual installation of our system the central office terminal unit 24 is preferably packaged as a small compact electronic component using conventional assembly techniques. Thus, it may be easily attached to the standard iron frame used for conventional telephone equipment, with the terminals for the connections, as described, being readily accessible.

The subscriber terminal unit 28, as shown in detail in Fig. 5, generally is similar to the central office terminal unit 24 in that it has transmitter and receiver sections 82 and 84 and equivalent components for filtering, amplifying, detecting and controlling signals, as described below. The transmitter and receiver sections are connected to the cable transmission pair 16 and, through a hybrid transformer 86, to the added subscriber telephone set 34. In accordance with the principles of the invention, the subscriber terminal unit 28 is powered by a self-contained battery 88 which is charged by DC voltage originating from the central office station and existent on the transmission cable pair 16. This battery, which may be any suitable form of rechargeable cell, such as the nickel-cadmium type, is constantly charged during the time that the circuit A is idle. Every time circuit A becomes active, the battery 88 is disconnected by means of a battery control circuit 90 in the subscriber terminal unit 28, the operation of which will become apparent as the detailed description of the apparatus proceeds.

With the battery 88 no external power source is required for either end of the equipment, and this is an important feature of our invention. Both the central office terminal unit 24 and the subscriber terminal unit 28 are powered by the "talking battery" power source which is normally supplied by the central office switching equipment 10. Moreover, this power is supplied to each subscriber circuit B in such a way that no interference occurs with its normal utilization for operating the switching relays and for providing normal telephone set transmitter current to subscriber A. In some instances the

13 central office terminal unit may be supplied
with voltage directly from the central office
source without involving the associated line
equipment, but this in no way changes the
5 operation of the invention.

The aforesaid and other features of the invention will now be described in greater detail by reviewing the various modes of operation of a typical system incorporating the invention.
10 In an "idle circuit" condition direct current power (e.g., 50 volts) of the polarity indicated is continuously applied from the normal "talking battery" power source to the circuit
15 A through the windings of a line relay 92 (Fig. 2), which is connected to the line selecting equipment (block 10). This voltage is thus present on the transmission pair 16 and is applied to the subscriber terminal unit 28 through a pair of terminals 94 and 96 and to its battery charging control circuit 90.
20 Here, the positive voltage is applied through a lead 98, a diode 100, and a current limiting resistor 102 to the collector of a NPN transistor 104, which is biased to a conducting condition by a bias network consisting of a resistor 106, a capacitor 108 and a resistor 110. When the transistor 104 conducts, a positive voltage is applied to the battery 88, which is connected through the return circuit through a lead 112 to the terminal 94.
30 Thus, a charging current is provided to the battery 88 which is limited (e.g., to approximately 5MA) by the resistor 102. The battery 88 is connected on its positive voltage side to a lead 115 which connects to all of the various components of the subscriber terminal unit 28, as shown in Fig. 5. To conserve space and avoid confusion, these connections from each component to the lead 266 are indicated by a lead from each component terminating with a plus sign.

Though the charging current is not sufficient to operate the line relay 92 at the central office, it would introduce a significant
45 bias to any dial pulse originating from the normally connected subscriber telephone set 18 and, therefore, must be eliminated. In telephone set 18 the removal of the handset 114 from the switch hook cradle closes switch
50 hook contacts 116, which through normally closed contacts in the dial 118 applies a resistance circuit between a pair of terminals 120 and 122. This resistance circuit appearing across the cable pair 16 serves to operate the relay 92, thereby seizing the central office switching equipment and at the same time substantially lowering the voltage appearing across the pair 16. This voltage across the terminals 94 and 96 results in a downward shift of the bias voltage of the transistor 104 being applied to its base from the junction of resistors 106 and 110, thereby causing the transistor 104 to become non-conducting and effectively disconnecting the battery 88 from
65 the line. Thus, removal of the handset 114

from its hook cradle in the telephone set interrupts the charging of the battery.

Operation of the dial 118 on the conventionally connected subscriber telephone set 18 causes a succession of open-circuit pulses to appear across the transmission pair 16, and these in turn cause a pulsing operation of the relay 92 in the central office switching equipment 10. An open-circuit condition such as introduced by the opening of the dial 118 contacts will instantaneously cause the voltage to increase across the transmission pair 16, and through the terminals 94 and 96 to be applied, as previously described, to the battery 88 through the charging circuit. However, the time constant of the resistor 110 and the capacitor 108 are such that the bias voltage appearing at the junction 109 of resistor 110 and resistor 106 will not allow the base bias of transistor 104 to rise sufficiently to cause conduction. Transistor 104, therefore, will remain in a non-conducting condition during dialing intervals.

An answered condition from the called party will cause a reversal of polarity of the voltage applied to the relay 92; thereby, reversing the polarity of the voltage appearing across transmission pair 16. This occurs because the calling party always gets reversed battery supervision. This reversed voltage, appearing at terminals 94 and 96 and acting at diode 100 effectively disconnects the battery charging circuit 90 for the duration of the conversation through the reversed voltage condition appearing at the diode 100. In addition, reply of circuit A to a ringing condition disconnects the battery charging circuit 90 of the subscriber terminal 28 and keeps it in a disconnected condition through the entire duration of the conversation. During this period, the subscriber terminal unit 28 will be operating directly off the stored energy in the battery 88.

The foregoing describes the normal call sequence of the circuit A, and we shall proceed to describe the carrier circuit B in greater detail.

The central office terminal unit 24 is completely powered by normal talking battery current, which is supplied from the line relay circuit of the central office equipment 10 that controls a line relay 125 to a pair of line terminals 126 and 128. In the "idle circuit" condition, voltage of the polarity shown in Fig. 2 which is applied to these latter terminals, is supplied through leads 132 and 134 to the terminals 20 and 22 of the central office terminal unit. This voltage through the lead 136 and a winding 140 of the hybrid transformer 48 is applied through a lead 142 to a power regulation and control circuit 144, and it returns through lead 146 and a network consisting of a dialing relay contact 148, a pair of current limiting resistors 150 and 152 and a capacitor 154. An arc suppression resistor

51 is connected to the relay contact 148 in parallel with the resistor 150.

5 Voltages derived from this circuit just described are used to: (1) Power the stand-
by circuit of the receiver section 46 of the
central office terminal unit 24 during the
"on-hook" condition; (2) Turn on the trans-
mitter section 44 when a carrier frequency
10 signal is received from the subscriber terminal unit 28; and (3) Turn on the transmitter
section 44 when ringing voltage is applied
to the carrier-derived circuit B and the sub-
scriber terminal unit 28 is "on-hook".

15 The aforesaid functions are accomplished
through a series of output leads that extend
from the power regulation and control unit
144. A first such lead 158 extends to the
detector 70 and the carrier amplifier 72 of
the receiver unit 46 and also by a branch lead
20 160 through a relay coil 162 to the detector,
providing standby current to the receiver. A
second output lead 164 is the common return
lead for all electronic circuits. A third output
lead 166 provides controlled DC power to the
25 VF amplifiers 50 and 66 to both the receiver
and transmitter sections and to the modu-
lator 54 and the oscillator 56 of the latter.

30 The power regulation and control circuit
144 may be arranged for either series or
parallel mode operation. In the series mode,
shown in detail in Fig. 3, this control circuit
includes a bridge rectifier 168 having four
terminals 170, 172, 174, and 176. The input
lead 142 is connected to the terminal 170
35 and the opposite terminal 172 is connected to
the lead 146 of the dialing relay network.
The terminal 174 is connected to the first and
second output leads 158 and 164, and the
opposite terminal 176 is connected to the third
40 output lead 166.

45 In the "idle circuit" condition, the voltage
through the input lead 142 to the bridge rec-
tifier 168 causes a DC voltage to appear
across a capacitor 178 in a conductor con-
nected between the opposite terminals 174 and
176. From the terminal 174 a lead 180
extends through junction 181 to a junction
182 which is at a common potential level.
Between the lead 180 and the output lead
50 166 is a lead 184 in which two zener diodes
186 and 188 are connected in series. In the
portion of the lead 180 between junctions 181
and 182 and in parallel with the first zener
diode 186 is a capacitor 190. A lead 192
55 interconnects the lead 180 at the common
junction 182 to a junction 193 between the
two zener diodes.

60 The DC voltage appearing across the rec-
tifier capacitor 178 in the "idle circuit" con-
dition causes a voltage to appear across the
first zener diode 186 and the capacitor 190.
This voltage thus is also present in the first
output lead 158 and maintains the carrier
65 amplifier 72, the detector 70 and the auto-
matic gain control circuit 80 in an active

circuit condition. The rest of the electronic
circuitry of the central office terminal 24 is
supplied with power through the lead 166
from the opposite terminal 176 which is of
such a magnitude as not to allow the second
70 zener diode 188 to reach its zener voltage.
This is due to the current limiting action of
the resistors 150 and 152. It is seen, therefore,
that in the "idle condition" the receiver of the
central office terminal 24 is at all times in a
75 condition to receive a transmitted signal of
frequency F_2 .

80 The application of a ringing signal in the
central office switching equipment 10 will
cause an alternating voltage to be super-
imposed upon the DC voltage apparent at the
tip and ring terminals 126 and 128. This
alternating voltage acting through the hybrid
terminal windings 140 and 141 as previously
described, will be rectified by the bridge cir-
cuit 168. The return circuit is through the
85 capacitor 154 which is of such a value as to
effectively shunt the current limiting resis-
tor 150, thereby causing an increased voltage
to appear across the rectifier capacitor 178.
This latter voltage reaches a magnitude that
causes the zener diode 188, which is shunted
by the electronic load, to reach its clamping
voltage. This increase in voltage in turn will
activate through the output lead 166, the VF
95 amplifier 50, the modulator 54, the oscil-
lator 56, and the carrier frequency amplifier
58, thereby causing a signal at frequency F_1
to be transmitted through the bandpass filter
60 over the leads 26 and 27 to the terminals
36, placing the signal on the transmission pair
16.

100 In the parallel operation mode for the
power regulation and control circuit 144a
shown in Fig. 4, the second zener diode 188
of the previous embodiment is replaced by a
network which is connected in parallel with
the first zener diode 186a and the capacitor
190a. The network here comprises another
zener diode 192 and a pair of resistors 194
110 and 196 in series therewith in a lead 197
extending between a pair of leads 180a, 166a
from the rectifier terminals 174a and 176a,
the latter being at a positive voltage (e.g., 8
volts) and the former being at a common
potential. A transistor 198 is base-connected
to a junction 200 between the resistances 194
and 196, its emitter 202 being connected to
the lead 166a, and its collector 204 being
115 connected to an output lead 166b. In the lead
180a which is connected to a junction 206
with the output lead 166a and in parallel with
the lead 197 is a resistor 208 and the zener
diode 186a in series. In parallel with the
zener diode 186a is a lead 210 connected be-
tween the junctions 212 and 214 the capacitor
190a. In the initial "idle" condition with the
resistance 150 in the circuit there is not enough
125 voltage difference developed between the plus
lead 166a and the common lead 180a to cause
130

current to flow through the zener diode 192. When the relay contacts 148 are closed, in response to a signal from the subscriber station indicating that the telephone set 34 is "off-hook", and the resistance 150 is thereby shunted out, the potential difference between the leads 180a and 166a is sufficient to cause the zener diode 192 to draw current through the resistors 194 and 196. This establishes a turn-on bias between the base and the emitter of the transistor 198, thus applying voltage through the output lead 166b to the various components of the central office terminal.

Although the operation of the circuits of Figs. 3 and 4 have been described with reference respectively to a ringing current applied from the central office and to initiation of a call from the subscriber terminal unit, it should be noted that both circuits respond to both conditions in analogous manner.

The major difference between the foregoing series and parallel modes of operation for the power regulation and control circuit 144 is that in the series arrangement shown in Fig. 3, the voltage on the output lead 166 is positive with respect to common, and the voltage on the output lead 158 is negative with respect to common. In the parallel mode, the voltage on both of the output leads 166b and 158a is positive with respect to common. The parallel mode therefore has the advantage of being able to utilize components of the same polarity.

When a carrier signal having an impressed ringing frequency is transmitted from the central office terminal 24 and appears at the terminals 94 and 96 of the subscriber terminal unit 28, it travels through a pair of leads 216 and 218 and is selected by a bandpass filter 220 of its receiver section 84. A carrier frequency amplifier 222 connected to the latter filter, a detector 224 and an automatic gain control circuit 226 of this receiver section 84 are normally activated by voltage from the battery 88 through a lead 230. These components, therefore, are in a condition to react to any signal selected by the bandpass filter 220. Upon reception, this incoming signal is amplified by the carrier frequency amplifier 222 and is detected by the detector 224. The AGC circuit 226 acts through its associated pad to maintain the output of the detector at a predetermined level. The detector through a lead 232 actuates a ringer control circuit 234, which through a lead 236, applies a DC voltage to the subscriber telephone set 34, actuating a DC ringer 238 which may be the conventional type.

In the ringing control circuit 234 shown in Fig. 6, the received signal from the central office terminal 24 at the frequency F_1 appears across the primary 241 of a transformer 240, which is part of the detector circuit 224. This signal is coupled to the sec-

ondary winding 242 which is connected between the emitter and base of a transistor 244. A positive voltage through a lead 266 from the battery 88 is applied through a pair of resistors 246 and 248 to the collector of the transistor 244. The voltage developed at the junction 247 between these resistors 246 and 248 is that voltage which is applied through the lead 232 to the ring control circuit 234. In its initial condition (without signal) the detector transistor 244 is in a non-conducting condition. Appearance of a signal from the secondary winding 242 to the base of transistor 244 through lead 232 causes this transistor to become conducting, thereby causing a voltage drop to appear across the resistors 246 and 248. This voltage drop in the polarity indicated is applied through the lead 232 to a ring control transistor 250, which was initially in a non-conducting stage, causing it to become conducting and to apply a positive DC voltage from the lead 286 through a lead 252 and the lead 236 to the DC ringer 238, thereby actuating it.

Removing the handset 254 of telephone set 34 will cause closure of its switch hook contact 256 (Fig. 5), which closes a circuit through the normally closed contacts of a dial 258 of the set 34 and a lead 260 to a terminal 262 of the hybrid transformer 86. The voltage thus appearing at a terminal 264 and in a lead 266 will cause a negative voltage from a lead 268 to be applied through the set 34 to a VF amplifier 270 in the receiver 84, a VF amplifier 272 in the transmitter 82, and an oscillator 274, a modulator 276 and a carrier frequency amplifier 278 of the transmitter section 82, thereby applying a signal at the frequency F_2 to a bandpass filter 280. This signal through leads 282 and 284 and leads 112 and 98 will be applied to the terminals 94 and 96 connected to the transmission pair 16. Simultaneously the negative voltage from lead 266 is applied to a lead 286 of the ring control circuit 234 (as shown in Fig. 6). A transistor 288 of the ring control circuit is initially non-conducting, being biased "off" through a resistor 290. Application of negative voltage from the lead 286 through a resistor 292 to the base of the transistor 288 causes it to become conductive. This effectively shorts the bias resistor 244 causing the transistor 250 to become non-conductive, thereby deactivating DC ringer 238 and keeping it inactive as long as the handset 254 remains "off hook".

At the central office terminal unit 24, the signal transmitted from the subscriber terminal unit 28 at frequency F_2 , as long as the handset 254 is "off hook", appears through the transmission pair 16 at a pair of terminals 294 and 296 and is conducted through the leads 76 and 78 to the bandpass filter 74. It is then amplified by the carrier frequency amplifier 72 and is detected by the detector 70

at a predetermined level established by the AGC circuit 80 and its associated pad. Detection of this signal acting through lead 160 will cause operation of the relay 162 causing closure of its contacts 148 which acting through the windings 140 and 141 of the hybrid transformer 48 will present a resistant condition of such magnitude to appear across the terminals 20 and 22 that the ringing signal from the central office switching equipment 10 will be cut off. This then would leave both the subscriber terminal 28 and the central office terminal 24 in a fully active condition and in readiness to provide two-way voice frequency communications. This is by virtue of the fact that the circuit limiting resistor 150 has been shunted out by the much lower resistance of the arc suppression resistor 151.

The signal level from the subscriber terminal is not high enough to cause the relay 162 to be operative. However, the current stored in the capacitor 190 (Fig. 3) provides the initial pulse of current of sufficient magnitude to operate the relay 162 when a signal from the subscriber terminal is received by detector 70, and closure of the contact 148 will maintain the current at an adequate level to keep this relay in an activated condition so long as a signal is maintained through the detector 70.

In the case of a call initiated from the subscriber end, the circuitry functions as follows: Removal of the handset 254 from its switch hook cradle, as shown in Fig. 5, will close the switch hook contacts 256, thereby applying negative voltage derived from the lead 268 through the lead 260 at the terminal 262 and the primary winding of the transformer 86 apparent at the terminal 264 through lead 266 to all the connected circuit elements. As previously described, this will place a signal at frequency F_2 through the terminals 94 and 96 to the transmission pair 16. Selection of this signal by the bandpass filter 74 of the central office terminal unit 24 will activate the detector 70 and cause operation of the relay 162 and closure of its associated contacts 148. This will apply full voltage to all elements of the central office terminal 24 at the same time causing a resistant circuit condition to appear across terminals 20 and 22. This resistant circuit condition through leads 132 and 134 will be applied to the line switching equipment terminals 126 and 128, seizing the line relay 125 of the line switching equipment and causing a dial tone to be applied to the terminals 126 and 128. This tone is transmitted back by the carrier frequency circuit B to the subscriber telephone set 34. After reception of the dial tone, the subscriber will commence dialing. Operation of the dial 258 will interrupt the DC voltage being applied to the various circuit elements from the lead 268 through the lead 266. This

will cause the signal at frequency F_2 to be interrupted in a digital manner in accordance with the dial information. This dialed interruption of signal F_2 detected in the detector 70 of the central office terminal will cause an instep operation of the relay contacts 148, which in turn will cause a pulsing of the relay 125 in the associated line switching equipment 10. The answered condition of the called party will cause a reversal of polarity to appear at terminals 126 and 128 in the conventional manner. Due, however, to the bridge circuit characteristics of the rectifier circuit 168, this reversal of polarity will have no effect on the power utilized by the terminal equipment.

Under talking circuit conditions conversation appearing at the terminals 126 and 128 through the leads 132 and 134 appearing at terminals 20 and 22 of the terminal equipment are impressed across the windings 140 and 141 of the hybrid transformer through a capacitor 300 in a lead interconnecting these windings. This conversation is coupled to a winding 302 of the hybrid transformer, is amplified by the VF amplifier 50 and impressed through the VF low pass filter 52 on the modulator 54 where it effectively modulates the carrier signal F_1 developed from the oscillator 56. This modulated signal is then applied to the carrier frequency amplifier 58 through the bandpass filter 60, through leads 26 and 27 and to the terminals 36 on the transmission pair 16. This signal then appears at the terminals 94 and 96 at the subscriber terminal 28 and is connected through leads 216 and 218 to the bandpass filter 220. It is then amplified by the carrier frequency amplifier 222, is detected by the detector 224, and the AGC circuit 226 acts to maintain the demodulated VF signal at a constant level. This signal is integrated in the low pass VF filter 271 and is amplified by the VF amplifier 270 before being applied to the secondary winding 85 of the hybrid transformer 86.

The VF information appearing between the terminals 262 and 264 of the transformer primary 87 effectively modulates the DC current flowing through the telephone set 34 which in turn is heard through the handset 254 of the telephone. In the reverse direction, the handset of the subscriber telephone set 34 is effectively in series with a primary winding 87 of the hybrid transformer 86 and the electronic equipment powered through the lead 266. This information appearing across the terminals 262 and 264 is effectively being coupled from this primary winding 87 to the secondary winding 89 and to the VF amplifier 272 of the transmitter 82. From this point forward the sequence of events is identical to that described in the previous paragraph.

From the foregoing it should be apparent that the present invention provides an effective

solution to the problem of furnishing additional subscriber facilities without increasing physical cable installations. As described, the system fully and efficiently performs all normal telephone functions and maintains sufficient operating power by the battery 88 which is charged by current from the normal central office source.

WHAT WE CLAIM IS:—

1. A telephone system comprising a central office including switching and line finding circuits, a cable transmission pair extending from the central office to a remotely located subscriber station and connected to a first telephone set to form a non-carrier subscriber circuit, a power supply in the central office for supplying power to the transmission pair, and a carrier circuit providing an additional subscriber facility for the same transmission pair, wherein a central office terminal unit having carrier transmitter and receiver sections is connected to the central office and to the transmission pair, a subscriber terminal unit also having carrier transmitter and receiver sections is connected to the transmission pair at the subscriber station, a second telephone set is connected to the subscriber terminal unit, and a rechargeable battery is provided in the subscriber terminal unit for supplying power to operate the subscriber terminal unit sections, the battery being connected to the transmission pair through charging control means for recharging by the power supply of the central office.
2. A telephone system according to claim 1, wherein the central office terminal unit and the subscriber terminal unit are each adapted by means of their transmitter and receiver sections respectively to apply to, and derive from, the transmission pair a double sideband amplitude modulated voice frequency signal.
3. A telephone system according to claim 1 or 2, wherein the transmitter section of the central office terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a modulator connected to an oscillator operating at a first predetermined frequency, a carrier amplifier and a bandpass filter having output leads connected to the transmission pair; and wherein the receiver section of the central office terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a detector, a carrier amplifier and a bandpass filter set at a second predetermined frequency and having a pair of input leads connected to said transmission pair.
4. A telephone system according to claim 3 including automatic gain control means in the receiver section of the central office terminal unit for maintaining a constant VF output with a wide range of signal power input levels.
5. A telephone system according to claim

4 including a hybrid transformer connected to the transmitter and receiver sections of the central office terminal.

6. A telephone system according to any one of claims 3 to 5, wherein the transmitter section of the subscriber terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a modulator and an oscillator connected thereto operable at the second predetermined frequency, a carrier amplifier and a bandpass filter having output leads connected to the transmission pair; and wherein the receiver section of the subscriber terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a detector, a carrier amplifier and a bandpass filter set at the first predetermined frequency with a pair of input leads connected to said transmission pair.

7. A telephone system according to any preceding claim, wherein the charging control means for the battery in the subscriber terminal unit is responsive to activation of the non-carrier subscriber circuit for stopping the flow of current from the transmission pair to the battery.

8. A telephone system according to claim 7, wherein the charging control means includes a transistor and a network connected to the cable transmission pair and the transistor and response to a reduced current flow in the transmission pair to bring the transistor to a non-conducting level.

9. A telephone system according to claim 8 including a capacitor in the network of the charging control means having a predetermined time constant and operable to prevent activation of the transistor during dialing by the first telephone set.

10. A telephone system according to any preceding claim wherein the central office terminal unit comprises a single package component having one pair of terminals connected to line finder terminals of the central office equipment and another set of terminals connected to the preselected cable pair, and the subscriber terminal unit comprises a single package component adapted for installation at the subscriber station and having one set of terminals connected to the preselected cable pair and another set of terminals connected to the second telephone set.

11. A telephone system according to any preceding claim, wherein the central office terminal unit includes a power regulation and control means for regulating the voltage from the central office power supply to a predetermined level and supplying it to the carrier receiver and transmitter sections.

12. A telephone system according to claim 11 including a receive relay and a relay network associated therewith including a current limiting resistor connected to the power regulation and control means, said receive relay being operable to close in response to a sig-

solution to the problem of furnishing additional subscriber facilities without increasing physical cable installations. As described, the system fully and efficiently performs all normal telephone functions and maintains sufficient operating power by the battery 88 which is charged by current from the normal central office source.

WHAT WE CLAIM IS:—

1. A telephone system comprising a central office including switching and line finding circuits, a cable transmission pair extending from the central office to a remotely located subscriber station and connected to a first telephone set to form a non-carrier subscriber circuit, a power supply in the central office for supplying power to the transmission pair, and a carrier circuit providing an additional subscriber facility for the same transmission pair, wherein a central office terminal unit having carrier transmitter and receiver sections is connected to the central office and to the transmission pair, a subscriber terminal unit also having carrier transmitter and receiver sections is connected to the transmission pair at the subscriber station, a second telephone set is connected to the subscriber terminal unit, and a rechargeable battery is provided in the subscriber terminal unit for supplying power to operate the subscriber terminal unit sections, the battery being connected to the transmission pair through charging control means for recharging by the power supply of the central office.

2. A telephone system according to claim 1, wherein the central office terminal unit and the subscriber terminal unit are each adapted by means of their transmitter and receiver sections respectively to apply to, and derive from, the transmission pair a double sideband amplitude modulated voice frequency signal.

3. A telephone system according to claim 1 or 2, wherein the transmitter section of the central office terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a modulator connected to an oscillator operating at a first predetermined frequency, a carrier amplifier and a bandpass filter having output leads connected to the transmission pair; and wherein the receiver section of the central office terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a detector, a carrier amplifier and a bandpass filter set at a second predetermined frequency and having a pair of input leads connected to said transmission pair.

4. A telephone system according to claim 3 including automatic gain control means in the receiver section of the central office terminal unit for maintaining a constant VF output with a wide range of signal power input levels.

5. A telephone system according to claim

4 including a hybrid transformer connected to the transmitter and receiver sections of the central office terminal.

6. A telephone system according to any one of claims 3 to 5, wherein the transmitter section of the subscriber terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a modulator and an oscillator connected thereto operable at the second predetermined frequency, a carrier amplifier and a bandpass filter having output leads connected to the transmission pair; and wherein the receiver section of the subscriber terminal unit comprises a VF amplifier connected in series to a VF low pass filter, a detector, a carrier amplifier and a bandpass filter set at the first predetermined frequency with a pair of input leads connected to said transmission pair.

7. A telephone system according to any preceding claim, wherein the charging control means for the battery in the subscriber terminal unit is responsive to activation of the non-carrier subscriber circuit for stopping the flow of current from the transmission pair to the battery.

8. A telephone system according to claim 7, wherein the charging control means includes a transistor and a network connected to the cable transmission pair and the transistor and response to a reduced current flow in the transmission pair to bring the transistor to a non-conducting level.

9. A telephone system according to claim 8 including a capacitor in the network of the charging control means having a predetermined time constant and operable to prevent activation of the transistor during dialing by the first telephone set.

10. A telephone system according to any preceding claim wherein the central office terminal unit comprises a single package component having one pair of terminals connected to line finder terminals of the central office equipment and another set of terminals connected to the preselected cable pair, and the subscriber terminal unit comprises a single package component adapted for installation at the subscriber station and having one set of terminals connected to the preselected cable pair and another set of terminals connected to the second telephone set.

11. A telephone system according to any preceding claim, wherein the central office terminal unit includes a power regulation and control means for regulating the voltage from the central office power supply to a predetermined level and supplying it to the carrier receiver and transmitter sections.

12. A telephone system according to claim 11 including a receive relay and a relay network associated therewith including a current limiting resistor connected to the power regulation and control means, said receive relay being operable to close in response to a sig-



from said subscriber terminal when its telephone is "off-hook" and to short out the limiting resistor thereby causing the central office terminal to draw increased current, the power regulation and control means being responsive to the increase in current to supply controlled DC operating current to carrier transmitter components.

13. A telephone system according to claim 12 including a capacitor, in the relay network, responsive to a ringing voltage applied to the central office terminal unit when the subscriber terminal is in the on-hook condition, the ringing voltage being applied through the capacitor to shunt the limiting resistor and causing the power regulation means to produce a controlled DC output for turning on the transmitter of the central office terminal.

14. A telephone system according to any one of claims 11 to 13, wherein the power regulation means comprises a bridge rectifier, first and second zener diodes in a control network connected to an output from the rectifier and a capacitor connected in parallel to the first zener diode, said second zener diode being prevented from reaching its zener voltage during the idle circuit condition but reaching its clamping voltage in response to a ringing signal to the central office terminal, thereby activating carrier transmitter components.

15. A telephone system according to claim 12 or 13, wherein the power regulation and control means comprises a bridge rectifier, first and second zener diodes in a parallel arrangement, the first zener diode being in series with a pair of resistors, and a transistor switch being base connected between the resistors with its collector providing a power output lead, and its emitter connected to a rectifier output terminal, the first zener diode being operative to draw current through the pair of series-connected resistors to establish a turn-on bias for said transistor when the carrier circuit is activated upon closing of the receive relay contacts.

16. A telephone system according to any preceding claim, wherein said subscriber terminal unit includes a ringing control circuit for applying power to the bell of the second telephone set when a ringing signal is received by the subscriber terminal unit from the central office terminal unit and the second telephone set is in the on-hook condition.

17. A telephone system according to claim 16, comprising means for deactivating the ringing control circuit and applying power to the subscriber terminal unit transmitter when said second telephone set is placed in the off-hook condition.

18. A subscriber terminal unit for use in a telephone system to provide service via a carrier derived circuit to an additional telephone set at a subscriber station, which station

includes a first telephone set connected by a cable transmission pair to a central office to constitute a non-carrier subscriber circuit, the transmission pair being supplied with power from a power supply in the central office, such subscriber terminal unit comprising carrier transmitter and receiver sections having a first pair of terminals for connection to the transmission pair and a second pair of terminals for connection to the additional telephone set, a rechargeable battery for supplying power to operate the transmitter and receiver sections, and charging control means connected to the battery and adapted to be connected to the transmission pair, whereby the battery is rechargeable from the transmission pair under the control of the charging control means.

19. A subscriber terminal unit according to claim 18, wherein the charging control means is adapted to respond to activation of the non-carrier subscriber circuit to stop charging of the battery from the transmission line.

20. A subscriber terminal unit according to claim 19, wherein the carrier transmitter section comprises a voice frequency amplifier connected in series to a voice frequency low pass filter, a modulator and an oscillator connected thereto operable at a predetermined frequency, a carrier amplifier and a bandpass filter having output leads for connection to the transmission pair; and wherein the carrier receiver section comprises a voice frequency amplifier connected in series to a voice frequency low pass filter, a detector, a carrier amplifier and a bandpass filter set at another predetermined frequency with a pair of input leads for connection to the transmission pair.

21. A subscriber terminal unit according to claim 19 or 20, wherein the charging control means comprises a charging circuit, and a diode bridge means through which the charging circuit is connectable to the transmission pair and which will conduct current only when the voltage apparent across the transmission pair exceeds the voltage of the battery.

22. A subscriber terminal unit according to claim 19 or 20, wherein the charging control means includes a transistor and a network adapted to be connected to the cable transmission pair and the transistor and adapted to respond to a reduced current flow in the transmission pair to bring the transistor to a non-conducting level.

23. A subscriber terminal unit according to claim 22, including a capacitor in the network of the charging control means having a predetermined time constant and operable to prevent activation of the transistor during a dialing by the first telephone set.

24. A subscriber terminal unit according to any preceding claim, including a ringing control circuit for applying power to the bell of the additional telephone when a ringing



signal is received by the subscriber terminal unit from a central office terminal unit and the additional telephone set is in the "on-hook" condition, and means for deactivating the ringing control circuit and applying power to the subscriber terminal unit transmitter when the additional telephone set is placed in the "off-hook" condition.

25. A central office terminal unit for use in a telephone system to provide service via a carrier derived circuit to an additional telephone set at a subscriber station, which station includes a first telephone set connected by a cable transmission pair to a central office to constitute a non-carrier subscriber circuit, the transmission pair being supplied with power from a power supply in the central office, such central office terminal unit comprising carrier transmitter and receiver sections having input leads for connection to the central office and output leads for connection to the transmission pair, the transmitter section comprising a voice frequency amplifier connected in series to a low pass filter, a modulator connected to an oscillator operating at a first predetermined frequency, a carrier amplifier and a bandpass filter having a pair of output leads for connection to the transmission pair, the receiver section comprising a voice frequency amplifier connected in series to a voice frequency low pass filter, a detector, a carrier amplifier, a bandpass filter set at a second predetermined frequency and having a pair of input leads for connection to the transmission pair, and automatic gain control means for maintaining a constant voice frequency output, and power regulation and control means for regulating the voltage from the central office power supply to a predetermined level and supplying it to the receiver and transmitter sections.

26. A central office terminal unit according to claim 25, wherein the power regulation and control means includes means for supplying power to the receiver section when the additional telephone set is in the "on-hook" condition, means for turning on the transmitter section in response to a carrier frequency signal from the subscriber station, and means for turning on the transmitter section when ringing voltage is applied to the carrier derived circuit and the additional telephone at the subscriber station is in the "on-hook" condition.

27. A central office terminal unit according to claim 25, wherein the power regulation and control means includes a relay network with a receive relay and a current limiting resistor, the receive relay being operable to close in response to a signal from said subscriber station when the additional telephone is "off-hook" and to shunt out the limiting resistor thereby causing the central office terminal

unit to draw increased current, and means responsive to the increase in current for supplying controlled D.C. operating current to the transmitter section.

28. A central office terminal unit according to claim 27, including a capacitor in the relay network responsive to a ringing voltage applied to the terminal unit when the additional telephone set is in the "on-hook" condition, the ringing voltage being applied through the capacitor to shunt the limiting resistor and causing the power regulation means to produce a controlled D.C. output for turning on the transmitter section.

29. A central office terminal unit according to claim 26 or 27, wherein the power regulation means comprises a bridge rectifier, first and second zener diodes in a control network connected to an output from the rectifier and a capacitor connected in parallel to the first zener diode said second zener diode being prevented from reaching its zener voltage during an idle circuit condition but reaching its clamping voltage in response to a ringing signal to the central office terminal, thereby activating carrier transmitter components.

30. A central office terminal unit according to claim 26 or 27, wherein the power regulation and control means comprises a bridge rectifier, first and second zener diodes in a parallel arrangement, the first zener diode being in series with a pair of resistors, and a transistor switch being base connected between the resistors with its collector providing a power output lead, and its emitter connected to a rectifier output terminal, the first zener diode being operative to draw current through the pair of series-connected resistors to establish a turn-on bias for said transistor when the carrier circuit is activated upon closing of the receive relay contacts.

31. A telephone system substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

32. A subscriber terminal unit substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

33. A central office terminal unit substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawings.

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