Jan. 13, 1959 M. J. DI TORO 2,868,882

COMMUNICATION SYSTEM

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Fig. 2

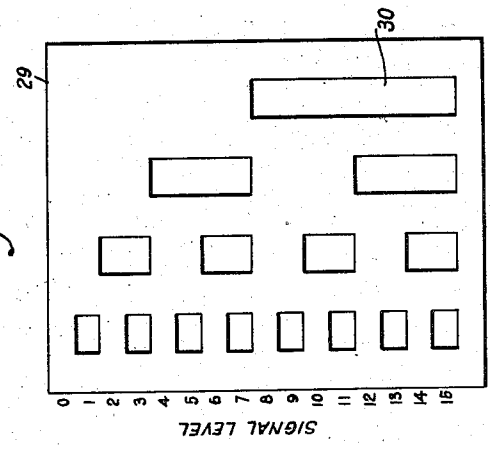
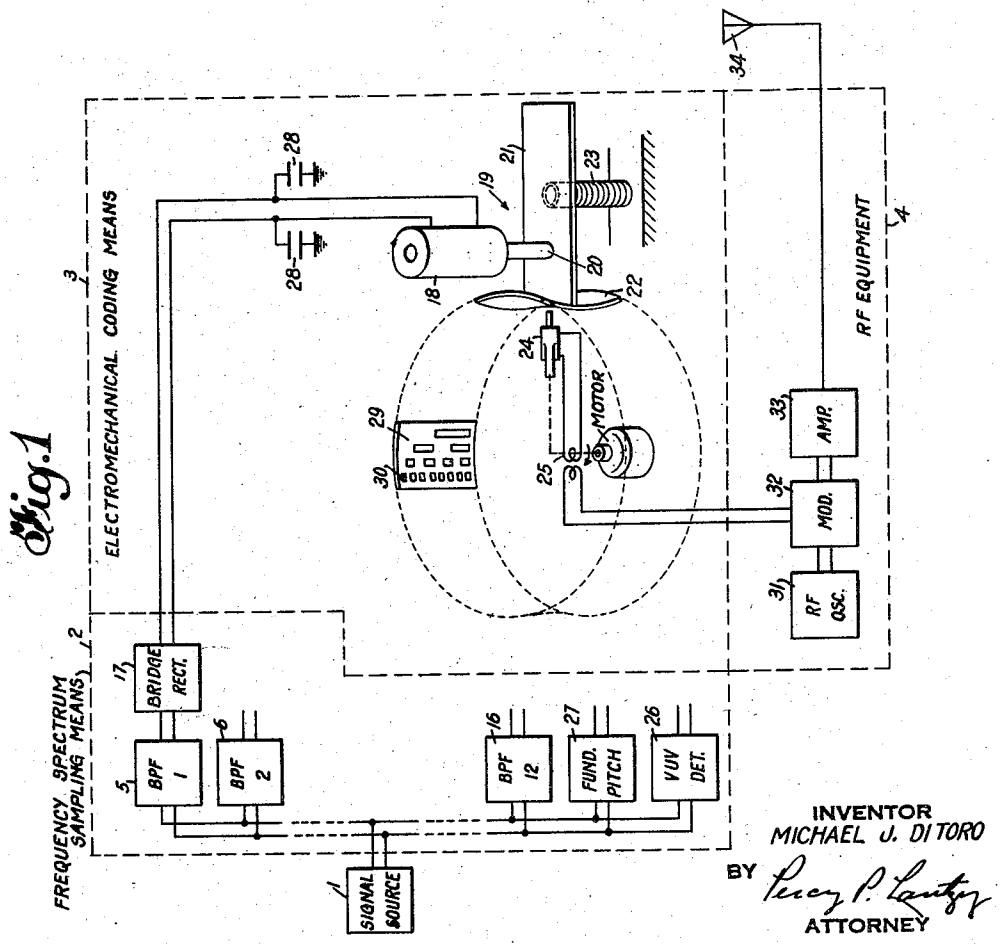


Fig. 1



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COMMUNICATION SYSTEM

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This invention relates to communication systems and more particularly to a means for reducing the bandwidth of wide frequency band signals, such as speech, and for encoding the resultant signals for transmission utilizing the principles of pulse code or cyclic permutation modulation.

The information transmitted by speech does not, at any one time, necessarily require all the frequency space allotted to it by the human voice. The lack of utilization of the entire available spectrum all of the time is obvious when it is observed that one person's speech is mostly a time sequence of voiced or quasi-periodic and unvoiced or aperiodic sound, each having different and restricted spectra. Voiced sounds, including vowels and consonants like L, M, and N, involve the use of the vocal cords and comprise a number of variable frequency carriers which are harmonically related to the varying fundamental pitch of the sound, while unvoiced sounds, such as T, K, and P, are produced in the mouth. In general, the significant energy of the voiced sounds occupy the lower portion of the frequency spectrum and contains a definite fundamental frequency while the significant energy of the unvoiced sounds occupy, almost exclusively, the high portion of the audible frequency spectrum and has no fundamental frequency present.

The presence of these two substantially distinct bands of audible sounds have led to attempts at communicating over a frequency bandwidth corresponding exactly to the width of one of these bands, instead of the combined width of both thereby effecting frequency compression. The entire speech spectrum is passed through time invariant filters causing the intelligence of the output speech to vary for different locations of the filter's center frequency. When the center frequency of the filter is located in the lower portion of the audio spectrum, the voiced sounds are best understood but the significant energy of the unvoiced sounds is lost, while when the center frequency of the invariant filter is placed in the upper portion of the spectrum, the voiced sounds are essentially lost. It is obvious that this method of frequency compression loses the significant energy of either the voiced or unvoiced sounds which lie in the spectrum outside the frequency pass band of such an invariant filter whose center frequency is located in the unvoiced or voiced portion of the speech spectrum, respectively.

To overcome the losing of unvoiced or voiced sounds by the above mentioned compression method, an anlysis-synthesis all-electronic compression system has been employed to achieve optimum syllable and/or word articulation. The general functions of such a system are well known. Briefly, the system comprises approximately ten bandpass filters, of increasing bandwidth with increasing frequency, which sample the spectrum of the sound wave present within their bandwidth. Each of the bandpass filter outputs is rectified and passed through low pass filters of approximately 25 C. P. S. bandwidth. The outputs of the low pass filters represent the spectrum

profile of speech sounds and contain the significant information desired by the ear in understanding the sound. The additional information necessary is whether the sound is voiced or unvoiced, and if voiced, the fundamental pitch is required.

This information is transmitted to a receiver, which has a source of noise, to duplicate the unvoiced sounds, and a source comprising a periodic set of impulses spaced at the fundamental pitch indicated by the transmitter. These sounds generated at the receiver are fed alternately in time into a set of ten bandpass filters whose bandwidth correspond with those of the transmitter bandpass filters. The outputs of these receiver bandpass filters are controlled by the 25 C. P. S. bandpass signals received from the ten low pass filters at the transmitter. Accordingly, the sound wave spectrum profile with its approximate time pattern is recreated at the receiver.

This type of all-electronic compression system allows the achievement of optimum syllable and/or word articulation at the signal or speech wave analyser or transmitter. To maintain this condition in order that the signal wave synthesizer or receiver may properly reproduce the original signal or speech wave, it is necessary to provide a type of radio transmission which will be substantially noise free or at least enable the recovery of the message despite a large amount of noise, and also, to some extent, be recoverable in the presence of fading arising from multipath transmission due to ionospheric reflections. Further, a type of radio transmission should be selected whose R.-F. propagation is not adversely affected by encountering numerous repeater stations normally present in long range communication systems in the high frequency band.

A pulse code or cyclic permutation type of radio transmission employing time division provides the type of transmission which is suited for transmitting information through difficult media and thereby allows substantially accurate reproduction of the original information despite noise interference, fading due to ionospheric reflections, and the number of repeater stations between the transmitter and receiver. Furthermore, the outputs of the various bandpass filters and the fundamental pitch detector and/or the voiced-unvoiced detector is ideally suited to such code type transmission arrangements wherein the compressed message signal and necessary synchronizing signals may be readily encoded for transmission to a distant receiver.

If the all-electronic frequency compression system outlined above were combined with the present code equipment, the resulting terminal equipment will tend to become rather bulky. Therefore, an object of the present invention is the provision of an improved means to compress the bandwidth of wide band frequency signals; and a further object is to code the resultant compressed signals to provide a predetermined code type of transmission.

Another object of this invention is the provision of an electromechanical system to aid in compressing the bandwidth of speech energy and to code resultant signals in a manner to pulse code modulate an R. F. carrier.

Still another object of this invention is the employment of electromechanical coders to derive a predetermined code from resultant sub-band signals of wide band frequency signals.

A feature of this invention is the provision of twelve bandpass filters each having a predetermined bandwidth to cover a particular portion of the spectrum of the frequency signal wave so arranged that the band pass filters sample their particular portion of the frequency spectrum to obtain optimum syllable and/or word articulation, the outputs therefrom constituting sub-bands of frequencies.

The energy contained in these sub-bands of frequencies is rectified for application to an electromechanical type coder. To achieve the desired reproduction of the original frequency signal wave at a distant receiver, it is necessary to derive from this signal wave information as to whether the signal wave is voiced or unvoiced and, if voiced, the fundamental pitch or frequency is required. This information is applied to the electromechanical type coder for inclusion in the resultant code pulse group train output from said coder.

Another feature of this invention is the provision of an electromechanical coder including twelve electromechanical components each activated by energy in a particular sub-band of frequencies and a predetermined number of electromechanical components responsive to voiced-unvoiced information derived from the signal wave. The electromechanical components are arranged about the circumference of a circle and include a relay type structure whose armature is deflected proportional to the rectified signal present in a particular sub-band, and whose mass and compliance results in a mechanical equivalent of a lowpass filter having a bandwidth of approximately 25 C. P. S. On the end of each armature is carried a coding plate of a predetermined reluctance variation constituting a particular permutation code of the binary or equivalent cyclic permutation type. The resultant code pulse groups of the energy in the plurality of sub-band frequencies is arranged in time division by a mechanical rotating arm which sweeps past the coding plates in time sequence to produce a time sequence of code pulse groups with the necessary synchronizing information including the presence or absence of a fundamental pitch.

Still another feature of this invention is the provision of a coding plate composed of a high permeability material having holes punched therein to conform to a predetermined permutation code suitable for reproduction of the original signal wave at a receiver or intermediate repeater from the resultant code information.

A further feature of this invention is the provision of a coding plate composed of a dielectric material having high permeability material inserts therein arranged to conform to a predetermined permutation code.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram of an embodiment of the electromechanical coder of this invention; and

Fig. 2 is a diagram representing one arrangement of the code plates incorporated in the coder of Fig. 1.

Referring to Fig. 1, an embodiment of a frequency compression type communication transmitter following the principle of this invention is illustrated and the operation thereof will be described with reference to a speech signal wave by way of example. This transmitting system is shown to comprise a signal source **1**, such as a microphone or like devices, including an amplifier having preferably an automatic volume control, frequency spectrum sampling means **2** including means to detect whether a sampled signal is voiced or unvoiced, an electromechanic coding means **3** to code the outputs from the sampling means **2**, and radio frequency equipment **4** coupled to coding means **3** wherein the coded output therefrom modulates a radio frequency carrier signal for transmission to a distant receiver.

Frequency spectrum sampling means **2** includes a plurality of bandpass filters preferably numbering twelve as shown herein. Bandpass filters **5–16** have their bandwidths arranged to divide the frequency spectrum of speech energy from source **1** into a plurality of sub-band frequencies in a predetermined manner to obtain optimum syllable and/or word articulation. The speech energy from source **1** is presented to all of the bandpass filters **5–16** for sampling thereof. At a particular instance of time the speech energy may occupy that portion of the frequency spectrum covered by the sub-band of frequencies established by filter **5**, an instant later the speech energy may be located in the sub-band of frequencies represented by the bandwidth of filter **6**. When the bandpass filters **5–16** are activated by speech energy located in their particular sub-band of frequencies, the unfiltered outputs therefrom are detected and a fluctuating D.-C. voltage of either positive or negative polarity is produced by means of bridge rectifier **17** shown at the output of bandpass filter **5**.

Assume that at the instant of sampling the speech energy is located in the sub-band of frequencies represented by the bandwidth of bandpass filter **5**. The output from filter **5** is detected by rectifier **17** producing a fluctuating D.-C. voltage for application to coil **18** of relay **19**. The armature **20** of relay **19** has secured on the end thereof a base plate **21** to form a rigid assembly which will be deflected upward proportional to the rectified signal input coupled to coil **18**. To the end of the base plate **21** is secured a coding plate **22** which may be considered the mechanical equivalent of the coding mask included in a pulse code modulation electronic coding tube. This assembly is arranged to have mass and compliance resulting in a mechanical equivalent of a 25 C. P. S. bandwidth low-pass filter. The upward deflection of this electromechanical assembly is restricted in a predetermined manner by non-linear spring **23**. By proper construction of spring **23** volume compression may be obtained by employing a spring having increasing stiffness for an increasing deflection of the assembly.

The rectified output of each bandpass filter **5–16** activates substantially identical electromechanical components. Thus, the coding plates responsive to the outputs of each sub-band, similar to coding plate **22** is arranged around the circumference of a circle as diagrammatically indicated in Fig. 1. This circular arrangement of the electromechanical transducers provides a means to obtain a code pulse group indicative of the amplitude of the speech energy present in a particular sub-band of frequencies at the instance of sampling the signal input and to interleave a plurality of such code pulse groups on the basis of time division multiplexing by means of the diagrammatically indicated rotating or scanning arm **24**. Physical contact is not necessary between the scanning arm **24** and the coding plates since the pickup of the code pulse groups is accomplished by a variation of reluctance present in the coding plates to be discussed hereinbelow. The coded information as determined by the rotating arm **24** is coupled to the R. F. equipment **4** by means of slip-rings or preferably a rotating-to-fixed electrical transformer located as indicated at point **25**.

In order that optimum syllable and/or word articulation is obtained at the receiver it is necessary to obtain information as to the frequency range in which the speech energy is located at the instant of sampling, or in other words is the sound voiced or unvoiced. Therefore, in the frequency spectrum sampling means **2** there is located a voiced-unvoiced detector **26** to detect whether the speech energy is voiced or unvoiced, and if voiced the fundamental pitch detector **27** derives the fundamental pitch or frequency from the speech energy. The details of these two detectors and embodiments thereof are fully disclosed in the copending applications of M. J. Di Toro et al., Serial No. 289,344, filed May 22, 1952, now Patent No. 2,810,787, and M. J. Di Toro et al., Serial No. 289,345, filed May 22, 1952, now Patent No. 2,699,464, respectively. The outputs of these two detectors, when present, are modified in a manner similar to the outputs of bandpass filters **5–16** to activate electromechanical units substantially identical to the units described in connection with bandpass filter **5**. The coding plates of the electromechanical units of detectors **26** and **27** are disposed in a predetermined manner with respect to the coding plates of bandpass filters **5–16** as described hereinbelow.

Having determined that a 25 C. P. S. bandwidth, as established by the mass and compliance of the sub-band relays similar to relay **19**, is sufficient for the rectified output in each sub-band, it will be sufficient to sample each sub-band code plate at a rate of 50 C. P. S. which will avoid unfilterable spectra arising in the translation from PAM to PCM. Further, the coded outputs of pitch detector **27** and voiced-unvoiced detector **26** should be sampled at 100 C. P. S. to obtain the required pitch resolution. Where the sub-band code plates and the code plates of the detectors **26** and **27** are disposed on the circumference of a circle, the arm **24** is caused to rotate at a rate of 50 C. P. S. to accomplish the desired rate of sampling for each sub-band output. The 100 C. P. S. sampling rate of detectors **26** and **27** is accomplished by having two electromechanical units for each detector including relays similar to relay **19**, in a parallel arrangement with respect to the rectified output of the detector. The two code plates of each detector should be arranged upon the circumference of the code plate circle to be disposed 180° from each other with the code plates of detector **26** adjacent the code plates of detector **27**. In this manner the voiced-unvoiced and pitch information will be present twice per frame, each frame being a complete sampling or scanning of the code plates, which is equivalent to a sampling rate of 100 C. P. S.

Further information required is that of synchronization which enables the receiver to determine the beginning and end of a frame and thereby provides for the decoding of each code pulse group in proper sequence to reconstruct the original spectrum signal. In the embodiment of this invention illustrated, a synchronizing or marker pulse may be produced for transmission by inserting a particular code plate adjacent the code plate for the first sub-band of frequencies such that the marker pulse occurs prior to the production of the code pulse group representing the rectified output of filter **5**. Such a code plate should provide a distinct characteristic to the produced pulse whereby the distant receiver may easily recognize the presence of such a pulse and thus expedite the reproduction of the original signal.

Other necessary features incorporated in this system are storage means for the rectified sub-band frequency outputs to assure the coding of the speech energy present at a particular instant of sampling and means to assure that the rectified signal outputs are quantized so that the code plates are deflected in a manner whereby the rotating arm **24** will not scan between two code signal levels thereby producing a spurious output.

The storage means for each of the rectified outputs from frequency spectrum sampling means **2** is provided by a condenser associated therewith, such as condenser **28**. This storage device is provided to store the amplitude of the fluctuating voltage for a predetermined length of time to assure that arm **24** has sufficient opportunity to scan the coding plate activated by the speech energy occurring in a particular sub-band of frequency at a particular instant.

Signal level quantization, to assure that arm **24** scans only one signal level at a time, can be accomplished by a predetermined cooperation between the amplitude of the output from the bandpass filters and the stiffness of the restricting springs, similar to spring **23**. Further assurance of signal level quantization can be accomplished by making the scanning end of arm **24** very narrow so that the possibility of overlapping two signal levels on the coding plate is substantially an impossibility. However, the scanning end of arm **24** must have sufficient width to obtain an indication of the code pulse group representative of speech energy amplitude present in a sub-band of frequencies.

As was hereinabove observed, the coding plates employed in this invention depend upon a variation of reluctance which is arranged in a particular manner for producing a predetermined permutation code. A representative

sub-band frequency coding plate similar to coding plate **22** is illustrated in Fig. 2. To achieve the desired reproduction of the original speech, it has been discovered that amplitude quantizing the output from each bandpass filters **5–16** to 16 levels will be sufficient. Therefore, a simple four digit binary permutation code will be adequate for achieving the desired reproduction, or if desired an equivalent cyclic permutation code may be employed rather than the binary code. The body **29** of the representative coding plate is composed of high permeability material, such as mu-metal, having holes punched therein, such as at **30**, in a manner to form the conventional four digit binary code as illustrated, or the known four digit cyclic permutation code. However, it should be understood that the body **29** need not be composed of high permeability material with holes punched therein to form the code. An alternative arrangement is to make the body **29** of dielectric material and have inserted therein mu-metal inserts disposed in the same manner as the punched holes in the mu-metal body for production of the four digit binary code.

Further, the coding plates should have a curvature in the horizontal plane to fit the circumference of a circle and also a curvature in the vertical plane such that the distance between the coding plate and scanning head is always the same wherever the plate may be deflected. This later curvature is desirable since spring **23** behaves similar to a pivot point thus causing the end of base plate **21** to travel in a slight arc.

The output from electromechanical coding means **3** is coupled to R. F. equipment **4** comprising an R. F. oscillator **31** for establishing a desired R. F. carrier signal, a modulator **32** to accomplish modulation of the R. F. carrier signal in accordance with the signal from coding means **3**, and amplifier **33** to provide sufficient power for radiation of the desired information from antenna **34** to a distant receiver.

The distant receiver employed to receive, decode, and reproduce the original signal may be any conventional pulse code modulation receiver and decoder incorporating a noise source to duplicate the unvoiced sounds and a source comprising a periodic set of impulses spaced at the fundamental pitch as indicated by the transmitter. The decoded signals and signals from these two sources are combined to reproduce the original signal in a manner as indicated for the all-electronic compression system described hereinabove. Also, the desired decoding may be accomplished by employing an electromechanical system complementary to the electromechanical system described herein for coding a speech signal.

Further reduction of the size of the pulse code modulation speech compression transmitter may be accomplished by eliminating the voiced-unvoiced detector **26**. This may be done without adversely affecting the functioning of the speech compression system since when a fundamental frequency is detected by detector **27** there is immediate indication of a voiced sound. The absence of an output from detector **27** indicates an unvoiced sound. Therefore, a voiced-unvoiced switch located in a receiver may be activated by the presence or absence of a fundamental pitch to put into operation a noise source for unvoiced sounds or an impulse generator for voiced sounds.

Another step toward the reduction of the size of such transmitting equipment may be made by replacing the electrical bandpass filters **5–16** by their corresponding electrometchanical counterparts. For example, the Frahm vibration meter may be successfully employed as such a replacement.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. In a wideband transmitting system, a source of wideband frequency signals, compression means arranged in a predetermined manner to divide the frequency spectrum of said frequency signals into a plurality of sub-band frequencies, detector means for detecting the presence of quasi-periodic frequencies in said frequency signals, and coding means including means responsive to the signal energy present in each of said sub-band frequencies and the output of said detector means to represent each amplitude of the signal energy at given instances of time in each of said sub-band frequencies and at the output of said detector means as a multiple digit code pulse group and means to time interleave said code pulse groups of each of said sub-band frequencies and said detector means to provide a train of code pulse groups capable of being decoded for reproduction of said frequency signals.

2. In a wideband transmitting system, a source of wideband frequency signals, compression means arranged in a predetermined manner to divide the frequency spectrum of said freqency signals into a plurality of sub-band frequencies, detector means for detecting the presence of quasi-periodic frequencies in said frequency signals, and coding means responsive to the signal energy present in said sub-band frequencies and the output of said detector means for providing a train of multiple digit code pulse groups in time sequence capable of being decoded for reproduction of said frequency signals, said coding means including a plurality of electromagnetic coding devices disposed about the circumference of a circle each of said coding devices being responsive to the signals of one of said sub-band frequencies and a rotating means to scan said coding devices for delivering a time sequence of code pulse groups.

3. In a system according to claim 2, further including identical electromagnetic coding devices responsive to the output of said detector means disposed on said circumference of said circle to be scanned at a rate twice that of said coding devices responsive to the signals of said sub-band frequencies.

4. In a system according to claim 2, wherein said coding devices comprises a relay type element and a coding plate carried on the armature of said relay type element, said relay type element responsive to the rectified output of a particular one of said sub-band frequencies.

5. In a system according to claim 4, wherein said coding plate comprises a plate of high permeability material having aperture therein arranged in a manner to provide a predetermined permutation code for presenting a multiple digit code pulse group indicative of the amplitude of said rectified output to said rotating means upon scanning.

6. In a system according to claim 4, wherein said coding plate comprises a plate of dielectric material having inserts of high permeability therein arranged in a manner to provide a predetermined permutation code for presenting a multiple digit code pulse group indicative of the amplitude of said rectified output to said rotating means upon scanning.

7. In a system according to claim 1, wherein said detector means comprises at least a fundamental pitch detector to produce a signal representative of the fundamental frequency characteristic of the signal energy present in a particular one of said sub-band frequencies.

8. A wideband frequency signal transmitting system comprising a source of wideband frequency signals, a means compressing the bandwidth of signals from said source into a plurality of narrow bandwidth frequency segments, coding means including means responsive to the signal energy present in each of said segments to represent each amplitude of the signal energy at given instances of time in each of said segments as a multiple digit code pulse group and means to time interleave said code pulse groups of each of said segments to provide a train of said code pulse groups capable of being decoded for reproduction of said frequency signals, and radiation.

9. A transmitting system according to claim 8, wherein said compressing means comprises a plurality of frequency responsive means arranged in a manner to divide the wideband signal frequency spectrum into a predetermined number of sub-band frequency spectrums, means to detect the presence of quasi-periodic energy at said particular instant, and rectifying means coupled to the output of each of said frequency responsive means and said detecting means.

10. A transmitting system according to claim 9, wherein said detecting means comprises at least a fundamental pitch detector to produce a signal representative of the fundamental frequency of a quasi-periodic signal.

11. A transmitting system according to claim 9, wherein said detecting means comprises a fundamental pitch detector activated by quasi-periodic signals and a voiced-unvoiced detector activated by a periodic signal.

12. A wideband frequency signal transmitting system comprising a source of wideband frequency signals, a means compressing the bandwidth of signals from said source into a plurality of narrow bandwidth frequency segments, coding means coupled to said compressing means to provide a train of multiple digit code pulse groups in time sequence wherein each code pulse group represents the amplitude of said frequency signal in a particular one of said frequency segments at a particular instant, and radiation means modulated in accordance with said train of code pulse groups, said compressing means including a plurality of frequency responsive means arranged in a manner to divide the wideband signal frequency spectrum into a predetermined number of sub-band frequency spectrums, means to detect the presence of quasi-periodic energy at said particular instant, and rectifying means coupled to the output of each of said frequency responsive means and said detecting means, and said coding means including a plurality of electromagnetic devices arranged to be activated by the output of said rectifying means arranged about the circumference of a circle to code the amplitude of the activating signal and a rotating means to scan said electromagnetic devices for development of a time sequence of multiple digit code pulse groups.

13. A transmitting system according to claim 12, wherein each of said electromagnetic devices comprises a relay responsive to the rectified output of a particular one of said frequency responsive means and said detecting means, and a coding plate disposed on the end of said relay carrying a predetermined permutation code arranged thereon for presenting a multiple digit code pulse group indicative of the amplitude of said rectified output to said rotating means.

14. A transmitting system according to claim 13, wherein said coding plate comprises a plate of high permeability material having aperture therein arranged in a manner to provide a predetermined permutation code for presenting a multiple digit code pulse group indicative of the amplitude of said rectified output to said rotating means.

15. A transmitting system according to claim 13, wherein said coding plate comprises a plate of dielectric material having inserts of high permeability therein arranged in a manner to provide a predetermined permutation code for presenting a multiple digit code pulse group indicative of the amplitude of said rectified output to said rotating means.

16. A speech transmitting system comprising a source of speech signals, a frequency spectrum sampling means coupled to said source in a predetermined manner to accomplish compression of the bandwidth of said speech signals, electromechanical coding means including means responsive to the signal energy present in each of a par-

ticular narrow bandwidth of said speech signal spectrum to represent each amplitude of the signal energy at given instances of time in each of said narrow bandwidths as a multiple digit code pulse group and means to time interleave said code pulse groups of said narrow bandwidths to provide a train of said code pulse groups capable of being decoded for reproduction of said speech signals.

17. A transmitting system according to claim 16, wherein said sampling means comprises a plurality of frequency responsive means arranged in a manner to divide the wideband signal frequency spectrum into a predetermined number of narrow bandwidths frequency spectrums, means to detect the presence of quasi-periodic energy at the time of sampling, and rectifying means coupled to the output of each of said frequency responsive means and said detecting means.

18. A transmitting system according to claim 17, wherein said detecting means comprises at least a fundamental pitch detector to produce a signal representative of a fundamental frequency characteristic of the sampled speech signal.

19. A speech transmitting system comprising a source of speech signals, a frequency spectrum sampling means coupled to said source in a predetermined manner to accomplish compression of the bandwidth of said speech signals, electromechanical coding means associated with said sampling means providing a time sequence of multiple digit pulse code groups, and each of said code pulse groups corresponding to the characteristics of said speech signal present in a particular narrow bandwidth of said speech signal spectrum at the time of sampling, said sampling means including a plurality of frequency responsive means arranged in a manner to divide the wideband signal frequency spectrum into a predetermined number of narrow bandwidths frequency spectrums, means to detect the presence of quasi-periodic energy at the time of sampling, and rectifying means coupled to the output of each of said frequency responsive means and said detecting means, and said coding means including a plurality of relay devices arranged to be activated by the output of each of said rectifying means arranged about the circumference of a circle to code the amplitude of the activating signal and a rotating means to scan said relay devices for development of a time sequence of multiple digit code pulse groups.

20. A transmitting system according to claim 19, wherein each of said relay devices comprises a coil responsive to the rectified output in a particular narrow bandwidth of said speech signal spectrum, and a coding plate disposed on the end of the armature of said relay device carrying a predetermined permutation code arranged thereon for presenting a multiple digit code pulse group indicative of the amplitude of said rectified output to said rotating means.

21. A communication system comprising a source of wide frequency band signals, means to form a plurality of narrow sub-bands of frequencies different from each other from said wide band signals, means responsive to the signal energy in each of said narrow sub-bands of frequencies to represent each amplitude of the signal energy at given instances of time in each of said narrow sub-bands of frequencies as a multiple digit code pulse group, a source of carrier frequency energy and means to pulse modulate said carrier frequency energy responsive to said indications.

22. A pulse coding device comprising a plurality of identical electromagnetic coding devices disposed about the circumference of a circle, a plurality of input signal sources to be encoded, means to move each of said coding devices responsive to one of said signals and rotating means to scan said plurality of coding devices for delivering a time sequence of code pulse groups.

23. A pulse coding device comprising a plurality of electromagnetic coding devices each having a relay type element and a coding plate carried on the armature of said relay type element, sources of a plurality of input signals to be encoded, means to couple each of said signals to one of said armatures to cause said associated coding plate to move responsive to said signal and rotating means to scan said plurality of coding devices for delivering a time sequence of code groups.

24. A device according to claim 23 wherein each of said coding plates comprises a plate of high permeability matter having apertures therein arranged in a manner to provide a predetermined permutation code for presenting a code pulse group indicative of the amplitude of said signal to said rotating means upon scanning.

25. A device according to claim 23 wherein each of said coding plates comprises a plate of dielectric material having inserts of high permeability therein arranged in a manner to provide a predetermined permutation code for presenting a code pulse group indicative of the amplitude of said signals to said rotating means upon scanning.

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