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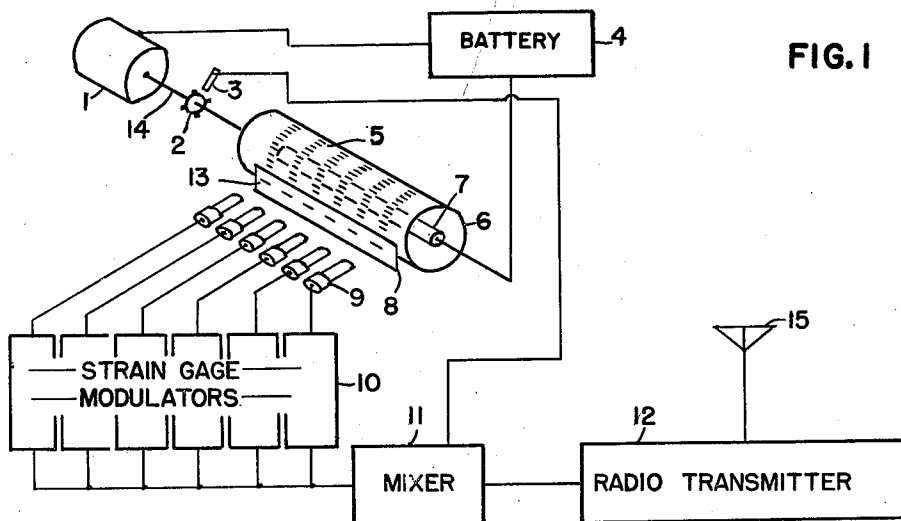
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MULTIPLEX PHOTOELECTRIC RECORDING SYSTEM AND METHOD

Filed May 16, 1945

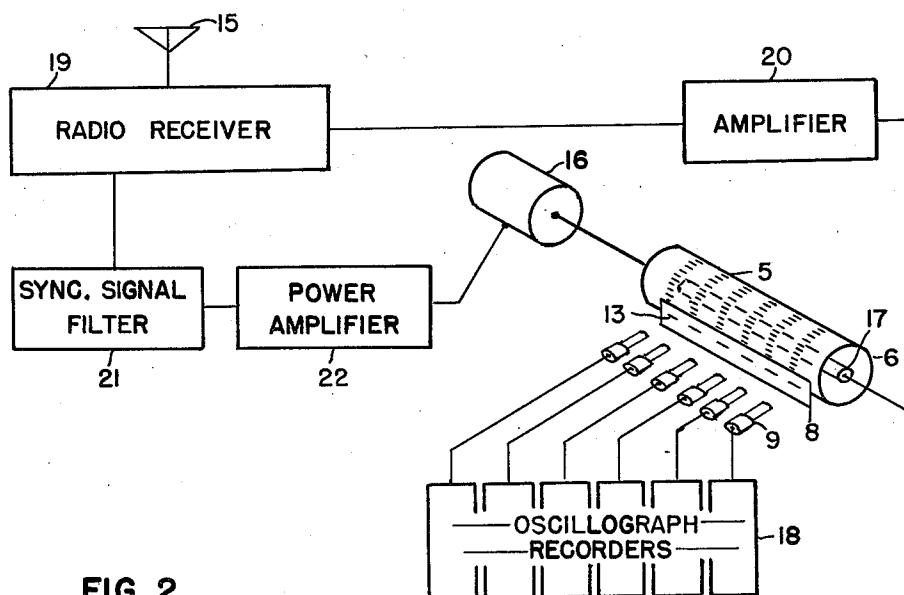
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## UNITED STATES PATENT OFFICE

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MULTIPLEX PHOTOELECTRIC RECORDING  
SYSTEM AND METHODEarle L. Kent, Elkhart, Ind., assignor to the  
United States of America as represented by the  
Secretary of the Navy

Application May 16, 1945, Serial No. 594,047

14 Claims. (Cl. 177-351)

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This invention relates in general to a multi-channel radio transmitter and receiver system, and more particularly to a radio system so designed that the transmitter may be placed in an airplane to be tested; to transmit to the receiver, on the ground or in another plane, certain test data such as a series of readings of stresses in certain structural members and the like.

In the copending application of Virgil H. Disney for Discriminator Circuit, Serial No. 593,605, filed May 14, 1945, there is disclosed in Figs. 1 and 2 an all electronic multi-channel radio system as distinguished from the electro-optical multi-channel radio system of this invention. While this all electronic system operates satisfactorily, it is cumbersome and heavy, particularly for airborne equipment, and simplification is very desirable.

Applicant discovered that by generating the subcarrier frequencies of the transmitter optically, and reinserting optically a duplicate of said frequencies in the receiver, that due to the filtering effect of a rotating pattern the recorders could be designed to respond solely to the modulations of the subcarriers by the strain gages, thus eliminating the electrical discriminators and greatly simplifying the apparatus.

It is an object of this invention to produce a multi-channel radio system that is easily portable and particularly adapted for airborne use.

Another object of this invention is to produce a multi-channel radio system in which the subcarriers are generated optically.

Another object of this invention is to produce a multi-channel radio system in which the subcarriers are generated optically and the recording elements are tuned to the modulation frequencies of the subcarriers.

Another object is the provision of a multi-channel radio system which will be economical to manufacture, reliable in operation and which possesses all of the qualities of ruggedness and dependability in service.

Fig. 1 is a partial block diagram of the radio transmitter of this invention, illustrating the apparatus for optically generating the subcarriers.

Fig. 2 is a partial block diagram of the radio receiver of this invention, illustrating the apparatus for the optical reinsertion of the subcarriers in the receiver and the omission of the electrical discriminators.

This invention consists essentially in the use of the filtering effect obtained by a rotating pattern having a sinusoidal coefficient of transmis-

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sion, as distinguished from the electrical discriminating action of the network of the copending application described above.

In Fig. 1 of this disclosure illustrating the transmitter, the battery 4 furnishes power to drive motor 1 and to illuminate lamp 7 in drum 6. On drum 6 a number of tracks 5 having a sinusoidal coefficient of transmission may be either of the variable area or variable density type of track. The purpose of each track is to produce a definite subcarrier frequency and there are obviously as many tracks as there are frequencies to be produced. Motor 1 rotates drum 6 at a constant speed. When the light of lamp 7 is viewed through slit 13 of mask 8 it is found to be modulated at the frequency of the particular track between slit 13 and the lamp. This modulated light beam passes to photocell 9 where said cell produces an electric current of corresponding frequency, or in other words the subcarrier.

Each subcarrier is modulated by its particular strain gage 10 and then all of the strain gage modulated subcarriers are fed to mixer 11 before modulating the transmitter carrier wave, along with a synchronizing signal generated by tooth-wheel 2 fixed to motor shaft 14 and inductor coil 3. The purpose of the synchronizing signal is to make the drums 6 at the transmitter and at the receiver operate in synchronism. The complex signal is broadcast from antenna 15 of the transmitter 12.

Antenna 15 of receiver 19 picks up the signal and produces an output that is of the same waveform as the input to the transmitter. From part of this output the synchronizing signal is filtered by 21, this signal is amplified at 22 in sufficient strength to operate motor 16 in synchronism with motor 1. The remainder of the output is amplified linearly at 20 and illuminates glow lamps 17 whose illumination is proportional to the undulations in the electrical current which at this stage of the device is in the form of a complex wave. The complex wave in the form of light is now again modulated by separate beams of the subcarrier frequencies which in turn illuminate photocells 9 through slits 13 in mask 8. The current produced by the photocells contains the corresponding modulations placed on the subcarrier at the transmitter and of course the subcarrier frequency. The individual recording elements are tuned to the strain gage modulation frequencies and consequently do not record the relatively high frequency of the subcarrier. In this manner, the variation of the strain gages in the ship under test is faithfully recorded ei-

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ther in another plane or on the ground, so that no matter what happens to the plane under test, the data up to the point of failure is obtained.

In devices of this kind, microphonics play an important part in the successful operation of the apparatus. The optical production of the subcarriers eliminates apparatus particularly susceptible to the generation of microphonics, and in this manner produces a system of improved operation.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a multiplex photoelectric recording system, sending apparatus for generating a wave of radiant energy modulated at a plurality of frequencies including a synchronizing frequency, said sending apparatus comprising, in combination, a rotatable drum having a plurality of translucent sinusoidal frequency producing tracks therein, means for rotating said drum at a substantially constant speed, means operatively connected to said rotating means for obtaining a synchronizing signal of said synchronizing frequency, a lamp in said drum, means connected to said lamp for energizing the same, mask means disposed in predetermined position with respect to said drum and having a plurality of slits therein corresponding to said plurality of tracks respectively, a plurality of photoelectric means disposed in predetermined positions with respect to said plurality of slits respectively for producing from the light energy passing through said slits a plurality of electrical signals of substantially sinusoidal waveforms, a plurality of means for modulating said plurality of electrical signals respectively, means for generating radiant energy, and means operatively connecting said plurality of modulating means and said means for generating a synchronizing signal to said means for generating radiant energy whereby the radiant energy is modulated by all the signals.

2. In a multiplex photoelectric recording system, receiving apparatus adapted to receive a wave of radiant energy modulated at a plurality of signal frequencies and a synchronizing frequency and to record modulation components of said signal frequencies comprising, in combination, energy receiving means, signal filter means operatively connected to said receiving means for obtaining therefrom a synchronizing signal, motor means energized by said synchronizing signal, a rotatable drum operatively connected to said motor means to be rotated thereby at a substantially constant speed predetermined by said synchronizing signal and having therein a plurality of translucent sinusoidal frequency producing tracks corresponding to said signal frequencies, lamp means disposed within said drum and adapted when energized to illuminate all said tracks, means for amplifying the output of said receiving means and energizing said lamp means therefrom, a plurality of photoelectric means disposed in predetermined positions with respect to said plurality of tracks respectively, means operatively associated with said drum and all said photoelectric means for limiting the light energy reaching each photoelectric means to that coming from

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its respective track, and a plurality of oscillograph recorders operatively connected to said plurality of photoelectric means respectively, each of said recorders being tuned to eliminate the component of signal frequency applied thereto and to record the modulation component.

3. In a multiplex photoelectric recording system for remotely recording test data, in combination: optical means for generating a plurality of signals of a plurality of subcarrier frequencies and including a rotatable drum having therein a plurality of transparent sinusoidal frequency producing tracks, means for rotating the drum at a substantially constant speed, a lamp in said drum, means for energizing said lamp, and a plurality of photoelectric means associated with said plurality of tracks respectively for generating said plurality of subcarrier signals; a plurality of means for modulating said plurality of subcarrier signals respectively; means for generating a radio wave and modulating said radio wave by said plurality of subcarrier signals; an additional rotatable drum having a plurality of tracks therein similar to the tracks in said first named drum; means including radio receiving means and operatively connected to said additional drum for rotating said additional drum in synchronism with said first named drum; means operatively connected to said receiving means for illuminating the tracks of said additional drum by light energy modulated at said modulated subcarrier signal frequencies; photoelectric means associated with said additional drum; and recording means operatively connected to said photoelectric means.

4. A multiplex photoelectric recording system for remotely recording test data comprising, in combination, means including a rotating drum having a plurality of translucent frequency producing tracks therein for generating and transmitting a radio wave modulated by a plurality of signals of subcarrier frequencies each of which is amplitude modulated at an intelligence frequency, and means including a plurality of recorders and an additional rotating drum having a plurality of translucent frequency producing tracks therein similar to the tracks in said first named drum for deriving from said radio wave modulation components corresponding to said intelligence frequencies and recording said components.

5. A multiplex photoelectric recording system for remotely recording test data comprising, means including a rotating drum having a plurality of translucent frequency producing tracks therein for generating a plurality of subcarrier signals each of which is amplitude modulated at an intelligence frequency, means operatively connected to said means for generating a radio wave for modulating said wave by said subcarrier signals, radio receiving means, means operatively connected to said receiving means and including an additional rotating drum having a plurality of translucent frequency producing tracks therein similar to the tracks in said first named drum for deriving from said radio wave subcarrier signals modulated at said intelligence frequencies, and recorder means operatively connected to said last named means for recording components corresponding to said intelligence frequencies.

6. Method of multiplex photoelectric recording comprising the steps of generating a syn-

chronizing signal, photoelectrically generating a plurality of subcarrier signals of a plurality of subcarrier frequencies respectively, amplitude modulating said plurality of subcarrier signals at a plurality of intelligence frequencies respectively, generating a radio wave, simultaneously modulating said radio wave by all said modulated subcarrier signals and said synchronizing signal, receiving and demodulating said radio wave to provide a complex signal having a plurality of modulation components including said plurality of subcarrier signals and said synchronizing signal, photoelectrically separating said modulation components to provide a plurality of signals corresponding to said subcarrier signals, and recording the modulation components of said subcarrier signals corresponding to said intelligence frequencies.

7. Method of multiplex photoelectric recording employing sending and receiving apparatus each including a rotatable drum having a plurality of translucent sinusoidal frequency producing tracks therein, which comprises the steps of illuminating and rotating the drum of the sending apparatus and photoelectrically generating therefrom a plurality of subcarrier signals of a plurality of subcarrier frequencies corresponding to the tracks in said last named drum, generating a synchronizing signal, amplitude modulating said plurality of subcarrier signals at a plurality of intelligence frequencies respectively, generating a radio wave, simultaneously modulating said radio wave by all said modulated subcarrier signals and said synchronizing signal, receiving and demodulating said radio wave in the receiving apparatus to produce a complex signal having a plurality of modulation components including those corresponding to said plurality of subcarrier signals and said synchronizing signal, utilizing said complex signal to rotate and illuminate the drum of the receiving apparatus, photoelectrically obtaining from said last named drum a plurality of signals corresponding to said subcarrier signals, and recording the modulation components of said subcarrier signals corresponding to said intelligence frequencies.

8. In a multiplex photoelectric remote recording system, in combination, sending apparatus and receiving apparatus; said sending apparatus comprising a first rotatable drum having a plurality of translucent sinusoidal frequency producing tracks therein, means for rotating said first drum at a substantially constant speed, means operatively connected to said rotating means for generating a synchronizing signal of synchronizing frequency, a lamp in said first drum, means connected to said lamp for energizing the same, mask means disposed in predetermined position with respect to said first drum and having a plurality of slits therein corresponding to said plurality of tracks respectively, a plurality of photoelectric means disposed in predetermined position with respect to said plurality of slits respectively for producing from the light energy passing through said slits a plurality of electrical signals of substantially sinusoidal waveforms of a plurality of signal frequencies, a plurality of means for modulating said plurality of electrical signals respectively, means for generating radiant energy, and means operatively connecting said plurality of modulating means and said means for generating a synchronizing signal to said means for generating radiant energy whereby the radiant energy is modulated by all said signals; said receiving ap-

paratus comprising radiant energy receiving means, filter means operatively connected to said receiving means for obtaining a motor energizing signal, motor means energized by said last named signal, a second rotatable drum operatively connected to said motor means to be rotated thereby and having therein a plurality of translucent sinusoidal frequency producing tracks corresponding to the tracks in said first drum, lamp means disposed within said second drum and adapted when energized to illuminate all the tracks in said second drum, means for amplifying the output of said receiving means and energizing said lamp means therefrom, a plurality of additional photoelectric means disposed in predetermined positions with respect to the tracks of said second drum respectively, means operatively associated with said second drum and all said additional photoelectric means for limiting the light energy reaching each additional photoelectric means to that coming from its respective track, and a plurality of oscillograph recorders operatively connected to said plurality of additional photoelectric means respectively, each of said recorders being tuned to eliminate the component of signal frequency applied thereto and to record only the modulation component of the signal.

9. In a multiplex photoelectric recording system for remotely recording test data, means including a rotating drum having a plurality of transparent sinusoidal frequency producing tracks therein for generating a plurality of signals of a plurality of subcarrier frequencies respectively, means for modulating said plurality of subcarrier signals in accordance with variations in a plurality of quantities to be measured, means for transmitting to a remote point a continuously varying energy wave having said subcarrier signal modulation components as components of said variations, and means at said remote point for recording said modulation components thereby to obtain indications of variations in the quantities to be measured.

10. In apparatus of the character disclosed, in combination, a rotatable drum having a plurality of translucent sinusoidal frequency producing tracks therein, means for illuminating said tracks, a plurality of photoelectric means operatively associated with the plurality of tracks of said drum respectively, means limiting the light reaching each photoelectric means to that coming from its associated track, utilization circuit means operatively connected to said plurality of photoelectric means, and means for rotating said drum at a substantially constant predetermined frequency thereby to energize said utilization circuit by a plurality of signals of predetermined frequencies.

11. In a multiplex photoelectric recording system, sending apparatus for generating a wave of radiant energy modulated at a plurality of frequencies including a synchronizing frequency, said sending apparatus comprising, in combination, a rotatable drum having a plurality of translucent sinusoidal frequency producing tracks therein, means for rotating said drum at a substantially constant speed, means operatively connected to said rotating means for obtaining a synchronizing signal of said synchronizing frequency, a lamp in said drum, means connected to said lamp for energizing the same, a plurality of photoelectric means disposed in predetermined positions with respect to said plurality of tracks respectively for producing from the light energy

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passing through said tracks a plurality of electrical signals of substantially sinusoidal wave-forms, a plurality of means for modulating said plurality of electrical signals respectively, means for generating radiant energy, and means operatively connecting said plurality of modulating means and said means for generating a synchronizing signal to said means for generating radiant energy whereby the radiant energy is modulated by all the signals.

12. In a multiplex photoelectric recording system, receiving apparatus adapted to receive a wave of radiant energy modulated at a plurality of signal frequencies and a synchronizing frequency and to record modulation components of said signal frequencies comprising, in combination, energy receiving means, signal filter means operatively connected to said receiving means for obtaining therefrom a synchronizing signal, motor means energized by said synchronizing signal, a rotatable drum operatively connected to said motor means to be rotated thereby at a substantially constant speed predetermined by said synchronizing signal and having therein a plurality of translucent sinusoidal frequency producing tracks corresponding to said signal frequencies, lamp means disposed within said drum and adapted when energized to illuminate all said tracks, means for amplifying the output of said receiving means and energizing said lamp means therefrom, a plurality of photoelectric means disposed in predetermined positions with respect to said plurality of tracks respectively, and a plurality of recorders operatively connected to said plurality of photoelectric means respectively, each of said recorders being tuned

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to eliminate the component of signal frequency applied thereto and to record the modulation component.

13. In apparatus of the character disclosed, in combination, photoelectric means, illuminating means, moving track forming means operatively associated with said photoelectric means and said illuminating means and constructed and arranged to generate at least one A.-C. signal in said photoelectric means, means for modulating said signal in accordance with variations in a quantity to be measured, and means for transmitting energy corresponding to said signal to a remote point.

14. In apparatus of the character disclosed, in combination, energy receiving means, illuminating means operatively connected to said energy receiving means and energized therefrom, photoelectric means, movable track forming means operatively associated with said photoelectric means and said illuminating means and constructed and arranged to generate in said photoelectric means at least one A.-C. signal, and recording means operatively connected to said photoelectric means.

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