

March 14, 1939.

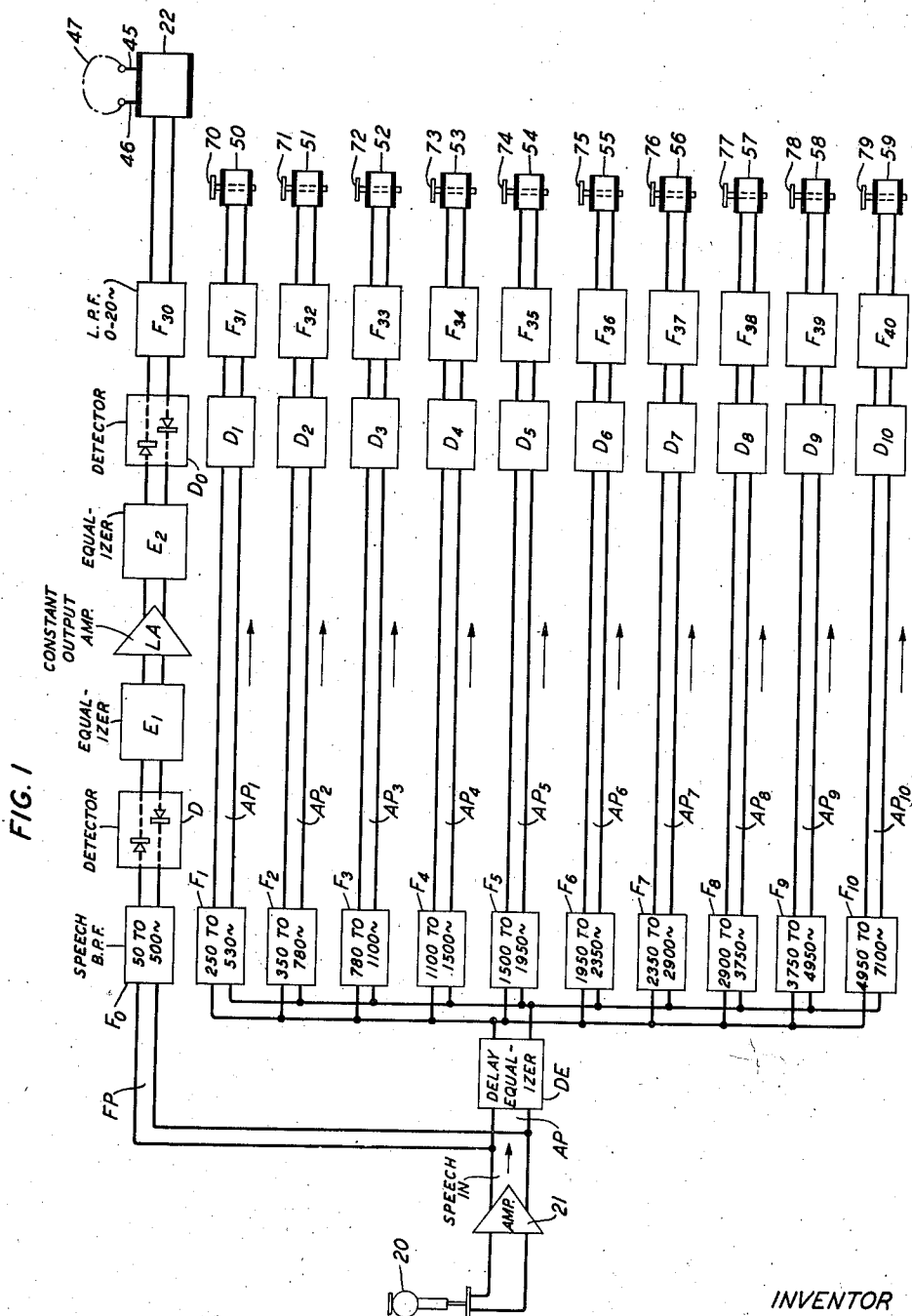
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2,150,364

SIGNALING SYSTEM

Filed July 31, 1937

3 Sheets-Sheet 1



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SIGNALING SYSTEM

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3 Sheets-Sheet 2

FIG. 2

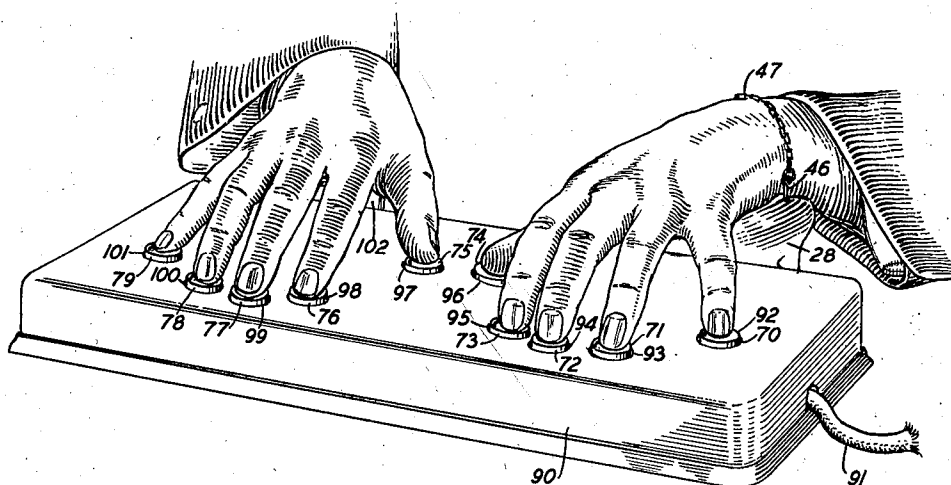
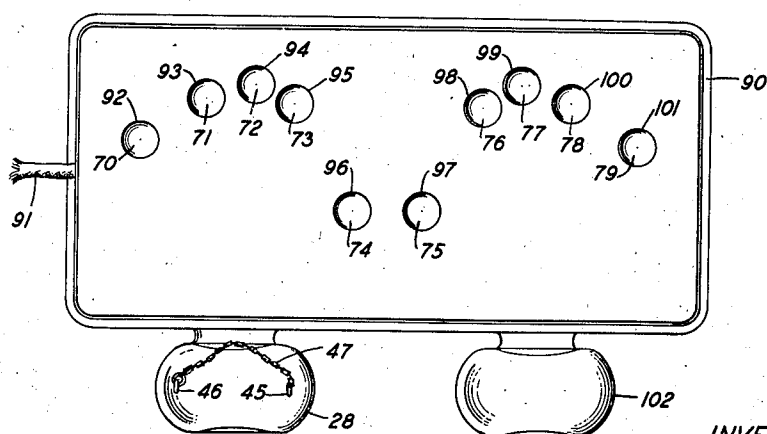


FIG. 3



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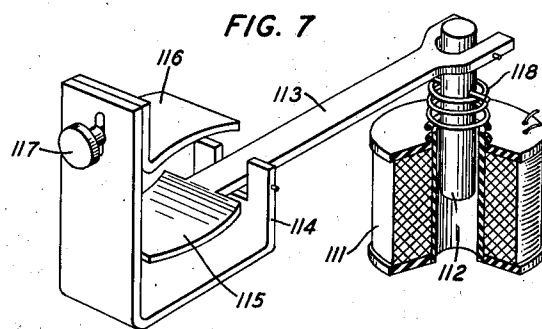
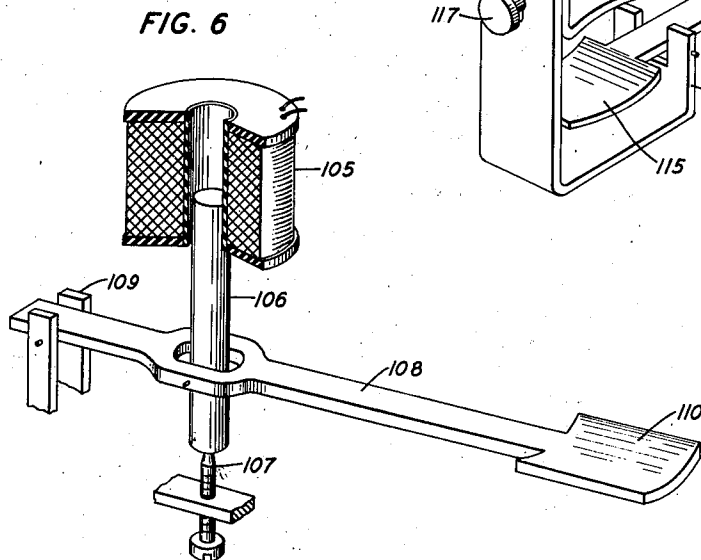
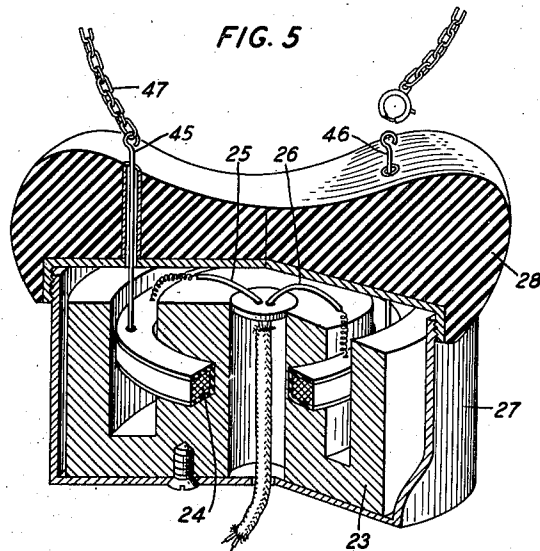
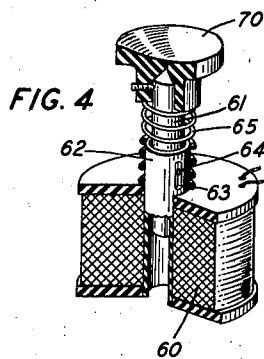
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SIGNALING SYSTEM

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3 Sheets-Sheet 3



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2,150,364

SIGNALING SYSTEM

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Application July 31, 1937, Serial No. 156,707

9 Claims. (Cl. 179—107)

This invention relates to signaling systems and has for an object the transformation of speech frequency signals into vibrations capable of being interpreted by the touch sensitive regions of the human body.

It has heretofore been proposed as a means to assist the deaf to understand speech through lip reading to have the speech picked up by a microphone and impressed upon a loud-speaker or other vibrating device in contact with the fingers of the deaf person. Such a proposal has not proven satisfactory since the higher speech frequencies do not penetrate the fingers in such a way as to be recognized. Consideration of the proposal will indicate that the main difficulty is due to the inability of the finger to respond to a frequency range that is designed for the ear with the same efficiency as it responds to the far lower frequency range to which the finger is accustomed.

In accordance with this invention it is proposed to transform a speech frequency message from aural material to tactile material capable of recognition and interpretation by the tactile sensitive regions so that we have what may be termed a vibrotactile recognition of speech sounds.

The information transmitted by speech does not absolutely require all the frequency space allotted to it in the human voice. A specific case can be worked out as to how wide a frequency band is required as a minimum, for example, by determining and taking account of the number of the independent variables or parameters involved in speech production (that is, the number of the independently movable physical elements of the vocal system that are involved in speech production), and the rate at which these vary. Speech signals satisfy the condition for possible frequency range reduction in an outstanding manner, for in one stage of speech production, namely, the muscular, there is a very simple set of controlled motions of the muscular parts making up the speech signal. Several muscular elements move to form the speech signal but the rates of motion are the slow muscular or syllabic frequency rates. As an example, the lips move for ordinary speech at a cyclic rate not ordinarily exceeding 7 cycles per second for the fundamental or basic motion. Several other parts of the vocal system such as the lungs, uvula, tongue and teeth move also, but they too move at slow rates not ordinarily exceeding 7 complete cyclic changes per second.

However, there are two types of change, oscillatory in nature, that have motions occurring at much higher rates than 7 cycles per second but

even these two types have a basic rate of change of not over 7 cycles per second. The first motion is that of the vocal cords where the fundamental frequency for men is around 125 cycles per second, and for women over 200 cycles per second. This motion differs from the others mentioned, in that it is a natural frequency of stretched cords. The tension of the cords is controlled volitionally and can only be changed at slow muscular or syllabic rates. The vocal cords not only have a high fundamental frequency but they also give a wave shape which is rich in harmonics up to several thousand cycles per second. The vocal cords have a steady energy source in the lung pressure which produces their vibration at their natural frequency depending upon the tension to which they are stretched, but this tension can change only at a slow rate, generally not exceeding 7 cycles per second.

The second type of high frequency energy source in speech production may for convenience be called a stricture. This stricture or closing with air forced through to form a sort of hissing sound may occur between the lower lip and upper teeth as for the "f" sound or between the tongue and front part of the hard palate as for the "s", or at other places for other unvoiced or breathed sounds. Such sounds have a continuous frequency spectrum with no definite fundamental frequency. It will be noted that in all such unvoiced sounds the volitional control is again applied at the lower frequency muscular or syllabic rate generally not exceeding 7 cycles per second.

From the foregoing detailed discussion of the mechanics of speech sound production, it is seen that the various speech sounds are produced by voluntarily controlled variations in the muscular system at slow syllabic frequency rates of 7 cycles per second or less. The important muscular elements or variables used in speech production are eight in number as follows: lung pressure; vocal cord tension and position; rear mouth resonance chamber; front mouth resonance chamber; opening from front to rear resonant chambers; opening from mouth; position of uvula; position of any stricture in the sound path.

Since the important muscular variables are only eight in number it is seen that the total frequency range required to produce sounds in the vocal system is very limited, it being limited in fact to the number of such variables multiplied by the frequency range required to express the motion of each, which may be 14 cycles per second if the reasonable assumption is made that the

fundamental rate of change plus its first upper harmonic defines the motion reasonably well.

A simple ideal system for frequency range reduction in speech would be to analyze the speech sounds to determine what the important motions are and then prescribe a narrow frequency band, say, of 20 cycles width, to define each motion, but it is difficult if not impossible, to do it in this simple way because of the analyzing difficulties. Thus, for example it is very difficult to determine from a speech sound just what position the tip of the tongue had in its production. However, it is reasonably simple to do this by the use of equivalent parameters. So long as the parameters are entirely independent we note mathematically that we can use any parameters we choose. Not only can they be chosen in any fashion provided they are independent, but if they are not entirely independent enough more parameters can be chosen to make up for the lack of independence. Thus, as a preferred example the sounds can be analyzed into independent variables that are easily determined such as the power in each of several small frequency sub-bands within the speech range. The power in each sub-band is not entirely independent of that in the other sub-bands but is sufficiently so that the average power level in, say, 8 or 10 sub-bands of the speech range will give us a very satisfactory set of parameters for speech definition. The analysis of the power level in small frequency sub-bands is preferably done electrically by circuit arrangements described hereinafter.

In one specific aspect of the invention, the speech message is analyzed electrically for its fundamental frequency and the average power in properly chosen sub-bands of frequency. In analyzing for the fundamental frequency a unidirectional current is produced whose magnitude defines the fundamental frequency and whose magnitude varies with the syllabic rate of change in the fundamental frequency. The magnitude of this unidirectional current will also be indicative of the presence of any unvoiced sounds which, having no definite fundamental frequency, will result in a substantially zero value of the defining unidirectional current. The analyzer may also be arranged to produce separate unidirectional currents each defining the average power level in a chosen sub-band of the frequency range of the message. These unidirectional currents are preferably individually impressed upon vibrating devices for applying the vibrations to the human body at points where the sense of touch is well developed. Thus, the vibrating devices may be adapted to contact with the fingers to convey sufficient information to the mind to enable the vibrations to be properly interpreted much in the same manner as if the sounds before analysis were received directly by the human ear, except that the speech defining signals by the above analyzing procedure have been reduced to a frequency range to which the sense of touch is readily capable of responding.

In a specific example the vibrating devices which designate the presence or absence of a fundamental frequency, and if present, the pitch of the fundamental frequency may be applied to the wrist, and each of the ten fingers may rest on a vibrating device whose vibrations define the energy level variations in one of ten sub-bands into which the speech frequency range has been divided by the analyzer.

However, if less complete information is desired as to the message, as for example, where

the invention is to be employed merely as an aid to lip reading, the number of independent variables chosen to define the speech message may be considerably reduced and for such uses it may be entirely satisfactory to divide the speech frequency range into, say, only four sub-bands of frequency and apply the fundamental frequency defining vibrations to the thumb of one hand while the vibrating devices defining the energy level in each of the four sub-bands may be applied to the four fingers, thereby utilizing only one hand for securing the information to enable the speech to be interpreted.

Referring to the drawings,

Fig. 1 is a schematic circuit embodying this invention by means of which speech or other vocal sounds may be transformed into defining signals capable of interpretation by the touch sensitive areas of the human body;

Fig. 2 is a view in perspective of one type of receiving device for the speech analyzing circuit of Fig. 1;

Fig. 3 is a top view of the device of Fig. 2;

Fig. 4 is a view partly in section of a finger actuating vibrator employed in the device of Fig. 2;

Fig. 5 is a view partly in section of the pitch controlled vibrating device of Fig. 2;

Fig. 6 is an alternative form of the vibrating device of Figs. 4; and

Fig. 7 is an alternative form of the vibrating device of Fig. 5.

Fig. 1 illustrates a preferred arrangement of this invention by means of which speech or other vocal sounds may be analyzed and transformed into speech defining signals of low frequency capable of being correctly interpreted by the touch sensitive areas of the human body.

Speech may be regarded as having a dual characteristic. On the one hand we have fixed parts or elements setting up oscillatory waves containing high frequency patterns. On the other hand we have varying parts or elements setting up modulatory waves of low syllabic frequency pattern. The fixed features include: (a) existence of definite frequency sub-bands in which the power distribution is sensibly uniform; (b) the existence of a frequency spectrum that alternates from a continuous type of spectrum with no definite fundamental frequency to a discrete type with varying fundamental and with all principal harmonics always present; and (c) the fact that time variations of the fundamental frequency and of the power in the frequency sub-bands occur only at syllabic frequency rates. The variable features include: (a) the magnitude of the average power in each sub-band; and (b) the nature of the signal spectrum as to whether it is continuous or discrete, and in the latter case, the frequency of the fundamental frequency and its possible variations from sound to sound.

Since there is foreknowledge as to the fixed features or characteristics of the speech signal it is unnecessary to transmit information regarding them, to the touch sensitive areas of the human body. It is sufficient merely to transmit information defining the variable characteristics of the signal.

The first-mentioned variable feature is the magnitude of the average power in each sub-band into which the speech signal is divided. The number of sub-bands chosen depends upon the degree of intelligibility desired, the greater the number of sub-bands the greater the degree of intelligibility in the speech defining signals. As has

been previously stated it will be satisfactory for a high degree of intelligibility to divide the speech frequency band into about eight or ten sub-bands and provide means for indicating the syllabic rate of change of the average power in each sub-band. In Fig. 1 the speech signal is divided into ten sub-bands. The sub-bands are preferably not of equal width but each sub-band has a width depending upon its importance function in the production of speech as described. For example, in my copending application Serial No. 47,393, filed October 30, 1935, on Signal transmission.

The second-mentioned variable feature of speech concerning which information should be transmitted is the nature of the speech spectrum, as to whether it is continuous without any definite fundamental frequency or whether it is a discrete spectrum, and in the latter case as to what is the frequency of the fundamental frequency for each voiced sound analyzed. This information is transmitted in a simple manner by the apparatus of Fig. 1.

In the arrangement of Fig. 1 the speech or other vocal sound to be analyzed is picked up by a suitable microphone 20 and amplified to a desired level by an amplifier 21 whose output is divided into a frequency pattern control circuit FP and an amplitude pattern control circuit AP.

The frequency pattern control circuit FP takes advantage of the fact that in vowels and other sounds having a decided fundamental frequency in the range from 80 to 320 cycles there is a high power level, while in sounds like the sibilant consonants where the power is in a continuous spectrum rather than a discrete spectrum the power level is much lower. When a high level discrete spectrum is received by amplifier 21 the frequency pattern control circuit FP sends to the electromagnetic vibrating device 22 a unidirectional current indicating what the fundamental frequency is but not indicating anything about the amplitude of the fundamental frequency. When a low level continuous spectrum speech signal is received from amplifier 21, the current amplitude transmitted through circuit FP is not sufficient to energize the vibrating device 22.

Referring more particularly to the details of the circuit FP a band-pass filter F_0 selects the band from 50 to 500 cycles of the voice signal so as to be sure to include at least two harmonics of speech if the fundamental is low. This is done in case the fundamental frequency may be 30 cycles or so, and, therefore, insufficiently amplified by amplifier 21. The output of this band-pass filter F_0 is fed to detector D which may be merely some small copper oxide elements. This insures that a fair amount of the fundamental frequency will be present if the power level is sufficiently high as in the case of vowels. The output from detector D is sent through an attenuating network E_1 more frequently termed an equalizer, which has a loss increasing with frequency for the purpose of insuring that the fundamental frequency comes out at a higher level than any particular harmonics that may be present. For practical purposes this purifies the fundamental tone. Next, the output from this equalizer E_1 is fed to a constant output amplifier LA so that from this amplifier there is obtained essentially a single frequency, the fundamental frequency of the speech signal at a constant power level regardless of what the frequency is.

This fundamental frequency may be from about 80 cycles to 320 cycles. Next, we pass this power through an equalizer E_2 similar to the one de-

scribed previously, except that the output from this equalizer increases as the frequency increases. This output is sent through another copper oxide detector D_0 which gives essentially a direct current bias which fluctuates as the fundamental frequency of speech fluctuates, that is, at syllabic frequencies. The detector output is then sent through a low pass filter F_{30} cutting off at 20 cycles so that the unwanted higher frequency components are eliminated. This output is now used as a biasing current applied to the winding of the electromagnetic device 22 whereby the armature of device 22 is retracted an amount which is proportional to the amplitude of the defining current from filter F_{30} . That is, the tension exerted on the armature of device 22 will be proportional to the frequency of the fundamental frequency so that a touch sensitive area of the human body subjected to the strength of the armature pull will be subjected to a pressure which defines the fundamental frequency of the energized sound. For a voice with a high pitch the pressure on the skin will be high while for a voice with a low pitch the pressure will be low, and the pressure will vary with any syllabic variations in the pitch of the voice. This will lead to a natural interpretation of the pitch by the person subjected to the tension from device 22 since in producing speech sounds the pitch of the voice increases with increased tension on the vocal cords.

However, when the frequency pattern control circuit FP receives a speech signal having a continuous spectrum such as when a sibilant consonant sound is impressed on microphone 20, the entire frequency spectrum is at a low level with no single frequency emphasized over the others. Hence, for such sounds there will be substantially no energy output from low pass filter F_{30} and hence device 22 will not be energized. The absence of tension on the touch sensitive area subjected to device 22, therefore, indicates an unvoiced sound.

One form the frequency pattern defining element 22 may take is illustrated in detail in Fig. 5 where it is shown as an electromagnetic device of the dynamometer type where an increase in current causes an increase in pull on a mechanical part. It comprises a slotted magnet 23 with a moving coil 24 suspended in the slot. The two conductors 25, 26 are so connected with respect to the polarity of the current output of filter F_3 that the impressed current creates a downward pull on coil 24. Mounted as a part of the casing 27 is a block 28 formed as a support for one wrist of the user. Light-weight pins 45, 46 are fastened to coil 24, extend upwardly through apertures in block 28 and terminate in eyes joined by a light-weight chain 47. The length of chain 47 should be such that when the user's wrist lies in the hollow of block 28 the wrist in the absence of any applied current from channel FP will support coil 24 approximately in the position shown in Fig. 5. The greater the current applied to coil 24 the greater will be the downward pull on the coil, and hence the tension exerted by chain 47 on the wrist of the user will be proportional to the frequency of the fundamental frequency of the voiced sounds, while an unvoiced sound having no fundamental frequency will supply substantially no current to coil 24 and hence substantially no tension to the wrist of the user. Hence, the device 22 will enable the user to interpret the pitch of each analyzed sound as well

as enabling one to distinguish between voiced and unvoiced sounds.

There remains to be described the apparatus for analyzing the speaker's energy in the different frequency sub-bands of the speech frequency range in order to determine the amplitude pattern characteristic of each speech signal. The amplitude pattern control circuit AP of Fig. 1 is essentially a circuit for measuring how much power there is in the speech signal in chosen small frequency bands and for transmitting this information by control currents to a plurality of vibrating devices, one for each sub-band. The amplitude pattern circuit AP at the output of amplifier 21 is divided by suitable band-pass filters F_1 to F_{10} into ten frequency sub-bands. As shown on the drawings, channel AP_1 receives the speech currents between 250-530 cycles; channel AP_2 passes the frequency range 530-780 cycles; channel AP_3 passes the frequency range 780-1100 cycles; channel AP_4 passes the frequency range 1100-1500 cycles; channel AP_5 passes the frequency range 1500-1950 cycles; channel AP_6 passes the frequency range 1950-2350 cycles; channel AP_7 passes the frequency range 2350-2900 cycles; channel AP_8 passes the frequency range 2900-3750 cycles; channel AP_9 passes the frequency range 3750-4950 cycles; and channel AP_{10} passes the frequency range 4950-7100 cycles.

Considering the channel AP_1 , for example, the output from the 250-530 cycle band-pass filter F_1 is fed to detector D_1 which, for instance, may be of the copper oxide type. The syllabic frequencies in the output from the detector D_1 are passed through a 20 cycle low pass filter F_{31} and used to energize a vibrating device 50 so that the magnitude of the vibrations of the armature of device 50 defines the average amount of power of each speech signal in the frequency band from 250-530 cycles, and the magnitude of the armature vibrations will increase or diminish at a syllabic rate in response to the syllabic variations of the power level in the designated sub-band.

Electromagnetic device 50 may be of various types, one of which is shown in greater detail in Fig. 4. The solenoidal winding 60 which is connected with the output of filter F_{31} has a magnetic core plunger 61 slidably mounted in a stationary collar 62 having a vertical slot 63 in which slides a pin 64 fastened to plunger 61 so as to limit the motion of the plunger. A coiled spring 65 serves to bias the plunger 61 to an outward position while the plunger will be pulled downwardly an amount proportional to the amplitude of the current through winding 60. The upper end of arm 61 has a key or finger rest 70 so that the syllabic vibrations of armature 61 will be received by the finger resting on key 70 to enable the user of the device to receive accurate information as to the amount of power in the sub-band 250-530 cycles and the syllabic variations of the power level in this sub-band.

Channels AP_2 to AP_{10} are similar to channel AP_1 just described except for the frequency range analyzed by each channel and vibrating devices 51 to 59 are similar to device 50 just described. Filters F_1 to F_{10} are alike except as to their band-pass range as indicated in the figure; detectors D_0 to D_{10} are alike; and filters F_{30} to F_{40} are alike in that each suppresses all frequencies above 20 cycles.

In order to receive tactile information sufficient to enable one to correctly understand and interpret the speech signals impressed upon the microphone 20 the person may rest his ten fingers

upon the ten finger rests 70 to 79 and may surround one wrist with the chain 47 of vibrating device 22. The tension exerted on the wrist surrounded by chain 47 will give intelligible information as to whether each element of the signal is voiced or unvoiced, and if voiced, information as to the frequency of the fundamental frequency of the signal. The magnitude of the vibrations of finger rests 70 to 79 will convey to the person the amplitude pattern of each signal component in such a form that each component may be correctly interpreted.

One type of assembly for the pitch defining means 22 and the amplitude pattern defining means 50 to 59 is disclosed in Figs. 2 and 3. Referring to these figures, there is shown a housing 90 adapted to enclose relays 22 and 50 to 59, inclusive, the electrical connections for which are supplied by a suitable cable 91. The upper surface of the housing has ten apertures 92 to 101, inclusive, through which project the finger rests 70 to 79, inclusive, in the order named, that is, finger rest 70 projects through aperture 92, and finger rest 79 projects through aperture 101. This means, as shown in Fig. 2, that the little finger of the left hand will receive defining signals for the lower sub-band and the little finger of the right hand will receive defining signals for the highest sub-band, with the intermediate fingers receiving information as to the power level of the intermediate sub-bands. The apertures 92 to 101 are so arranged that the ten fingers may comfortably rest on the vibrating keys 70 to 79 with the hands in a natural position without strain or stretching. The housing 90 also has an extension rest 102 for the right-hand wrist and an extension 28 for the left-hand wrist. Extension 28 which has previously been described in connection with Fig. 5 serves as a housing for the electromagnetic device 22 which defines the pitch of each signaling component. The upper surface of housing 28 contains two spaced apertures through which project the pins 45 and 46 joined by a light-weight flexible chain or wire 47 which is adapted to fit closely around the left wrist of the user as shown in Fig. 2 so that the left wrist will receive the pitch defining signals from the frequency pattern control circuit FP of Fig. 1.

The low frequency vibrations received by the left wrist and by the ten fingers with the apparatus of Fig. 2 suitably connected to the analyzing circuit of Fig. 1 will enable the user of the apparatus to understand and properly interpret the speech or other signals picked up by microphone 20.

It is, of course, to be understood that microphone 20 may, if desired, be located at a remote point from the rest of the apparatus but connected thereto by suitable means such as a telephone line. Since the frequency pattern control branch FP tends to have more inherent delay than the amplitude control branch AP it will generally be desirable to have a certain amount of delay in common with all the amplitude control circuits AP_1 to AP_{10} and such a delay equalizer DE is shown in Fig. 1 at the output of amplifier 21.

An alternative type of vibrating device for use in each amplitude pattern channel is shown in Fig. 6. The solenoidal winding 105 is adapted to be connected to the output of one of the channels AP_1 to AP_{10} and has a magnetic core plunger 105 adapted to be actuated by the amplitude defining variations of the current supplied to winding 105. For zero current through winding 105 the lower end of plunger 106 is adapted to rest

against a suitable stop 107. Pivotaly mounted on plunger 106 is a key plate 108 hinged at one end to a support 109. The free end 110 of key 108 is connected to serve as a rest for a finger in order that the defining vibrations of key 108 may be conveyed to the finger resting thereon. The mechanical vibrations received by the finger from the device of Fig. 6 will be greater in amplitude when the device of Fig. 4 is employed.

Fig. 7 represents an alternative type of vibrating device which may be employed in place of the device of Fig. 5 for the purpose of receiving the frequency pattern defining currents from channel FP of Fig. 1. The solenoidal winding 111 may be connected to the output of filter F₃₀ to receive the defining currents from that filter. The plunger type magnetic core 112 vibrated by the current variations through winding 111 has pivotally connected thereto one end of a lever 113 which is pivoted near its other end on a stationary support 114. The end 115 of lever 113 is shaped to form a finger rest. After a finger is placed on finger rest 115 a slidable extension 116 should be lowered to firmly contact with the upper surface of the finger for the normal position of lever 113 in the absence of any energizing current through winding 111. The upper finger contacting member 116 may be clamped in the desired position by set screw 117. Spiral spring 118 in an obvious manner normally maintains plunger 112 biased to an outward position and the electromagnetic action of winding 111 will serve to pull plunger 112 downwardly against the force of spring 118. It will be apparent from the foregoing description that the user's finger placed in between members 115 and 116 will be subjected to a varying pressure by the action of the currents defining the frequency pattern from channel FP in order that the user of the device may properly interpret the pitch of the speech signals and determine whether each speech component is a voiced or unvoiced sound. The device of Fig. 7 is particularly intended for use where there are less than ten amplitude pattern channels so that one finger may be utilized for receiving the frequency pattern defining signals with any desired number of the other fingers utilized to receive the amplitude pattern defining signals.

As previously stated, it may be desirable for high quality interpretation of the speech to employ as high as ten amplitude pattern channels as shown in Fig. 1. But for many purposes it will be satisfactory to employ fewer amplitude pattern channels, particularly when the apparatus of the invention is to be used as an adjunct to lip reading. For example, one vibrating device for pitch definition and four vibrating devices for defining certain frequency sub-bands of speech will give far better speech recognition than is obtainable by lip reading alone. Thus, if one vibrating device is employed for speech definition and four vibrating devices for amplitude pattern definition, then only the fingers of one hand will be needed to contact with the vibrating devices while the other hand will be free for other uses. It is also within the scope of the invention to apply the pitch and amplitude defining vibrating devices against adjacent parts of the forearm or other parts of the body, thereby freeing both hands for other uses in the same manner as for a person with normal hearing.

If fewer than ten channels are employed for amplitude definition it will, of course, be necessary to alter the frequency sub-bands assigned to

each channel over those given for illustrative purposes in Fig. 1 for filters F₁ to F₁₀. For example, with only four amplitude pattern channels the lowest channel may pass the frequency range 100 to 500 cycles; the second channel may pass the frequency range 800 to 1300 cycles; the third channel may pass the frequency range 2300 to 3000 cycles; and the fourth channel may pass the frequency range 3600 to 5000 cycles. However, in most instances it is not essential to adhere to these values as other widely differing values may be employed with satisfactory results.

In the circuit diagram of Fig. 1 certain filters F₃₀ to F₄₀ are disclosed for the purpose of eliminating all frequencies above 20 cycles. It will frequently be found unnecessary to employ these filters in view of the fact that the flesh itself will damp out the higher frequencies at a sufficiently rapid rate.

The above described embodiment of the invention is representative of other embodiments this invention may possess commensurate with the scope of the appended claims.

What is claimed is:

1. In a signaling system, means to produce a signal containing variable information and invariable information represented by a complex wave of a wide frequency band of speech frequencies, means to analyze said wave and derive therefrom a simple set of parameters having approximately the number of degrees of freedom of the variable elements of the signal source, means to translate said set of parameters into a set of low frequency defining waves that respectively define the variations of said parameters, each of said low frequency waves having a fundamental frequency of less than 10 cycles per second, a plurality of independent vibratory members adapted to be applied to the touch sensitive areas of the human body, and means for controlling each of said vibratory members in accordance with one of said defining waves.

2. In a signaling system, means to produce a signal containing variable information and invariable information represented by a complex electrical wave of a wide frequency band of speech frequencies, means to analyze said wave and derive therefrom a simple set of parameters having approximately the number of degrees of freedom of the variable elements of the signal source, means to translate said set of parameters into a set of low frequency defining waves that respectively define the variations of said parameters, each of said low frequency waves having a fundamental frequency of less than 10 cycles per second, a plurality of electromagnetic devices each having a winding and an armature, said armatures being adapted to be applied to the touch sensitive areas of the human body, and means for transmitting each of said defining waves to one of said windings to the exclusion of waves representing said invariable information.

3. A system for translating a message of a range of frequencies adapted to be interpreted by the human ear into a range of frequencies capable of interpretation by the tactile sensitive areas of the human body, comprising means to analyze said message and derive therefrom a set of substantially independent parameters corresponding in number to a selected number of the important independent movable elements of the vocal system involved in speech production, means to translate said set of parameters into a set of low frequency defining waves, each having a fundamental frequency of less than 10

cycles per second and each having an amplitude representing an essential characteristic of the message, individual finger supports, and means for vibrating each of said supports in accordance with one of said defining waves.

4. A system for translating a speech signal of a range of frequencies adapted to be interpreted by the ear into a range of frequencies capable of interpretation by the touch sensitive areas of the human body, in which the generation of said signal involves independently controlled sluggish muscular movements as well as the rapid vibration of the vocal cords, said system comprising means for transforming said signal into a plurality of substantially independent low frequency waves each of a fundamental frequency less than ten cycles per second, said waves collectively defining said sluggish muscular movements, and finger supports individually vibrated by said low frequency waves.

5. A system for communicating a message represented by a complex electrical wave of a wide frequency band within the speech frequency range, said system comprising a plurality of vibratory members adapted to contact with the touch sensitive areas of the human body, means for dividing said band into a plurality of sub-bands, separate means for demodulating each sub-band, and means for controlling each of said members in accordance with one of the demodulated currents.

6. A system for communicating a message represented by a complex electrical wave of a wide frequency band within a speech frequency range, said system comprising a plurality of vibratory members adapted to contact with the touch sensitive areas of the human body, means for selecting a number of substantially independent characteristics of said wave, means for producing a plurality of low frequency currents each having a fundamental frequency of less than 10 cycles per second and each defining one of the characteristics of said wave, and means for controlling each of said members in accordance with one of said defining currents.

7. A system for communicating a message represented by a wide frequency band within the speech frequency range comprising a plurality of vibratory members adapted to contact with the touch sensitive areas of the human body, means for dividing said band into a plurality of sub-bands, separate means for deriving from each sub-band a low frequency wave of a fundamental

frequency of less than ten cycles per second, which wave defines the average energy level in the sub-band, and means for controlling each of said members in accordance with one of said defining waves.

8. A system for translating a speech signal of a range of frequencies adapted to be interpreted by the ear into a low frequency range capable of interpretation by the touch sensitive areas of the human body in which the generation of said signal involves independently controlled sluggish muscular movements as well as the rapid vibration of the vocal cords, said system comprising means for transforming said signal into a plurality of substantially independent syllabic frequency waves each of a fundamental frequency of less than 10 cycles per second, said waves collectively defining said sluggish muscular movements, analyzing means for producing from said signal a low frequency wave of a fundamental frequency of less than 10 cycles per second whose amplitude defines the rate of vibration of the vocal cords, a plurality of vibratory members adapted to contact with the touch sensitive areas of the human body, means for controlling each of a plurality of said members in accordance with one of said syllabic frequency waves, and means for controlling another of said members in accordance with said low frequency wave which defines the rate of vibration of the vocal cords.

9. A system for communicating a message represented by a wide frequency band within the speech frequency range comprising a plurality of vibratory members adapted to contact with the touch sensitive areas of the human body, means for dividing said band into a plurality of sub-bands, means for deriving from each sub-band a low frequency wave of a fundamental frequency of less than 10 cycles per second and whose amplitude defines the average energy level in the sub-band, means for controlling each of a plurality of said members in accordance with one of said defining waves, analyzing means for producing from said signal a low frequency wave of a fundamental frequency of less than 10 cycles per second whose amplitude defines variations in the frequency of the fundamental frequency of said message, and means for controlling another of said vibratory members in accordance with said wave which defines the fundamental frequency of the message.

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