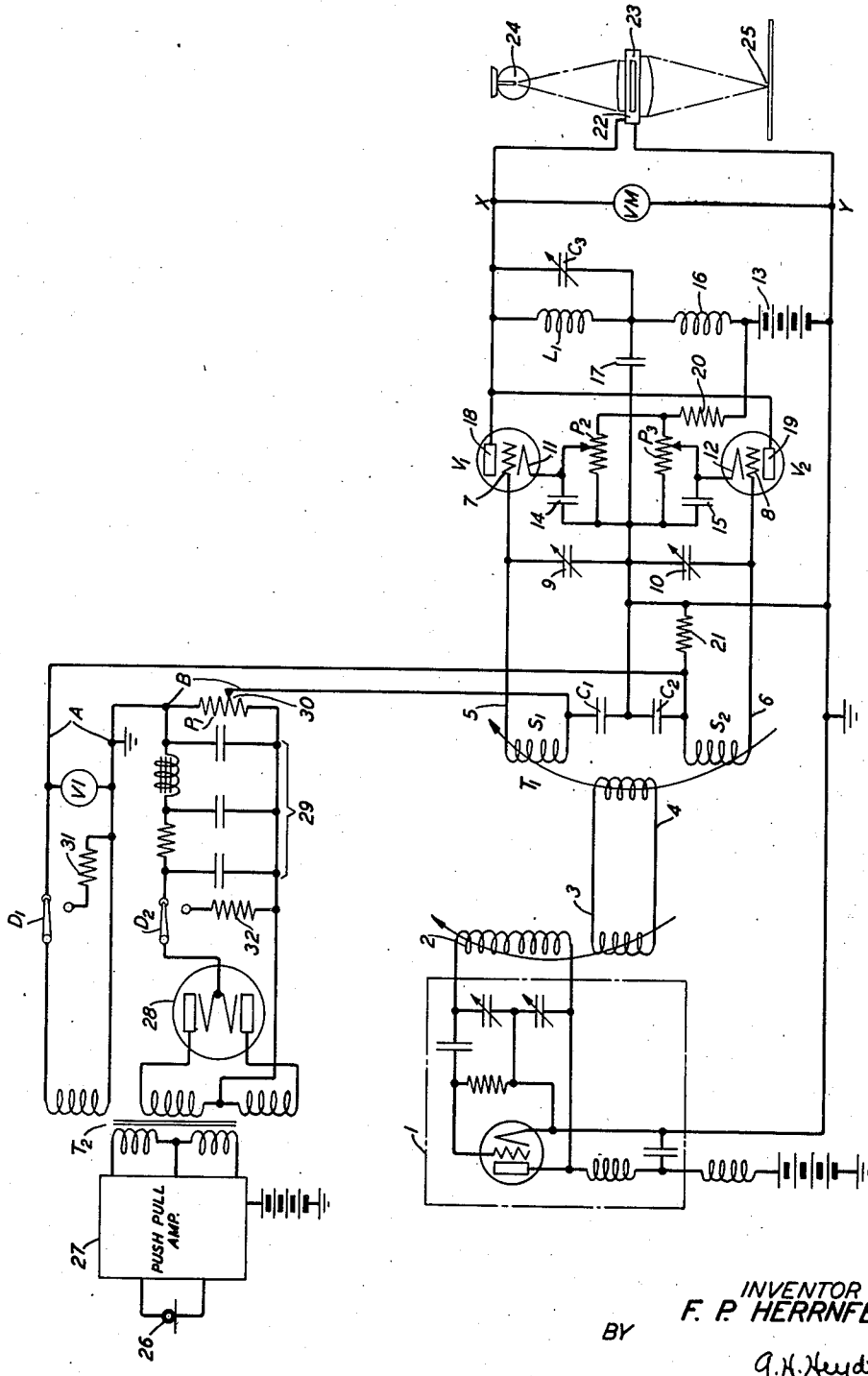
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SOUND RECORDING WITH SUPERSONIC MODULATOR

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SOUND RECORDING WITH SUPERSONIC MODULATOR

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This invention relates to electrical transmission of intelligence by means of a current of carrier frequency modulated by an audio frequency, particularly with reference to the photographic recording of such transmitted intelligence including the addition of freedom from disturbing noise during intervals when the modulating audio frequency is low in level or altogether absent. A preferred embodiment of the invention is described whereby noiseless photographic sound records of the variable density type may be obtained in a recording system in which the modulator is a supersonic valve such as that disclosed in United States Patent 2,287,587, granted June 23, 1942, to G. W. Willard.

The use in photographic sound recording of a supersonic valve of this general description is described in United States Patent 2,084,201, granted June 15, 1937, to A. Karolus. However, the disclosures of the prior art show no method or circuit means whereby the advantages of noise reduction now universally demanded of sound records can be added.

It is, therefore, an object of the present invention to provide means for photographic sound recording with noise reduction using a supersonic modulator. Reduction of noise in carrier transmission circuits during intervals of low or absent audio signals is taught, for example, in United States Patent 1,681,972, granted August 28, 1928, to O. B. Blackwell and H. A. Affel. For the present purpose, however, the greatest simplicity is desired in recording circuits and it is another object of the invention to provide a novel carrier transmission system of controlled carrier amplitude characterized by a minimum complexity of apparatus.

A feature of the invention is the provision of a pair of vacuum tubes by which is effected the final step of amplification of both the carrier frequency and the modulating signal frequency. These tubes are so arranged as to possess a net conductance varying with the level of the modulating signal between the maximum conductance of either tube alone and a minimum determined by the adjustment of the noise reduction control.

Other objects and features of the invention will be apparent from the following description when read with reference to the accompanying drawing in which the single figure schematically represents a circuit adapted to achieve the objects above declared.

In the figure, 1 is an oscillator tuned to a carrier frequency of, say, 8 megacycles per second. Tuning coil 2 of this oscillator is linked as desired through link circuit 3 to primary 4 of transformer T1, the secondary winding of which is divided into two parts, S1 and S2, joined by by-pass condensers C1 and C2 in series, the junction of these condensers being connected to ground. Terminals 5 and 6 of the windings S1 and S2 are connected respectively to grids 7 and 8 of vacuum tubes V1 and V2 which are represented in the figure as triodes but may, of course, be pentodes if desired. As indicated, link circuit 3 is adjustably linked at one end to oscillator tuning coil 2 and at the other end to primary 4 of transformer T1. The secondary circuits S1 and S2 of transformer T1 are provided with trimmer condensers 9 and 10 whereby the transformer output circuits are accurately tuned to the carrier frequency generated by oscillator 1.

Cathodes 11 and 12 of tubes V1 and V2, respectively, are maintained at the desired positive potentials with respect to grids 7 and 8, cathode 11 by a tap on potentiometer P2, cathode 12 by a tap on potentiometer P3. These potentiometers, in parallel, are in series with resistance 20 between the positive terminal of battery 13 and ground. By-pass condensers 14 and 15 are provided in shunt between ground and cathodes 11 and 12, respectively. It is to be understood that the cathodes named are heated by the usual power supply, not shown.

Inductance 16 and condenser 17 constitute a filter for the anode current supply of tubes V1 and V2 which is obtained from battery 13 through inductances 16 and L1, the purpose of the latter inductance being stated below. Anodes 18 and 19 of tubes V1 and V2 are joined together and to the terminal of inductance L1 remote from battery 13.

It will at once be observed that the grid-cathode circuits of tubes V1 and V2 are in push-pull connection while the corresponding anode circuits are in parallel. Therefore, if the conductances of tubes V1 and V2 are equal, no carrier voltage will appear between ground and the junction of anodes 18 and 19 whatever the input carrier voltage transmitted from oscillator 1 to the grid-cathode circuits of tubes V1 and V2. The conductances of these tubes are individually determined by adjustment of potentiometers P2 and P3.

The advantage in efficiency of operating a vacuum tube as a class B amplifier is well known and it is here preferred so to adjust P3 that tube V2 is just at cut-off when there is no carrier voltage on grid 8. P2 may then be adjusted so that a push-pull alternating voltage on grids 7 and 8 results in no alternating current in the

output circuit or P2 may be adjusted to provide a still greater negative bias of grid 7 in which case there is a net conductance for tubes V1 and V2 over the half-cycle of carrier voltage from oscillator 1 which V2 is permitted to pass. The value of this net conductance may be varied by suitably setting a tap on potentiometer P2 so that the opposition of tube V1 to tube V2 is complete to any desired degree.

With the tap on P2 so placed that no conductance results in V1, the circuit functions as a class B amplifier of the carrier voltage received on grid 8. If a modulating signal voltage is now impressed across the terminals of resistance 21, in series between ground and secondary winding S2, output terminals X and Y are capable of transmitting a modulated carrier wave to any desired transmission line or terminal apparatus; for example, XY may lead to the crystal 22 of a supersonic valve 23 and the modulated carrier voltage so impressed on crystal 22 may be used to modulate the light from source 24 transmitted through valve 23 to film 25 as described in the prior art. Film 25 is driven by conventional means not shown.

If, now in addition to the modulating signal voltage across resistor 21, it is arranged to provide a control of the net conductance of tubes V1 and V2 in accordance with the envelope of the modulating signal, one may so arrange matters that the net carrier voltage appearing across terminals X and Y is at all times only that which can be fully modulated by the audio frequency, thereby making possible a noiseless recording on film 25 of the variable density type.

Before providing audio signal and the noise control it is necessary to tune the tank circuit composed of inductance L1 and condenser C3 to the carrier frequency derived from oscillator 1 and by adjustment of the coupling of link circuit 3 to provide across terminals X and Y a carrier voltage (tube V1 being fully blocked for this purpose) of magnitude required to drive the crystal 22. A vacuum tube voltmeter VM is provided to measure the voltage between the terminals X and Y. Tank circuit L1—C3 serves to provide a sine wave of carrier voltage derived from the class B output of tube V1. A crystal modulator of the type here considered is sufficiently highly tuned so that no detuning of oscillator 1 is to be feared as the conductances of tubes V1 and V2 are varied.

It will be noted that secondary S1 of transformer T1 is conductively connected to ground through a portion of potentiometer P1 in the upper part of the figure. A steady or slowly varying voltage across P1 determines the control of the net conductance of tubes V1 and V2 as this depends upon the grid bias of tube V1.

For the carrier transmission circuit so far described, a modulating and noise controlling circuit is provided comprising microphone 26 succeeded by amplifier 27 which may include a plurality of push-pull amplifications. Through transformer T2 the output of amplifier 27 when sound waves are received by microphone 26 is in part transmitted as a signal voltage of audio frequency in path A whereby an instantaneous audio voltage is impressed across resistor 21. Simultaneously, a portion of the output of amplifier 27 is rectified by a full wave rectifier 28 and supplied through filter 29 so that a rectified voltage, the envelope of the audio signal, is variably selected by tap 30 of potentiometer P1 and applied through circuit B to grid 7 to control the conductance of tube V1. The portion of P1 included between tap 30 and ground is in series between ground and secondary winding S1 of transformer T1, and the indicated poling of rectifier 28 and connection of circuit B is such that as the level of the audio signal in circuit A varies, the conductance of tube V1 is correspondingly varied, thereby providing a net conductance for tubes V1 and V2 which varies with the level of the audio signal across resistor 21 which modulates the carrier voltage derived from oscillator 1. It may be preferred, as insurance of greater freedom from distortion in circuit A, to provide for each of circuits A and B a separate amplifier succeeding amplifier 27.

The adjustment of the circuit prior to recording the audio signal received by microphone 26 is as follows: Oscillator 1 is energized and tuned to the frequency of crystal 22 which is itself for this adjustment replaced by a dummy load, tube V1 being removed from the circuit. V2 is adjusted for class B operation. The output circuits of transformer T1 and circuit L1—C3 are tuned for maximum carrier output and link circuit 3 is adjusted to provide a carrier voltage on voltmeter VM sufficing to permit full modulation of the light transmitted by supersonic valve 23. Thereafter crystal 22 and tube V1 are replaced and P2 is so adjusted that V1 is just at cut-off with the carrier voltage applied.

Switches D1 and D2 are provided so that in preliminary adjustment either circuit A or circuit B may, as desired, be replaced by a resistor 31 or 32, respectively, without disturbing the adjustment of the companion circuit. If these switches are in position as indicated in the figure and the operations just described have been performed, conditions are such that the whole unit operates as a class B modulator wherein an input sound signal received by microphone 26 modulates the carrier voltage derived from oscillator 1. The output of rectifier 28 and filter 29 is so poled in conjunction with the initial adjustment of potentiometer P2 that tube V1 is not conductive no matter how high the audio input signal may be. A record of the microphone signal without noise reduction may now be made on film 25. The level of this signal is read on volume indicator V1.

To apply noise reduction, the audio input is removed by suitably operating switch D1 and potentiometer P2 is so adjusted that the conductance of V1 effects partial cancellation of tube V2. Voltmeter VM reads, say E1 when V1 is permitted a partial conductance and E2 when V1 is blocked, so that noise reduction in decibels may be stated as

$$NR = 20 \log_{10} \frac{E_2}{E_1}$$

The setting of tap 30 on potentiometer P1 is a margin setting provided for the accommodation of abrupt increases in audio signal level.

In the foregoing description there has been set forth the application of the present invention to the photographic recording of sound, but it will be clear that the invention is in no way limited to such application and may be used wherever carrier transmission of low frequency signals is required with or without the advantage of suppressing to a desired extent the carrier frequency during periods when the modulating signal is of low level or absent.

What is claimed is:

1. In a carrier transmission circuit, means for

generating a voltage of carrier frequency, means for simultaneously and differentially amplifying said carrier voltage in opposite phases in a pair of transmission paths, means for controlling the relative amplification in said paths, means for uniting the opposite phases of said carrier voltage as differentially amplified, means for generating a voltage of signal frequency, means for rectifying a portion of said signal voltage, and means for simultaneously controlling in accordance with said rectified portion the amplification in one only of said paths and modulating said carrier voltage in the other only of said paths by said signal voltage.

2. In a carrier frequency transmission circuit, a carrier frequency oscillator, an output circuit for said oscillator, power supply for said oscillator, a pair of vacuum tubes provided each at least with a control grid, a cathode and an anode, power supply for said tubes, a terminal connected to both of said anodes, a grounded terminal to which said cathodes are individually connected through adjustable resistances relatively adjusted to provide a net conductance for said vacuum tubes, individual input circuits between said control grids and said grounded terminal comprising each a resistor in series with inductive coupling to the output circuit of said oscillator, said input circuits being connected for push-pull coupling of said control grids to said output circuit, a source of audio frequency current, means for impressing across the resistor in one of said input circuits a voltage proportional to the instantaneous magnitude of said audio current, means for rectifying a portion of said audio current, and means for impressing across the resistor in the other of said input circuits a voltage proportional to the magnitude of said rectified current.

3. A sound recording circuit including in combination a supersonic light valve having a pair of terminals, a source supplying supersonic voltage to said valve comprising a supersonic oscillator, a pair of vacuum tubes provided each at least with a cathode, a control grid and an anode, said cathodes being individually connected to ground through variable resistances, said control grids being inductively coupled in push-pull to said oscillator and said anodes being connected together and to the ungrounded terminal of said valve, a source of audio frequency current, means for supplying to one of said control grids a voltage proportional to the instantaneous value of said current, means for rectifying a portion of said current, and means for supplying to the other of said control grids a voltage proportional to said rectified current whereby the supersonic voltage applied to said valve is varied in amplitude in accordance with the envelope of said rectified current.

4. In a sound transmission circuit in combination, an oscillator having an output circuit providing a voltage of supersonic frequency, power supply for said oscillator, a pair of amplifying tubes provided each at least with a control grid, a cathode and an anode, power supply for said tubes, a common connection of said anodes to an output terminal, adjustable biasing resistors individually connecting said cathodes to a common grounded output terminal, said biasing resistors being separately adjusted to provide unequal conductances for said tubes, input circuits individual to said tubes including each a series resistance connected to said grounded terminal, inductive coupling between said oscillator and said input circuits in push-pull connection, a source of voltage of audio frequency, means for applying said audio frequency voltage across the series resistance in one of said input circuits, means for rectifying a portion of said audio frequency voltage, and means for applying said rectified voltage across the series resistance in the other of said input circuits whereby there is produced between said output terminals a supersonic voltage modulated in accordance with the instantaneous value of said audio frequency voltage, and of average amplitude controlled by said rectified voltage.

5. In a signaling system in which a supersonic frequency is modulated by a signal of audio frequency, the method which consists in generating a voltage of supersonic frequency, amplifying said supersonic voltage differentially and oppositely in phase in a pair of transmission paths, combining said paths to produce a net amplified supersonic voltage, generating a voltage of audio frequency, introducing said audio voltage in one only of said paths, rectifying a portion of said audio voltage, introducing said rectified voltage in the other only of said paths, and simultaneously controlling the level of said net supersonic voltage in accordance with the envelope of said rectified voltage and modulating said net supersonic voltage by said audio voltage.

6. In a carrier signaling system in which a carrier frequency is modulated by signal frequency, the method which consists in generating a voltage of said carrier frequency, amplifying said carrier voltage differentially and in opposite phase in a pair of transmission paths, combining said paths to produce a net amplified supersonic voltage, generating a signal voltage, introducing said signal voltage in one only of said paths, rectifying a portion of said signal voltage, introducing said rectified voltage in the other only of said paths, and simultaneously controlling the level of said net carrier voltage in accordance with the envelope of said rectified portion and modulating said net carrier voltage by said signal envelope.

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