

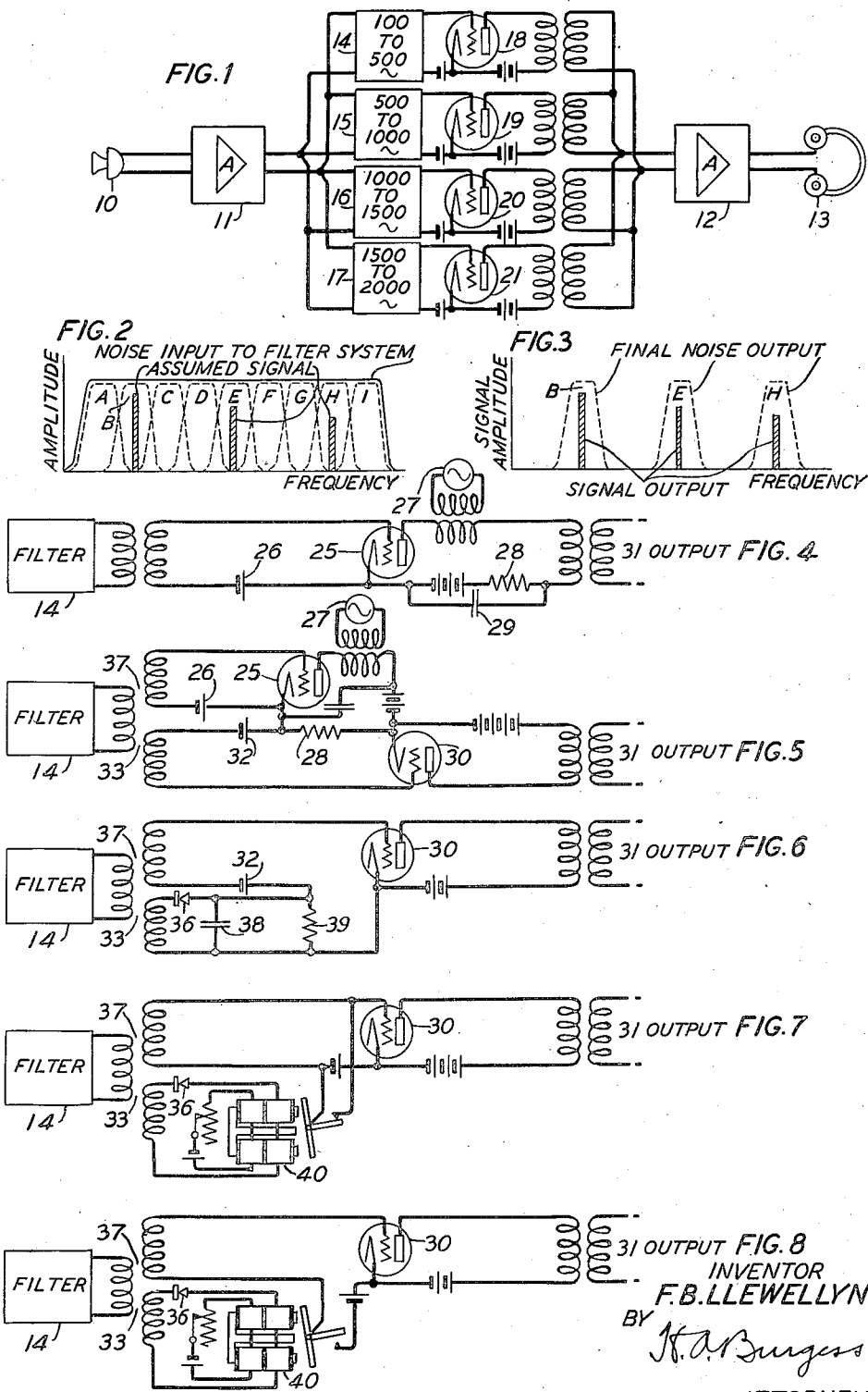
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F. B. LLEWELLYN

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NOISE SUPPRESSION CIRCUIT

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NOISE SUPPRESSION CIRCUIT

Frederick B. Llewellyn, Montclair, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

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This invention relates to the transmission of waves for signaling or similar purposes and relates more especially to the reduction of interference or noise effects in wave transmission systems.

A general object of the invention is to secure an overall discrimination against the interference energy and in favor of the signal.

In the case of speech and some other forms of signal waves, such as music, which are ordinarily spoken of as comprising a band of frequencies, it is an observed fact that the signal does not at all times contain components of all frequencies within the band. At some instants the signal may have principal components at only a few frequencies with perhaps less important frequencies also scattered in the band. At another instant the signal may comprise other frequency components but components which likewise do not fill up the whole band. Interference or noise, on the other hand, is often either of a random character as regards frequency distribution or, as in the case of resistance noise, may be substantially uniformly distributed over the frequency band.

A receiver connected to respond to the energy coming in over the entire frequency band will in such a case often receive a sum total of noise energy greater than the signal energy whereas the actual signal components at the instant of time under consideration may have energies greater than that of noise of the same frequencies.

In accordance with the present invention, the receiver does not have impressed upon it at all times the energy coming in over the entire signal band, but is controlled by the signal that is being received at any instant so that the signal and only something less than the total noise energy distributed over the entire band are impressed on the receiver. In particular, selective circuits are provided to prevent noise from being impressed on the receiver in portions of the frequency band not at the moment occupied by important signal components. In this way the signal to noise ratio is increased.

A more complete description of the invention and its various features and objects will be given in connection with the accompanying drawing in which:

Fig. 1 is a schematic circuit diagram of a general manner of carrying out the invention;

Figs. 2 and 3 show graphs representing the principle of operation of the invention; and

Figs. 4 to 8, inclusive, show modified types of

relay circuits that may be used in place of those shown in Fig. 1.

As stated above, observation shows that in ordinary speech only a few frequencies are actually present at any one time. For instance, a vowel sound may contain frequencies of 300, 900 and 1200 cycles. In order properly to reproduce this vowel sound it would be necessary to transmit only those three frequencies. On the other hand the random noise energy present in the receiving system is proportional to the total frequency band which is passed by the system. Consequently, an improvement in the signal-to-noise ratio may be obtained if the output of the receiving system is arranged to pass only those frequencies which are actually employed in transmitting speech components at the time in which they occur.

A circuit operating in this manner is shown in Fig. 1. An input source of waves is indicated at 10 in the form of a microphone on which speech or music waves may be impressed. Any other suitable source of input waves of a band of frequencies may be used in place of the microphone 10. This microphone or other source is connected to any suitable transmission network 11 which may contain, for example, amplification as indicated. A signaling channel such as a telephone line or any other suitable connection extends from the transmitting network 11 to the network 12 which may be at a distance from the transmitter 11 and is representative of any suitable type of receiving system terminating in a receiving instrument such as the headset 13.

It is assumed for convenience that the waves to be transmitted are comprised in the frequency band extending from 100 to 2000 cycles. The output waves from the transmitting network 11 are divided by means of four band filters 14 to 17 into subbands each about 500 cycles wide, the first band extending from 100 to 500 cycles, the second from 500 to 1000 cycles, etc. For simplicity in showing, only four filters are represented although it will become evident as the description proceeds that the more filters which are used and the narrower the band of each filter the greater will be the improvement in the signal-to-noise ratio. On the output of each filter is a relay 18, 19, 20 or 21, respectively, which in the absence of signal frequency in the band of the respective filter effectively cuts off the output network 12 from the corresponding filter. In Fig. 1 these relays are indicated as vacuum tubes which are biased slightly below the cut-off point, but these are intended to represent any suitable

type of relay and in later figures various other types of relays suitable for use at this point in the system will be disclosed.

The bias of the relays 18 to 21 is adjusted to such value that residual noise impressed on the filters 14 to 17 is insufficient to overcome the bias and is therefore not transmitted through any of the relay circuits. The essential speech components passing through any given filter, however, have sufficient amplitude to overcome the bias on the respective relay circuits so that they are transmitted through the relays and into the output network 12. The final energy in the output network contains only the output of those filters which carry sufficient signal energy to operate corresponding relays. The noise output is only that in the wave bands whose energies actually operate the corresponding relays, whereas the signal is the same as that in the input.

The operation of the system may be made more evident by reference to Figs. 2 and 3. In these figures nine filters are indicated by showing in broken lines their transmission frequency bands. The noise from the input is proportional to the areas of the transmission bands of these filters, that is, to $A+B+C+D+E+F+G+H+I$. No attempt is made in this diagram to show the actual level of the noise present in the system. It is assumed that the noise is of random character as regards both frequency distribution and energy content. The speech is assumed for purposes of illustration to consist at any one instant of three frequency components, one in each of the transmission bands B, E and H. It will be understood that each of the nine filters A to I, inclusive, has associated with its output a suitable relay, as has been indicated in Fig. 1. The signal component in the instant under consideration operates only the three relays attached to the filters B, E and H so that the output noise energy is proportional only to the areas B, E and H instead of the areas A to I, inclusive, as would be the case in the absence of the filters and relays. The signal energy, however, is the same in the two cases except, of course, for unavoidable transmission losses. For this example the improvement in the signal-to-noise ratio would be 4.77 decibels.

If thirty filters instead of nine had been used to cover the same overall transmission band, the gain would be 10 decibels for the three-frequency signals assumed. If the signal consisted of only a single frequency the improvement in this latter case would be 14.77 decibels. In general, the gain in decibels is equal to

$$10 \log \frac{\text{number of filters}}{\text{number of speech frequencies present.}}$$

It will be obvious from the foregoing description that the relays to be suitable for use in the system should preferably be capable of operating very quickly and susceptible of adjustment to a desired bias or operating margin in order to discriminate sharply between noise and signals. Suitable relay circuits alternative to those shown in Fig. 1 are illustrated in the figures now to be described. In Fig. 4 each of the subdividing filters, such as filter 14 in Fig. 1, has its output connected to the grid circuit of the gas-filled tube 25 the grid of which is normally biased so far negative as by battery 26 that the tube transmits no current when only noise from filter 14 is impressed on its input. The bias is so adjusted that a signal component transmitted through filter 14 drives the grid sufficiently far positive

to cause tube 25 to break down and transmit energy into the output circuit 31. The tube 25 is of the type in which the space current is caused principally by gas ionization within the tube, the grid serving to initiate the discharge, but thereafter having no further control on the discharge current so long as the externally applied plate voltage remains unchanged. In order to enable the grid to have effective control over the space current at all times an ultra-audio frequency generator 27 is coupled to the plate circuit for periodically making the plate positive and negative. When the source 27 drives the plate negative, the discharge through the tube is interrupted and will not resume unless the grid is still being influenced in a positive direction by the signal component in the filter 14.

Fig. 5 is similar to Fig. 4 but employs an amplifier tube 30 in addition to a gas-filled tube circuit 25. When tube 25 is broken down, as by a signal transmitted through coupling 37, space current flows through resistance 28 and a drop of potential is developed across resistance 28 sufficient to overcome the normal negative bias on tube 30 from battery 32 so as to change tube 30 from its normally blocked to its transmitting condition. The speech component present in filter 14 is then allowed to pass through tube 30 to the output 31, this component being impressed on the input of tube 30 through input transformer 33. When the speech impulse in filter 14 ceases, tube 25 is restored to its non-transmitting condition so that no potential now appears across resistance 28 and negative bias battery 32 is enabled to block the tube 30.

Fig. 6 is somewhat similar to Fig. 5 but employs a solid type rectifier 36 for controlling the unblocking of amplifier tube 30 instead of using the gas-filled tube for this purpose as in Fig. 5. The signal component from filter 14 is impressed through both couplings 33 and 37 on the rectifier circuit 36 and on the grid of tube 30 simultaneously. The resulting rectified current from 36 develops the potential difference across resistance 39 which overcomes the normal bias due to the battery 32 and changes tube 30 from its normally blocked condition to its transmitting condition so that the signal component is enabled to pass through into the output 31. A smoothing condenser 38 is shunted across resistance 39.

In Fig. 7 a polarized relay 40 is controlled by the current from rectifier 36 to change amplifier tube 30 from its normally blocked to its transmitting condition. In the normal condition the armature of relay 40 maintains a shunt across the grid circuit of tube 30 making that tube inoperative. When a speech component is transmitted through filter 14 it is impressed through both couplings 33 and 37 as in the case of the previous figures. The portion of the wave impressed through coupling 33 is rectified at 36 and causes relay 40 to shift its armature opening the shunt across the amplifier input so that the impulse transmitted through coupling 37 is allowed to pass through the tube 30 into the output. Relay 40 is shown with an adjustable biasing circuit for facilitating adjustment of the circuit to the desired marginal characteristics.

Fig. 8 differs from Fig. 7 only in having the armature of relay 40 included in a series circuit with the grid of tube 30 rather than in a shunt across the grid circuit. A peak impulse coming in through filter 14 as in the case of Fig. 7

causes relay 40 to shift its armature to close the lower contacts thus establishing the grid circuit of tube 30 which is normally open-circuited. The impulse impressed on the grid circuit through coupling 37 is thus allowed to be transmitted through tube 30 to the output 31.

In each of the relay circuits shown in Figs. 1 and 4 to 8, inclusive, the marginal effect can be readily adjusted by controlling the grid bias or other constants of the circuit including in the case of Figs. 7 and 8 a bias of the relay 40 or other of its constants.

It will be understood that the invention is not dependent upon the use of any particular type of relay circuit, but that any suitable type may be used, several different types having been shown by way of illustration in the various figures. The invention is not to be construed as limited to the specific form shown, nor by the frequencies or other quantities referred to, but only by the scope of the claims.

What is claimed is:

1. The method of discriminating against noise in systems transmitting waves occupying a band of frequencies, comprising subdividing the band into a plurality of subbands of frequencies in separate paths, normally blocking transmission through each individual path to suppress transmission of noise, selectively unblocking individual subband paths in response to signal energy in the respective path whereby the signal energy is allowed to be transmitted and recombining the signal energies transmitted through the unblocked paths.

2. In a signaling system for transmitting signals occupying a band of frequencies, such as speech, a source of signal waves, a plurality of filters connected to said source for subdividing the frequency band into narrow ranges, an outgoing path from each filter, a relay in each path normally biased against transmission, means responsive to energy in excess of a predetermined level transmitted through any given filter for unbiasing the corresponding relay and allowing such energy to be transmitted through the respective path, and receiving means coupled to all of said paths in common.

3. In a speech transmission system, a plurality of frequency selective elements for subdividing the speech frequency range into narrow frequency bands in separate circuits, means in each circuit normally blocking transmission whereby residual noise is suppressed, and means in each circuit operating in response to a speech component transmitted through any given selective element for unblocking the respective circuit and permitting the speech component to be transmitted, and a transmission path common to all of said circuits.

4. In a system capable of transmitting a broad band of frequencies, the method of discriminating against transmission of noise currents comprising

suppressing transmission of energy at all parts of the frequency band except in those portions which at a given instant of time are occupied by signal components which, together with noise of the same frequencies, have greater energy than the noise components of the same frequencies, and selectively and under control of such signal components permitting such components to be transmitted.

5. In combination, a source of speech waves to be transmitted, an outgoing circuit from said source, said circuit or source or both being subject to interfering noise currents, a plurality of wave filters connected to said circuit for subdividing the speech band into subbands, a relay circuit associated with the output of each such filter and biased to prevent transmission through the relay circuit, whereby noise of low energy is effectively suppressed, and means associated with each relay circuit for reducing its bias under control of a speech component transmitted through the associated filter whenever such speech component or such component together with the noise transmitted through the respective filter has substantially greater energy than the noise alone, whereby the speech component is transmitted by such relay circuit, and a speech receiver operatively associated with all of said relay circuits.

6. The combination defined in claim 5 in which each of said relay circuits comprises a gas-filled trigger tube having its grid biased negatively whereby said tube normally transmits no current, and means associated with its output for restoring the tube under grid control.

7. The combination defined in claim 5 in which each of said relay circuits comprises a vacuum tube having its grid circuit connected to the filter and its grid biased negatively by an amount slightly in excess of the value required to block transmission.

8. The combination defined in claim 5 in which each of said relay circuits comprises an electromagnetic relay having an armature normally positioned to disable the circuit outgoing from the respective filter, and means controlled by energy transmitted through the filter in excess of a predetermined magnitude for operating said relay.

9. The method of discriminating against noise energy distributed over a signaling frequency band comprising separately selecting into different circuits noise energy components from different portions of the band and any signal components that may at a given instant be present in one or more different portions of the band, blocking transmission through those of said circuits in which only noise energy is present, selectively and under control of signal energy permitting transmission through those circuits in which signal components are present and impressing on a response circuit the waves transmitted through all of said circuits in common that are in transmitting condition.

FREDERICK B. LLEWELLYN.