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ARRANGEMENT FOR LIMITING NOISE INTERFERENCE IN CARRIER TELEPHONE SYSTEMS

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1

The invention relates to telephone systems and particularly to built-up toll telephone systems comprising voice frequency and high frequency carrier telephone links or a plurality of voice frequency telephone links in tandem, in which alternating currents of voice and lower frequencies are utilized for ringing and other signaling or switching purposes.

An object of the invention is to reduce noise interference in a carrier or a voice frequency link of such a built-up telephone system due to the transmitted signaling currents.

Objectionable voice interference may be produced in such a system where a local voice frequency switching office has control of a toll connection, as is the case where decentralized switching is employed, when the local operator sends a 20-cycle ringing signal out over a trunk line to operate an alternating current control relay in the toll terminal office, which controls the operation of a ringer to send a disconnect or rering signal to distant toll operators over an associated carrier or other link. One source of interference is the audible ring-back tone superimposed on the 20-cycle ringing signal, which is used in local connections to inform the calling subscriber that the called subscriber is being rung but has no useful function in toll connections. This tone, which is composed mostly of frequencies between 200 and 500 cycles, is sent back to the calling subscriber through his loop circuit, but as a modulation of the 20-cycle ringing signal is also impressed directly on the trunk line leading to the toll office where it is impressed on an associated carrier or voice frequency telephone link. Other signaling tones, such as "all paths busy" and "zip" tones are impressed on the toll lines with the level at which they are used, but the audible ring-back tone usually has a level which is 50 to 60 decibels greater than the usable level so that it is one of the worst sources of interference impressed on the carrier link.

A second factor involved in the ringing interference is the modulation of the 20-cycle signaling wave caused by saturation of the signaling control relay at the toll office end of the trunk, to produce harmonics of 20 cycles (mainly 100, 140 and 180 cycles) which in some cases have amplitudes nearly as large as the worst audible ringing components. A third factor is the transient pulses which occur when the 20-cycle ringing voltage is applied and removed from the circuit. Although these transients are of short duration, their peak voltages may be very high if the amplitude of the ringing voltage wave is a

2

maximum at the time the circuit is made or broken.

Limitation of such interference is desirable from the standpoint of proper operation of such a system employing a carrier link. The power of the ringing signals is much greater than the total voice load and sufficient to overload the associated carrier channel and cause spurious noise interference through cross modulation in other channels of the same system. It also greatly increases the cost of gain regulation to make the carrier system sufficiently stable to transmit voice frequency telegraph signals.

In accordance with one embodiment of the invention, the effects of such interference on the operation of a carrier link in such a built-up system are minimized by the use at the terminal toll office of a circuit arrangement operating to effectively disable the outgoing carrier transmission path of an associated carrier channel only during periods in which the ringing signals are being received over the trunk line from a preceding local voice frequency switching office. One arrangement of this embodiment employs two varistor circuits and a control relay having a predetermined operating time. One varistor circuit which is connected across the input of the outgoing transmission path of the carrier link, operating as a vario-losser, normally provides a high impedance shunt thereon so that its effect on the transmission of voice frequencies during talking periods is very small. The second varistor circuit connected to the incoming toll line and tuned to 20 cycles, operates as a rectifier to selectively rectify the 20-cycle components of the incoming signals during signaling periods. The rectified signals are applied through the winding of the control relay as a bias to the varistors in the first varistor circuit in such direction as to reduce their impedance values to low values thereby lowering the shunting impedance of the latter circuit on the carrier path so as to insert quickly an appreciable loss in that path to the applied signaling currents. The relay operates with a predetermined amount of delay after initial operation of the vario-losser, in response to the applied rectified signals to completely short the input of the carrier transmission path so as to prevent thereafter any appreciable amount of the impressed signaling current of 20 cycles and voice frequencies, and all higher frequency transients due to signaling, from being transmitted out over that path.

In accordance with another embodiment of the invention, the complete interference limiting ar-

rangement including the vario-losser and the rectifier control arrangement therefor is inserted in the two-wire path on the trunk line side of a hybrid coil coupling that two-wire path to the incoming and outgoing paths of the carrier channel, and operates in a manner similar to that of above-described arrangement to effectively suppress the signaling currents and harmonics thereof from the carrier channel during signaling intervals.

The various objects and features of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawing, Fig. 1 of which shows schematically a built-up telephone system embodying the invention and Fig. 2 shows schematically a modified arrangement in accordance with the invention applied to the built-up telephone system at a different point.

Only sufficient parts of the built-up telephone system necessary to a proper description of the invention are illustrated in the drawing. As shown, this system includes a telephone subscriber station 1, which, when it is involved in a toll call, is adapted through the associated subscriber's loop circuit to be connected by the cord circuit 2 of the local voice frequency switching office A to a trunk line 3 extending to a distant toll terminal station B. The toll terminal station B is connected or adapted to be connected in well-known manner by a four-wire terminating set comprising a hybrid coil H and associated line balancing network N to the outgoing transmission circuit TC including the channel modulating unit M and associated carrier oscillator O₁, and incoming transmission circuit RC including the channel demodulating unit DM and associated carrier oscillator O₂, of one two-way carrier channel CC of a carrier link. The carrier link may include other two-way carrier channels CC₁ . . . each of which may be connected to other toll terminal equipments similar to that above described in similar manner. The carrier channels may be connected through two-wire or four-wire paths, or a radio path, to the far end (not shown) of the carrier link, which may be connected through similar toll terminal offices, trunk lines and local voice frequency switching offices to other subscribers' telephone stations to provide toll connections.

The local switching office A may include, as indicated, suitable signaling equipment including a source 4 of 20-cycle signaling current, a source 5 of relatively high amplitude audible ring-back tone composed mostly of voice frequencies in the range from 200 to 500 cycles, and a signaling lamp 6, which may be connected in series by the local operator by means of the ring key arrangement 7 across the cord circuit 2 to send out a 20-cycle ringing current, with superimposed ring-back tone, when she wishes to signal an associated local telephone subscriber, or a toll subscriber over the associated trunk line 3. The ring-back tone, which is made use of only in local connections for notifying a calling subscriber that the called subscriber is being rung, is connected back to the calling subscriber's loop circuit by the small condensers 8. Although this ring-back tone has no useful function in a toll connection, when the local operator rings after a toll connection has been set up, the high level ring-back tone will be superimposed on the 20-cycle ringing signal impressed directly on the trunk 3 and transmitted thereover to the toll terminal office B where it will be impressed by

the hybrid coil H on the outgoing transmission path of the associated carrier channel CC.

The equipment for accomplishing the purposes of the invention located at toll terminal office B includes the varistor bridge circuit 9, the varistor bridge circuit 10, and a relay 11 having a predetermined operating time, which may be the signaling relay of the office suitably modified and with additional contacts thereon for a purpose to be described later. The varistor bridge circuit 9 is utilized as a full-wave rectifier. The particular varistor bridge circuit used for this purpose which was constructed and operated satisfactorily had equivalent dry plate rectifiers or varistors of the copper-oxide type, poled as indicated, in its four arms, but any other type of full-wave rectifier may be used. One pair of opposite terminals of this bridge circuit, operating as the input terminals, are connected through series condensers 12 and 13 across the condenser 14 located between the windings of the hybrid coil H in series with the trunk line 3, the values of these condensers being selected with respect to the inductance of the relay 11 so that the input circuit of the rectifier 9 is tuned to 20 cycles. The second varistor bridge circuit 10 operates as a vario-losser. The particular bridge arrangement used for this purpose in the constructed circuit had equivalent dry plate rectifiers or varistors of the thallium copper type, poled as indicated, in its four arms, but any other vario-losser arrangement adapted for producing the same results may be used. One pair of opposite bridge terminals of the bridge circuit 10 is connected through the operating winding of the relay 11 across the output terminals of the varistor bridge circuit 9 and its other pair of opposite terminals is connected across the input of the outgoing transmission circuit TC of the carrier channel CC.

The impedances of the varistor elements in the four arms of the varistor bridge circuit 10 are selected so that normally, that is, when no biasing currents are supplied thereto from the output of the rectifier bridge circuit 9, the shunting impedance connected by the former varistor bridge circuit across the input of the outgoing carrier transmission circuit TC is high and thus the bridge normally provides a low loss in that circuit to voice currents. Since the path through the forward direction of these varistor arms includes the relay 11, the inductance of this relay must be high enough to provide a low bridging loss.

The manner in which the equipment at the toll terminal station just described functions to minimize noise interference in the carrier channel due to the low frequency signaling current transmitted over the trunk line 3 from the local voice frequency switching circuit A will now be described.

Assume that, after the toll connection has been set up in normal manner, the local operator at station A desires to send a disconnect or rerouting signal to distant toll operators. The local operator will operate his ring key arrangement 7 which connects the 20-cycle ringing source 4 and audible tone source 5 in series with the ringing signal lamp 6 across his cord circuit 2. The 20-cycle ringing signal from source 4 with the superimposed audible tone supplied by source 5 will then be transmitted to the cord circuit 2. The series condensers 8 in the cord circuit 2 are designed to provide a high loss (50 to 60 decibels) to the 20-cycle ringing frequency thus substan-

5

tially preventing the low level 20-cycle ringing circuit from being transmitted back into the loop circuit associated with subscriber station 1, but the relative high amplitude audible ring-back tone comprising mainly the frequencies of 200 to 500 cycles will be transmitted back to the calling subscriber through these condensers readily. The ringing signal with the superimposed audible ring-back tone will pass from local cord circuit 2 over trunk line 3 to the terminal toll office B and a portion thereof will be impressed by the hybrid coil H on the transmitting circuit TC of the carrier channel CC. A portion of the 20-cycle component of the incoming ringing signals will be picked off from the hybrid coil H by the tuned input circuit of the full-wave rectifier 9 and will be rectified by the latter. The rectified signaling currents in the output of the rectifier bridge 9 will pass through the winding of the slow-operate control relay 10 to the varistor bridge 10. The rectified currents will pass through the varistors in bridge 10 in such direction as to lower their impedances to a low value thereby providing a low impedance shunt across the input of the carrier transmitting circuit TC and thus a high loss (about 15 decibels for the particular vario-losser used) to the signaling current impressed on that circuit by hybrid coil H. A short time later (approximately .03 second with the particular relay used) the rectified signal current flowing through the winding of the slow-operate relay 11 will complete operation of that relay to provide a complete short circuit through its operated lower switching contacts across the input of the transmitting circuit TC. This will effectively prevent the signaling currents and all higher frequency transients due to signaling from being thereafter transmitted out over the carrier link.

If the relay 11 is also employed as the office ringing relay, as indicated here, its operation to open its normally closed upper contacts may be utilized to cause operation of an associated ringer (not shown) to send out a disconnect or rering signal to distant toll operators over the carrier link. As stated previously the relay 11 has another function which is to introduce sufficient impedance to the alternating current frequency components of the rectified signal currents in the output of varistor bridge 9 so that the impedance of the vario-losser varistor bridge 10 will be kept at a high enough value so as not to provide a shunt on the carrier transmission path during non-signaling periods.

A portion of the built-up telephone system of Fig. 1 including a modified arrangement in accordance with the invention is shown in Fig. 2. The figure shows the two-wire path 20 connecting the trunk line 3 from the local voice frequency switching office A to the hybrid coil H coupling to the carrier channel CC. The entire interference limiting arrangement including the vario-losser bridge 10 and the rectifier bridge 9 is located in this two-wire path. The rectifier bridge 9 is connected in series with the ringing control relay 16 and the condenser 17 in shunt of the path 20, and the vario-losser bridge 10 is connected directly in shunt to that path at a point therein nearer to the hybrid coil H. The retardation coil 15 is connected in series with the circuit connecting the output of the rectifier bridge 9 across the vario-losser bridge 10 to provide a high impedance to 20 cycles therebetween during signaling intervals. The necessary loss to 20 cycles between the rectifier and vario-losser

6

shunts to prevent the 20-cycle signaling current from being affected by the vario-losser action is obtained by tuning the elements (relay 16, condenser 17, the input circuit of rectifier 9, etc.) in series with the rectifier shunt to 20 cycles, and those elements in series with the vario-losser shunt to some higher frequency. The condensers 18 and 19 in series with the path 20 between the two shunts are used to help tune the vario-losser shunt.

Various other modifications of the circuit illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art. For example, the built-up telephone system may comprise a plurality of voice frequency links only and an arrangement such as illustrated in Fig. 1 or Fig. 2 may be employed for preventing noise interference in one of the four-wire or two-wire voice frequency links therein.

What is claimed is:

1. In combination, a telephone channel, a line for feeding voice frequency telephone signals to said channel, means for occasionally impressing auxiliary signals including voice and lower frequencies on said line for ringing or switching purposes, and means for limiting noise interference in said telephone channel due to said auxiliary signals comprising means responsive to the lower frequencies in the auxiliary signals received by said channel over said line during signaling intervals to insert a loss in the input of said channel sufficient to substantially prevent transmission thereby of said auxiliary signals and all higher frequency transients due to said auxiliary signals.

2. In combination in a telephone system, a carrier channel, a line for feeding voice frequency telephone signals to said channel for modulation therein on a carrier wave, means for occasionally impressing auxiliary signals comprising frequencies within the voice range and lower frequencies, on said line, switching means responsive to the lower frequencies in the auxiliary signals, connected to said line near the input of said carrier channel and means to limit noise interference in said carrier channel due to the transmitted auxiliary signals comprising means responsive on a frequency basis to said lower frequencies in the auxiliary signals transmitted over said line to insert a large loss in the input of said channel while the auxiliary signals are being received thereby.

3. The combination of claim 2, in which said interference limiting means includes a vario-losser bridged across the input of said channel and normally providing a relatively low loss therein to voice frequency telephone signals, and means selectively responsive to the auxiliary signals of said lower frequencies received over said line for adjusting said vario-losser so that it inserts a high loss in the input of said carrier channel during the auxiliary signal receiving intervals.

4. The combination of claim 2, in which said interference limiting means includes a vario-losser bridged across the input of said carrier channel, normally providing a low loss therein to voice frequency telephone signals, means for selecting and rectifying the lower frequency components of the auxiliary signals received over said line, and for utilizing a portion of the rectified signal components to bias said vario-losser so as to increase the loss inserted thereby in the input of said carrier channel.

5. The combination of claim 2, in which said interference limiting means comprises a vario-

7

losser bridged across the input of said carrier channel and normally adjusted to provide a high impedance shunt on said channel such as not to appreciably interfere with the transmission of voice frequency telephone signals therein, means to select and rectify a portion of the auxiliary signals of said lower frequencies received over said line, means responsive to the rectified signals for biasing said vario-losser so that it provides a low impedance shunt on said carrier channel, and delayed operating auxiliary means also responsive to said rectified signals to connect a direct short across said carrier channel so as to effectively prevent transmission thereby of said auxiliary signals and all higher frequency transients introduced thereby entering said channel.

6. The combination of claim 2, in which said interference limiting means comprises a vario-losser bridged across the input of said channel and normally providing a relatively low loss therein to voice frequency telephone signals, means to select and rectify signal components of said lower frequencies from the auxiliary signals received over said line, means for applying one portion of the rectified signal components as a bias to said vario-losser to vary its impedance so as to immediately appreciably increase the amount of loss inserted thereby in said channel and delayed operating relay means connected between the output of the rectifying means and said vario-losser responsive to the applied rectified signal components to close a direct short circuit across the input of said channel.

7. The combination of claim 2, in which said interference limiting means comprises one varistor bridge circuit connected across the input of said carrier channel and normally providing a high impedance shunt thereon such as not to appreciably affect the transmission of voice frequency signals, a second varistor bridge circuit having an input circuit tuned to said lower frequencies connected to said line near said carrier channel, operating as a rectifier to select and rectify the lower frequencies in the auxiliary signals applied to its input circuit, a relay having a predetermined time delay in operation and means to apply the rectified signal output of said second varistor bridge through said relay to said one varistor bridge circuit in such manner as to change the shunting impedance thereof on said carrier channel to a low value thereby inserting a high loss in said channel, said relay being operatively responsive with a predetermined amount of delay to the applied rectified signals to connect a direct short on the input of said channel so as to substantially prevent transmission of the auxiliary signals and high frequency transients applied thereto.

8

8. In combination, a telephone channel, a two-wire line for feeding voice frequency telephone signals to said channel, means for occasionally impressing auxiliary signals including voice and lower frequencies on said line for ringing or other switching purposes, a tuned relay selectively responsive to one of said lower frequencies in said auxiliary signals connected across said line in front of said telephone channel and means to limit noise interference in said telephone channel due to the transmitted auxiliary signals comprising a vario-losser bridged across said two-wire line beyond the point of connection of said relay thereto, and normally providing a relatively low loss therein to voice frequency telephone signals, tuned rectifying means connected in series with said relay across said line, for selectively rectifying a portion of said auxiliary signals of said lower frequencies and means responsive to the rectified signals for biasing said vario-losser, so that it provides a low impedance shunt across said line such as to provide a high loss therein in front of said telephone channel during auxiliary signaling intervals.

9. The combination of claim 8, in which a retardation coil is connected between the output of said rectifying means and said vario-losser, said retardation coil providing a high impedance to said one lower frequency during non-signaling intervals.

10. The combination of claim 8, in which the necessary loss to said lower frequencies between the line-shunting circuits including said rectifying means and said vario-losser, respectively, to prevent the low frequency signals supplied to said relay from being affected by the action of said vario-losser is obtained by tuning the elements in series with the shunting circuit including said rectifying means to said one lower frequency, and the elements in series with the shunting circuit including said vario-losser to some higher frequency.

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