

Aug. 8, 1950

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2,517,819

ELECTROACOUSTIC DELAY SYSTEM

Filed April 30, 1948

2 Sheets-Sheet 1

Fig. 1.

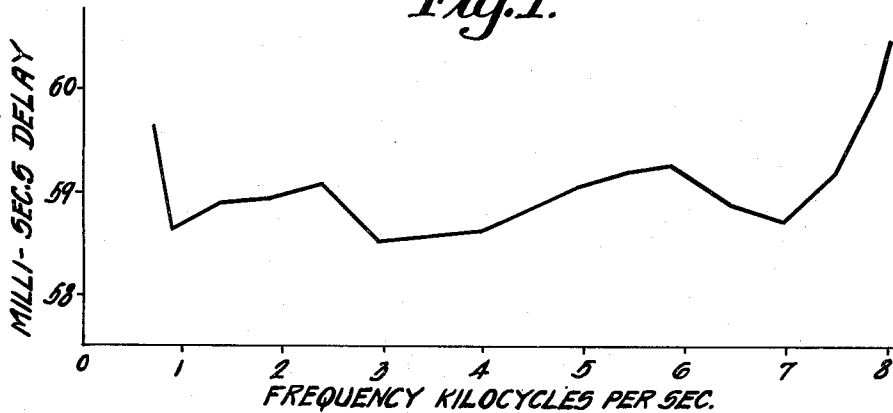
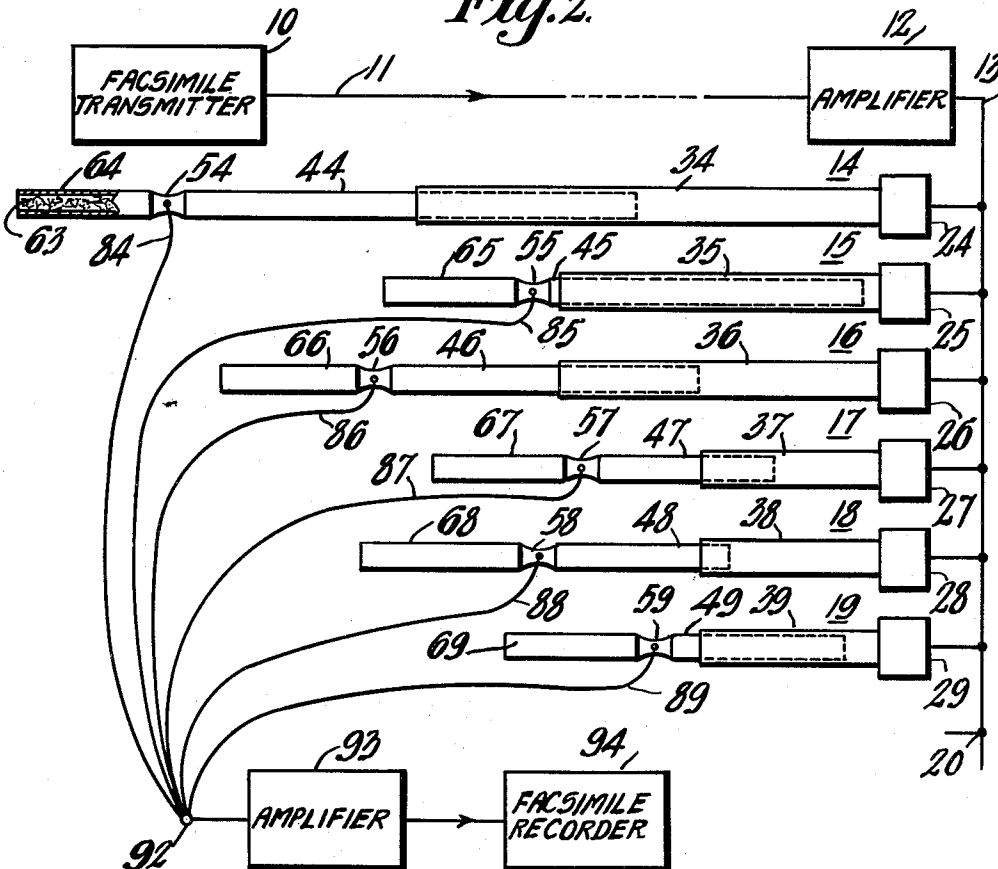


Fig. 2.



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UNITED STATES PATENT OFFICE

2,517,819

ELECTROACOUSTIC DELAY SYSTEM

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Application April 30, 1948, Serial No. 24,391

2 Claims. (Cl. 179-1)

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This invention relates to apparatus and method for using acoustic time delay in connection with electric signals, and more particularly to correcting delay distortion in facsimile and program transmission over long wire lines.

If a wire circuit is more than 50 miles long, some frequencies are delayed more than others, thus causing variations in envelope delay. Such variations must be kept small to prevent distortion. For instance, in facsimile transmission the variations in delay time throughout the transmitted band should not exceed the time to scan one picture element, which may be .12 milli-second (ms.) when sending at a rate of about 28 square inches per minute. The envelope delay over a 750-mile line may average 60 ms., so it is essential that accurate correction be applied to keep variations in such a long delay time within such a small limit.

Time delays selective as to frequency can be obtained with electrical filter networks, but when the delay correction is of the order of milli-seconds rather than of micro-seconds, such networks are very elaborate, expensive and troublesome, not readily adjustable, and must be distributed along the line instead of being disposed in one location.

The primary object of this invention is to use the relatively low velocity of sound to obtain relatively long time delays.

Another object is to provide the entire delay correction at one point of a line with simple and compact apparatus.

A further object is to make such apparatus readily adjustable to various lines or conditions.

Still another object is to obtain the desired quality of reception by manual adjustment while observing the effect thereof upon the reception.

Other objects and advantages of the invention will become apparent as the description proceeds.

The invention contemplates the use of electro-acoustic devices, or acoustic links, which may comprise a translator of electric signals into sound, a sound path of adjustable length to provide the desired delay, and a translator of sound into electric signals. Each such electro-acoustic device is arranged to operate on a portion only of the frequency band with sufficient overlap on adjacent portions thereof so that the combined effect of all such devices covers the entire frequency band of the signals.

In the accompanying drawings which illustrate one embodiment of the invention:

Figure 1 shows a delay curve of a typical pro-

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gram circuit which has been corrected to uniform amplitude only for broadcast use;

Figure 2 is a schematic diagram of a preferred embodiment of the invention;

Figure 3 is a partly structural and partly schematic illustration of one of the electro-acoustic devices shown in Figure 2; and

Figure 4 shows a series of selectivity curves for a number of electro-acoustic devices such as shown in Figures 2 and 3.

Similar parts are indicated by like reference characters in Figures 2 and 3.

Referring to the curve of Figure 1 which shows variations in time delay for various frequencies from about 700 to 8000 cycles, it will be noted that such variations amount to about 2 ms. even though the telephone circuit or wire line was amplitude corrected for broadcast use. Such a line would not be suitable for high-quality facsimile transmission which may, for example, require that the delay variation be not greater than .12 ms. On the other hand, facsimile transmission does not require a flat amplitude characteristic, especially when using sub-carrier frequency modulation.

The arrangement of Figure 2 illustrates an example of apparatus according to the present invention, by which a line as above described can have its delay distortion corrected to be more suitable for facsimile and also more suitable for program use if the line is very long, such as a transcontinental line. Reference character 10 represents transmitting apparatus which may comprise all apparatus required for facsimile or program transmission including generators of carrier frequencies and modulators thereof. The transmitter 10 is connected to a long line 11, which may be connected at the receiving end to an amplifier 12 and from the output of said amplifier through a wire 13 to a number of electro-acoustic devices or acoustic links indicated generally by reference characters 14 to 19 inclusive. More of such devices may be added as indicated at 20, and they may be connected in series to the output of amplifier 12 instead of in parallel as shown.

Considering the acoustic link 14, it may comprise a transducer 24 indicated schematically, but comprising means for translating electric waves into sound waves. One part 34 of a telescope tube is attached to the sound outlet of transducer 24. Another part 44 of said tube has its cross-section modified at point 54 to accommodate a transducer for translating sound waves into electric waves. The tube also has a third

part 64 containing material 63 which provides acoustic resistance, such as tufts of felt or other sound-absorbing material. The free end of the telescope tube is preferably left open.

The other acoustic links 15 to 19 are provided with similar telescope tubes 35 and 39 and 45 to 49 with modified cross-sections at 55 to 59 and terminations 65 to 69 containing acoustic resistance as described.

The acoustic link 14 is illustrated in more detail in Figure 3 as comprising a magnetic field structure 70 providing an air gap 71 in which is disposed a voice coil 72 mounted on the neck of a cone 73. The cone is supported at its periphery by frame 74, a corrugation such as 76 being provided to permit the cone to have limited movement longitudinally. A pair of leads 77 provides electrical connections to the voice coil 72 which may be connected directly or through a transformer to amplifier 12. One end of the telescope tube 34 may be flanged outwardly as indicated at 78 to form a substantially air-tight attachment to the frame 74. Part 44 of the telescope tube has its cross-section modified at 54 as above mentioned to provide an elongated space 80 in which is disposed a transducer 81 which may be a ribbon microphone having connecting leads 83 and 84. It should be understood that the microphone 81 is disposed in a magnetic field in known manner, the field structure not being shown in the drawing.

For ease of assembly the telescope tube at point 54 may be divided and the part 54 attached to part 44 by suitable flanges 90 and 91, with the microphone 81 secured therebetween. Parts 34 and 44 should have a sliding fit with little air leakage.

The acoustic link 14 thus provides an enclosed path for sound to travel from speaker 24, through tube 34—44, to microphone 81; the length of said path being adjustable. Assuming the velocity of sound in air to be 1100 feet per second, each foot of path will introduce a delay of .909 milli-second. Other rates of delay can be obtained, if desired, by filling the device 14 with other sound carrying media, including liquids, or by using solid sound conductors.

Referring again to Figure 2, each of the other acoustic links 15 to 19 inclusive may be constructed similar to link 14. The output leads 84 to 89 from the respective microphones are connected by flexible leads to a common terminal 92 which is connected to the input of an amplifier 93 and thence to receiving or recording apparatus 94. Such apparatus may comprise all apparatus required for recording facsimile, including demodulators and arrangements for restoring frequency bands to their proper relative positions in the event that the transmission was performed by the use of separated and transposed frequency bands. The apparatus 94 may also comprise all apparatus required for delivering the received signals to a broadcast transmitter.

The electrical connections in Figure 2 are shown by a single-line diagram, it being understood that the return connections are common and preferably grounded.

Each of the transducers 24 to 29 may be made selective to a component band of frequencies contained within the frequency band of the signals. Such selectivity may be obtained by the natural resonance of the cone structure 73 in Figure 3, or a loud-speaker diagram may be tuned by means well understood in the art. Figure 4 illustrates a possible tuning arrange-

ment for eight transducers which are tuned broadly to component frequency bands centering respectively on 1000, 2000, 3000, etc. cycles. The breadth of tuning is such that the curves overlap to an extent which will give a substantially flat characteristic to the combined bands over the signal range. Loud speakers are more efficient when thus tuned, so there is less loss than if each speaker had a flat characteristic. The number of component frequency bands is not fixed; if desired they may be spaced somewhat irregularly, and their breadth of tuning may be altered, depending on the nature of the delay correction required in a given case.

Selectivity may also be obtained by tuning the receiving transducer such as microphone 81; or both transducers at opposite ends of an acoustic link may be tuned to the same band of frequencies. Acoustic filters may be substituted for the telescope tubes.

The operation of the arrangement shown in Figures 2 and 3 is as follows. The signals in line 11 are amplified at 12 and divided into component frequency bands by the devices 14 to 19 and transmitted as sound bands through the parallel, but separate, acoustic paths provided by said devices. After translation back into bands of electric frequencies at points 54 to 59, said bands are combined in amplifier 93 to obtain the original signals with relative time delay of component bands. If delay distortion is present at the receiver 94 the acoustic paths provided by the links 14 to 19 are adjusted in length by sliding the movable parts 44 to 49 of the telescope tubes in or out of the fixed parts 34 to 39 respectively. The effects of these adjustments can be observed at the receiver 94 or otherwise communicated to the person manipulating the apparatus. Inasmuch as each telescope tube has an effect on only one component band of frequencies, it can be independently adjusted until that band is properly received. Thus the band which is delayed the least in transmission over the line 11 will have a relatively long delay added by extending its telescope tube. On the other hand, the band which is most delayed in transmission will have its tube almost completely telescoped so as to add a minimum of acoustic delay. Proper adjustment will result in adding sufficient acoustic delay to each component band so that the sum of the line delay and the acoustic delay will be substantially the same for all of the bands, thereby correcting the delay distortion and giving high-quality reception of signals.

In Figure 2 various groups of the telescope tubes are shown as having different lengths. For instance, tube 34 is the longest and the group of tubes 37 to 39 is the shortest. This is convenient because a greater range of maximum to minimum delay is obtained. However, all of the telescope tubes may be of the same length if desired. The tubes need not be straight but may be of U-formation to conserve space, or may be given other configurations so long as they remain adjustable in length.

In the above description the words "sound" and "acoustic" include supersonic as well as audible frequencies in any medium.

The invention described has general application to delay systems and, therefore, is not limited to facsimile systems or to the apparatus selected as an example.

What is claimed is:

1. In an image transmission system in which image signals are transmitted over a communication channel which causes different delay times

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for different frequencies of the image signals, a receiving station for said image signal at the receiving end of said transmission channel, apparatus at said receiving station to compensate for the different delay times for different frequencies comprising a plurality of sound reproducers each tuned to a component of said image signals, a microphone for each sound reproducer, means connecting each sound reproducer to its associated microphone and providing a sound path of adjustable length therebetween, each of said path providing means being adjusted to provide a longer delay time locally for the less delayed image signal component and a minimum of local delay for the most delayed component of the image signal, and means for combining the output of said microphones to form the original image signal so that the sum of the line delay and the acoustic delay will be substantially the same for all of the components.

2. In an image transmission system in which image signals are transmitted over a communication channel which causes different delay times for different frequencies of the image signals, a receiving station for said image signal at the receiving end of said transmission channel, apparatus at said receiving station to compensate for the different delay times for different frequencies comprising a plurality of sound reproducers each tuned to a component of said image

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signals, a microphone for each sound reproducer, a telescope tube connecting each reproducer to its associated microphone and providing a sound path of adjustable length therebetween, each tube being adjusted to provide a longer delay time, locally, for the less delayed image signal component and a minimum of local delay for the most delayed component of the image signal, and means for combining the output of said microphones to form the original image signal so that the sum of the line delay and the acoustic delay will be substantially the same for all of the components.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,098,956	Dudley -----	Mar. 16, 1937
2,209,326	D'Humy et al. -----	July 30, 1940
2,230,836	Hammond -----	Feb. 4, 1941
2,237,298	Bauer -----	Apr. 8, 1941
2,292,745	Davis -----	Aug. 11, 1942
2,318,417	Phelps -----	May 4, 1943
2,403,231	Parisier -----	July 2, 1946
2,403,232	Parisier -----	July 2, 1946