March 16, 1965 G. D. HENDRICKS ETAL 3,174,131

REMOTE CONTROL OF TRAFFIC CYCLE LENGTH

Filed July 28, 1959 3 Sheets-Sheet 1

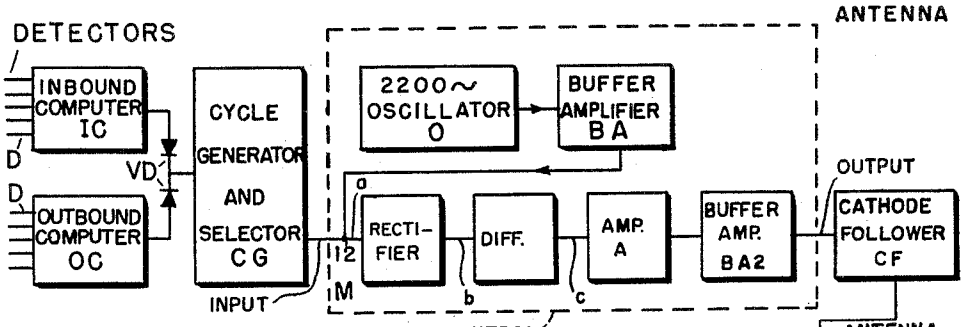


FIG. 1

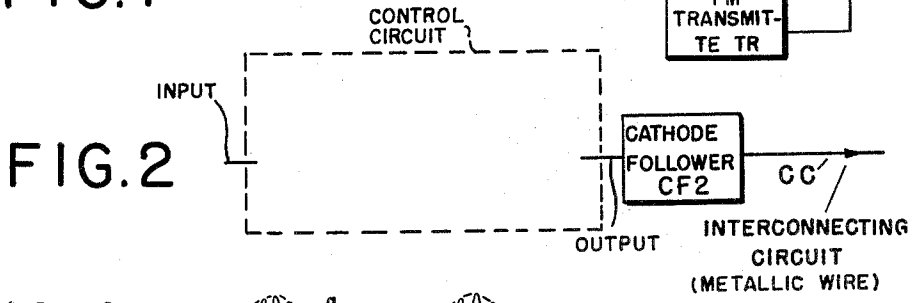


FIG. 2

FIG. 4

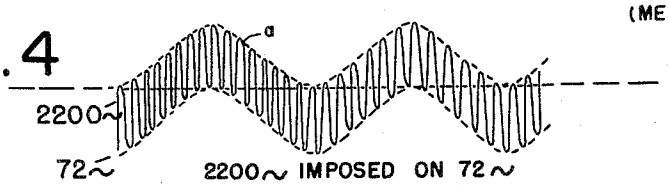
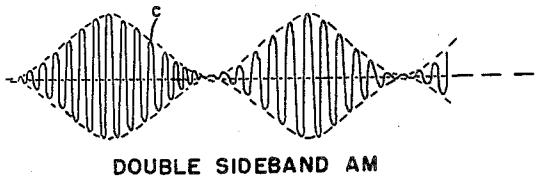


FIG. 5



FIG. 6



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REMOTE CONTROL OF TRAFFIC CYCLE LENGTH

Filed July 28, 1959 3 Sheets-Sheet 2

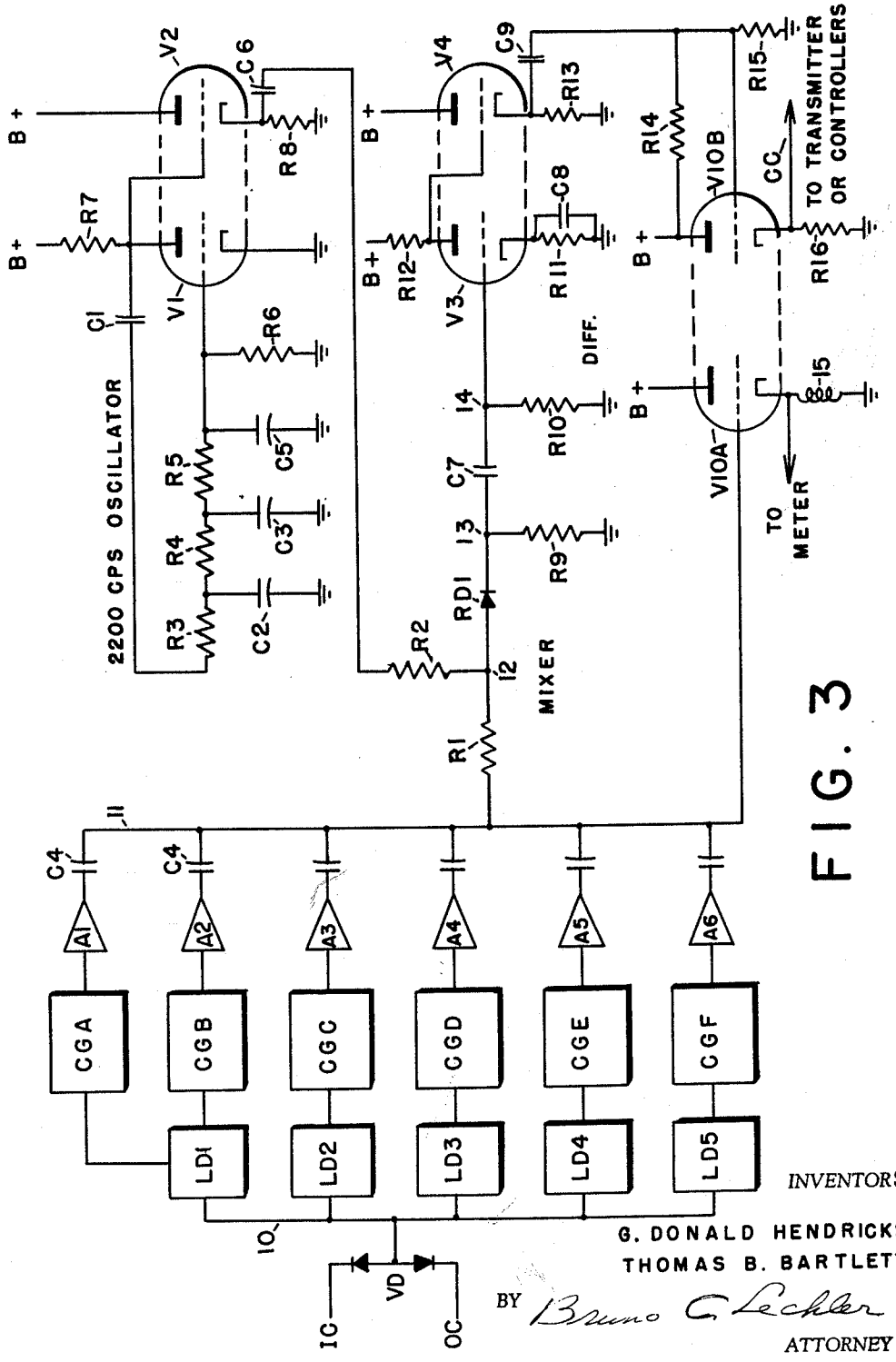


FIG. 3

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REMOTE CONTROL OF TRAFFIC CYCLE LENGTH

Filed July 28, 1959 3 Sheets-Sheet 3

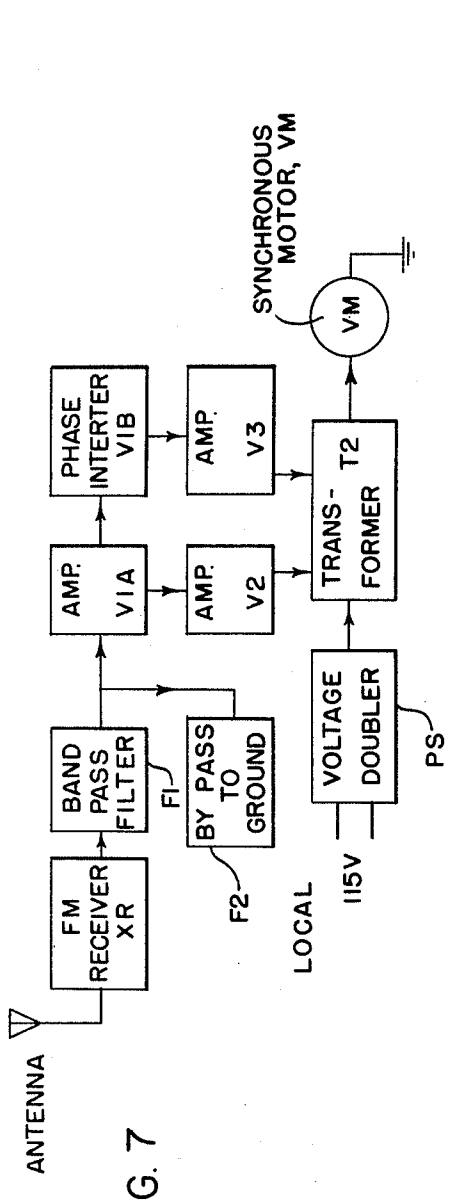


FIG. 7

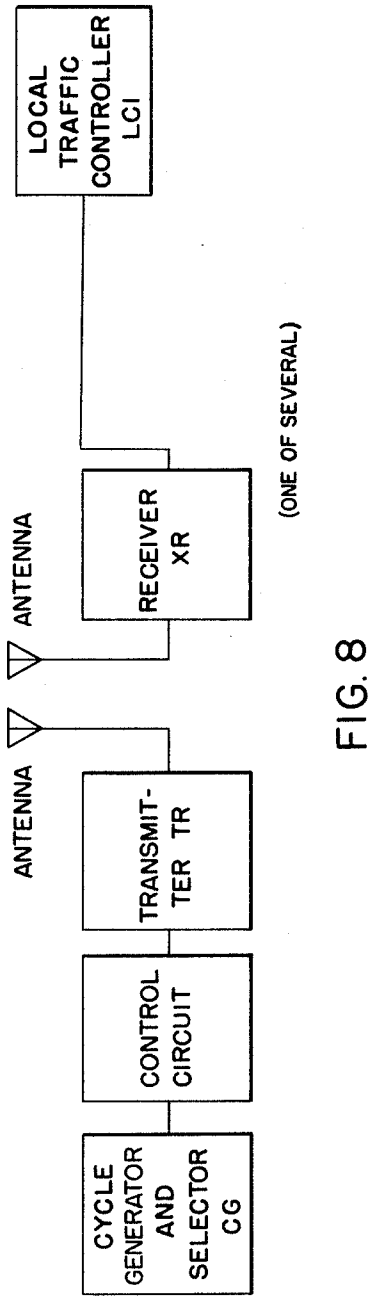


FIG. 8

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United States Patent Office 3,174,131 Patented Mar. 16, 1965

3,174,131
REMOTE CONTROL OF TRAFFIC CYCLE LENGTH

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Filed July 28, 1959, Ser. No. 830,096
7 Claims. (Cl. 340—35)

This invention relates to remote control of a number of variable speed motors by wire or by radio, and in particular to a system of remote control from a master traffic controller of a number of variable speed synchronous motor driven traffic cycle timers at a plurality of street traffic signal controllers to thus establish and maintain any one of a number of uniform traffic cycle durations at each controller.

The invention may be used in conjunction with a filtering and amplifying system located at one or more street traffic signal controllers and disclosed in United States Patent application 830,038, entitled Constant Current Traffic Control Amplifier, now abandoned, filed the same date as the present application.

The invention is directed toward a method of amplitude modulating a base or carrier frequency with a control frequency variable in steps proportional to traffic volume, transmitting the modulated base frequency to a plurality of intersection controllers, demodulating the base frequency to obtain the control frequency, and amplifying the control frequency and applying it to the synchronous timing motors.

Although many devices for varying the duration of a traffic signal cycle have been invented and disclosed, none to my knowledge, makes use of a base or carrier frequency modulated by a control frequency for continuously and accurately governing the timing of the cycle of signal change at a large number of traffic signal controllers.

The purpose of the invention is to provide means to make possible and practical the remote control of a synchronous motor by supplying it with variable frequency power controlled from a remote source. For economy it is desired to use a standard synchronous motor, such as a Telechron clock motor, and to energize it from a remote point over a radio link, or an interconnecting metallic wire circuit. The circuit may be a leased telephone pair and for that reason a low voltage signal of approximately 10 volts is employed. However, the 60 cycle static interference on the circuit may approach 50 to 60 volts, and drive the motor at all times and render the control frequency ineffective.

The problem is solved by employing a base or carrier frequency above 1,000 c.p.s. and modulating the base frequency with the control frequency. A higher frequency is not satisfactory because it would be attenuated on the interconnecting circuit. In the present embodiment of the invention a 2,200 c.p.s. carrier is preferred. A few of the control frequencies normally used are 30, 40, 48, 60, 72, and 90 cycles per second. These frequencies drive the motor at speeds from 50% to 150% of design speed and result in traffic cycle durations of 120, 90, 75, 60, 50, and 40 seconds, respectively.

Another advantage of using a base frequency modulated by the control frequency is that the 2,200 c.p.s. signal is a good frequency for modulating a radio frequency carrier for radio transmission used at each local controller to detect the radio frequency signal, demodulate it and obtain the base frequency. A special amplifier is used to detect the control frequency which is amplified and used to drive the synchronous motor. The motor is coupled to the amplifier through a transformer. The combination provides a substantially constant current

source. The impedance of the motor increases with the higher frequencies but the current supplied to the motor by the transformer secondary remains substantially constant because the voltage output of the transformer is automatically increased. Thus the motor provides a substantially constant torque output at all speeds between 50% and 150% of design speed.

Accordingly, apparatus is herein disclosed which will continuously and accurately control the timing of a plurality of local traffic signal controllers utilizing a modulated carrier or base frequency signal. Apparatus to develop the control frequency which is used to amplitude modulate the base frequency is also described. No claim is herein made to the control frequency generation apparatus, it having been disclosed and claimed in United States Patent 3,047,838, entitled Traffic Cycle Length Selector. Likewise, no claim is herein made to the utilization apparatus located in the local intersection controllers, it being disclosed and claimed in the co-pending United States patent application Serial Number 642,469, entitled Multiple Program Traffic Control Systems.

The invention comprises means to amplitude modulate a base frequency signal for transmission to all of the local controllers. The base frequency signal is amplitude modulated with a frequency inversely proportional to the traffic cycle duration desired.

An important feature of the invention is its adaptability for use as a source of signal for modulating a radio carrier frequency as well as for use as a means of controlling, over a wire circuit, an amplifier unit located at each intersection controller. For the latter use the output of the apparatus is applied directly to a wire circuit which connects with an amplifier in each local controller. For the former use, the output of the apparatus is used to frequency modulate a radio frequency carrier wave which is transmitted from the master controller and detected by a radio receiver at each local controller. The output of the receiver is employed to control an amplifier in each local controller. The method used will depend on the availability of a one wire circuit and common return.

In the preferred form of the invention six control frequencies are employed: 90, 72, 60, 48, 40, and 30 cycles per second, which correspond to six traffic cycle durations: 40, 50, 60, 75, 90, and 120 seconds per cycle, respectively. As many as fourteen cycle durations are available, with the user choosing six which best match his requirements. The present invention is illustrated as applied to traffic cycle length selector apparatus of the type disclosed in Patent 3,047,838, identified above, which provides means for detecting six levels of traffic volume and generating six frequencies. Of course, more or fewer levels and frequencies may be provided. The invention is also useful for other control applications.

The control frequencies are originated in a cycle generator and selector described in Patent 3,047,838, mentioned above. The apparatus employs a plurality of vibrating reed signal frequency generators each of which oscillate at one of the frequencies listed above. Each signal frequency is applied to its own amplifier. Which of the amplifiers is operative depends on the level of traffic volume on a thoroughfare. The level of traffic volume is determined by a six stage level detector which makes one of the amplifiers operative depending upon the running average of instantaneous traffic volume.

In the present invention the output of the effective one of the amplifiers is applied to a mixer circuit where the signal is used to amplitude modulate a base or carrier frequency signal. The amplitude modulated base frequency is next fed to an amplifier before being applied to the interconnecting circuit or to the radio transmitter. The signal is sent to all local intersection controllers where it is detected, amplified, demodulated, amplified,

and used to drive a small synchronous motor. The motor drives a cycle timing dial in the intersection controller and times each cycle of traffic signal change. Other apparatus is employed to effect a division of the traffic signal cycle between the two or more intersecting streets, and to time the start of the traffic signal cycle at each intersection at one of a plurality of offsets with respect to the traffic signal cycle at the master controller.

An example of apparatus employed to effect a division or split of the traffic signal cycle is shown in United States Patent application 742,160, filed June 16, 1958, and entitled Traffic Cycle Split Selectors.

An example of apparatus employed to time the start of the traffic signal cycle at each intersection at an offset with respect to the traffic signal cycle at a master intersection is shown in United States patent application 768,193, filed October 20, 1958, and entitled Traffic Cycle Offset Selector.

A primary object of the invention is to control the duration of a traffic signal cycle at a group of local controllers simultaneously over an interconnecting circuit or a radio link from a traffic adjusted master controller and transmitter.

Another object of the invention is to provide signal generation and modulation means adapted to develop a carrier frequency modulated by a control frequency inversely proportional to a desired traffic cycle duration.

Another object is to provide a plurality of low frequency signal sources and a fixed frequency signal generator coupled together through a mixer stage, and a differentiating network, an amplifier, a decoupling buffer, a cathode follower, and a single channel connected to a plurality of intersection controllers.

Another object is to provide a variable frequency signal which can be sent over a wire circuit or a radio link to control a plurality of intersection controller timers.

Another object is to provide apparatus capable of developing a signal adapted to modulate a radio frequency carrier wave.

Another object is to provide a variable frequency modulated carrier frequency generation and detection system substantially immune to static interference.

Another object is to provide apparatus to develop a signal suitable for transmission over a two wire circuit on which induced pickup may be of greater amplitude than the control frequency.

Another object is to provide a carrier frequency modulated by a control frequency detected at each local controller.

The invention will be described with reference to the following drawings, of which:

FIGURE 1 is a block diagram of the apparatus which is employed to frequency modulate a carrier frequency for transmission to all local controllers.

FIGURE 2 is a partial block diagram of one form of the invention employing an interconnecting circuit to all local controllers.

FIGURE 3 is a wiring diagram of the circuit including level detectors, reed vibrator and oscillation sustaining circuits, and modulator and amplifiers of the master traffic cycle length determining apparatus.

FIGURES 4, 5, and 6 show various wave shapes of the type utilized by this invention.

FIGURE 7 is a block diagram of the local controller apparatus designed for radio interconnection with the apparatus of FIGURE 1.

FIGURE 8 is a block function diagram illustrating a transmitting and a receiving block.

Referring to FIGURE 1, the subject invention is shown in the central portion of the figure bordered by dotted lines and entitled CONTROL CIRCUIT. Its function is to combine the control signal developed by the cycle generator and selector CG with a base frequency developed by the 2200 c.p.s. oscillator. The resultant amplitude modulated signal is applied to a standard FM transmitter TR for broadcast to all of the local controllers.

The cycle generator and selector CG receives an input voltage from voltage divider VD which passes the higher of the two potentials received from the inbound or outbound computer IC, or CC. The computers are designed to develop an output potential representative of a running average of traffic volumes in the inbound or outbound direction. They receive data from traffic detectors D mounted in the inbound and outbound lanes.

Apparatus within the cycle generator and selector CG is designed to detect the level of the input voltage and assign it to one of six levels. Whichever level detector is energized in turn makes one of a group of amplifiers effective. The input to each of the group of amplifiers is an ever-present signal frequency developed continuously by a group of reed controlled oscillators. The output of the effective amplifier is fed to a mixer circuit which is supplied also with a fixed, higher, base frequency. The base frequency is developed in oscillator O and is used to control a buffer amplifier BA which consists of a cathode follower.

The control frequency and the base frequency are applied to a junction 12, where the two waves are mixed. The resultant wave *a* is a 2200 c.p.s. wave riding on the control frequency wave. The resultant wave *a* is then rectified to form a wave *b*, and differentiated in the differentiator network M to obtain a double side band amplitude modulated wave *c*. The wave *c* is amplified in amplifier A and passed to a buffer amplifier BA2. The output is applied to a cathode follower CF. The AM signal may be applied to a standard FM transmitter TR as in FIGURE 1 or may be applied to another cathode follower CF2 and an interconnecting circuit CC as in FIGURE 2.

The CONTROL CIRCUIT of FIGURE 2 is identical with that of FIGURE 1 except for the second cathode follower CF2 and the metallic wire interconnecting circuit CC. If only a few controllers are to be energized from circuit CC, the second cathode follower CF2 may be eliminated.

Referring now to FIGURE 3, the circuit of the invention will be described in greater detail. The left portion of the figure shows the control frequency generators and the right portion of the figure shows the base frequency oscillator and amplifiers. The output of the final stage may be used to frequency modulate a radio frequency carrier in a standard FM transmitter or may be applied directly to a circuit connected to a number of local controllers.

The control frequency generators are disclosed in detail in United States Patent 3,047,838 and entitled Traffic Cycle Length Selector. They are shown here because they are the source of the control frequency. Six reed controlled oscillator circuits are indicated by the rectangles labeled CGA–CGF. Each oscillator is operative at all times so that all six control frequencies are available when needed. Each oscillator is provided with an amplifier A1–A6 which is normally inoperative because it is deprived of plate voltage. One of the amplifiers is supplied with plate voltage through one of the level detectors and switching devices LD1–LD5. Which of the level detectors is energized depends on the potential arriving on the common line 10 from the voltage detector VD which in turn passes the higher of the potentials arriving from the inbound traffic volume computer IC or the outbound traffic volume computer OC.

When the potential from the voltage detector VD is less than that required to pull in the lowest level detector LD1, the amplifier A1 associated with cycle generator CGA is supplied with plate potential and amplifies the control frequency A. As successively higher voltages appear at the voltage detector VD and at the level detectors LD1–LD5, succesive level detectors are energized. The highest energized level detector deenergizes the lower level detectors and applies plate potential to its corresponding amplifier. The energized amplifier amplifies the out-

put of its cycle generator. Each of the cycle generators CGA–CGF have their outputs connected to a common line 11 through a coupling capacitor C4. The output of the effective cycle generator and amplifier is applied to junction 12 through limiter resistor R1. Thus, any one of six cycle control frequencies A–F are applied to junction 12. The output of the base frequency oscillator is applied also to junction 12 through a limiter resistor R2.

The base frequency oscillator O is comprised of a triode vacuum tube V1 and a feedback circuit providing positive feedback of sufficient amplitude to maintain oscillation. The feedback circuit consists of a blocking capacitor C1, and a phase shift network consisting of resistors R3, R4, R5 and capacitors C2, C3, C5. Grid leak resistor R6 develops a voltage drop across it which provides the grid with bias voltage. Plate circuit resistor R7 limits the peak plate current and provides a voltage drop from B+ voltage at the plate of tube V1. This varying voltage drop is applied to the grid of triode V2 which serves as a buffer amplifier. Tube V1 is lightly loaded to insure frequency stability. Actually, the grid of tube V2 is the only load on tube V1 other than the limiter resistor R7 and the resonant feedback circuit.

Resistor R8 in the cathode circuit of tube V2 serves as a cathode follower. Voltage is taken off the cathode end of resistor R8 through coupling capacitor C6 and applied to junction 12 through limiting resistor R2. At junction 12 the control frequency and base frequency are mixed. The resultant wave *a*, see FIGURE 4, is a base frequency signal of 2200 c.p.s. riding on top of the control frequency signal of 72 c.p.s., for example. Note that the height of the 2200 c.p.s. wave does not vary and at the time the 72 c.p.s. wave reaches its positive peak the 2200 c.p.s. wave is entirely positive. When the 72 c.p.s. wave reaches its negative peak the 2200 c.p.s. wave is entirely negative.

An envelope of the type shown in FIGURE 4 cannot be used to modulate a carrier wave or be applied directly to the interconnecting circuit to energize the local timing motors. It must first be rectified and then differentiated.

A rectifying diode RD1 has one lead connected to junction 12 and its other lead connected to junction 13. Load resistor R9 is connected between junction 13 and ground. The rectified wave *b* appearing at junction 13 is shown in FIGURE 5. Note that the positive half of the signal is all that remains.

A differentiating network consisting of capacitor C7 and resistor R10 connected in series is connected between junction 13 and ground. The midpoint of this series connection is termed junction 14. A double sideband amplitude modulated signal wave *c*, see FIGURE 6, appears at junction 14. Note that the wave *c* is double sideband and amplitude modulated.

The output of the differentiating network appearing at junction 14 is applied to the grid of amplifier tube V3. Resistor R10 supplies a path to ground for the current passed by capacitor C7 and establishes a grid bias voltage. Resistors R9 and R10 are adjusted to obtain 100% modulation.

The signal shown in FIGURE 6 is amplified in triode V3. The amplifier is provided with a self biasing cathode resistor R11 and bypass capacitor C8. Resistor R12 in the plate circuit limits the current drawn by the plate.

The output of amplifier tube V3 is taken off at the plate and applied to the grid of a buffer amplifier tube V4 which serves as a cathode follower. The voltage developed across resistor R13 in the cathode circuit of tube V4 is applied to the grid of a cathode follower output stage through coupling capacitor C9. A positive bias is supplied to the grid of the low impedance cathode follower tube V10B through resistors R14, R15 which are connected between B+ and ground.

Tube V10B is shown also in United States Patent 3,047,838, identified above, at the top of FIGURE 4A. In practice, the tubes V1, V2 and V3, V4 are combined in two double triodes and are mounted with the cycle selector apparatus shown in FIGURES 4 and 4A of United States Patent 3,047,838, mentioned above. The voltage developed across cathode resistor R16 is applied as a modulating potential to a standard FM transmitter or may be applied directly to the circuit CC interconnecting the master controller with a group of local controllers.

Another cathode follower circuit is provided to supply control frequency signal to a frequency meter. The control frequency existing on common conductor 11 is applied to the grid of tube V10A. The potential developed across inductance 15 is applied to a voltmeter which serves as a frequency meter and is calibrated to read in seconds per traffic cycle.

The wave shape of the signal put out by the final stage, tube V10B, is similar to that shown in FIGURE 6. The circuit is designed to develop a double sideband amplitude modulated wave having a base frequency of 2200 cycles per second and an envelope varying at the control frequency, 72 cycles per second, for example. The circuit is designed to pass control frequency signals of from 30 to 90 c.p.s. with a good sinusoidal wave shape.

At each local controller designed to be governed or adjusted from the master controller a unique amplifier is employed. It is connected directly to the interconnecting circuit in those applications where a circuit is available. It is fed from a standard FM receiver in radio controlled applications. As shown in FIGURE 7, the broadest signal may be picked up by an antenna at each local controller. The signal is detected, amplified, and demodulated in a standard FM receiver XR. The carrier is eliminated and the audio frequency signal is applied to a band pass filter F1 which eliminates the static and passes only the modulated 2200 c.p.s. signal. The 2200 c.p.s. signal is bypassed to ground in the bypass filter F2 leaving only the control frequency remaining.

The control frequency is applied to amplifier V1A and a portion of the amplified output is applied to one half of a push pull amplifier V2. A small portion of the output of amplifier V1A is applied to a second amplifier V1B which also acts as a phase inverter. The inverter output is applied to the other half of the push pull amplifier V3. Both halves of the push pull amplifier drive a two winding transformer T2. A voltage doubler power supply PS provides power to the amplifiers and in turn to transformer T2. The output of transformer T2 is applied to a synchronous motor VM which drives the controller timing dial, not shown. The impedance of the motor is small in comparison with the impedance of the amplifier. As the impedance of the motor decreases at lower than normal operating frequency and increases at higher than normal operating frequency the amplifier provides a substantially constant current at all frequencies to permit the motor to supply a substantially constant torque.

Details of the amplifier are disclosed in United States patent application 830,038, filed the same date as the present application, and entitled Constant Current Traffic Control Amplifier, now abandoned.

In FIGURE 8 there is illustrated a block function diagram combining the elements of FIGURES 2, 3 and 7. Illustrated in the left hand portion of FIGURE 8 are the cycle generator and controller CG connected to the input of the CONTROL CIRCUIT. The output of the CONTROL CIRCUIT is connected to the FM transmitter TR. Illustrated in the right hand portion of FIGURE 8 is a FM receiver XR connected to a local controller LC_1.

Examples of the control frequency signals developed by the cycle generator and selector CG are listed below with the duration of the resulting traffic signal cycle tabulated alongside. The gearing between the motor and cycle timing dial is designed so that 60 cycle A.C.

power develops a 60 second traffic signal cycle. That is, 60 times 60 equals 3,600 cycles per traffic signal cycle.

Control frequency, cycles per second	Traffic cycle duration, seconds per cycle
30	120
32.7	110
36	100
40	90
42.4	85
45	80
48	75
51.4	70
55.4	65
60	60
65.5	55
72	50
80	45
90	40

It is understood that the figures and description of the circuits of the invention are made by way of illustration and not by way of limitation. Although a number of alternate forms of the invention have been pointed out above it is obvious to those skilled in the art that other modifications may be made without departing from the spirit of the invention as set forth in the following claims.

We claim:

1. For use in a traffic control system, including in combination, an inbound traffic volume computer, an outbound traffic volume computer, each of said computers adapted to develop an output signal substantially proportional to traffic volume in each direction along a thoroughfare, a detector connected to receive the output signal from each of said computers and to pass only the higher signal output, a plurality of control frequency generators and a selector including a like plurality of level detectors connected to receive from said detector said higher signal output and make effective one corresponding control frequency generator, a base frequency oscillator and buffer amplifier for developing a base frequency in the range of 1000 to 3000 cycles per second, means for mixing said effective control frequency and said base frequency, a rectifier for rectifying said mixed signals, differentiating network means for converting said rectified signals to a double sideband amplitude modulated wave, an amplifier connected to receive and amplify said modulated wave, a decoupling amplifier including a cathode follower connected to receive the output of said amplifier, a metallic circuit, and means to connect the output of said cathode follower to said metallic circuit.

2. For use with a local traffic signal controller timed by a synchronous motor energized through an amplifier having control frequency detection means, including in combination, at least one traffic volume computer to develop an output signal substantially proportional to traffic volume along a thoroughfare, a plurality of control frequency generators and selectors comprising a like plurality of level detectors connected to receive said output signal and make effective one corresponding control frequency generator, a fixed frequency generator for developing a fixed frequency in the range of 1000 to 3000 cycles per second, means for mixing said effective control frequency and said fixed frequency, rectifier means connected to said means for mixing for detecting said mixed signals, differentiating network means connected to said rectifier means for converting said detected signals to a double sideband amplitude modulated output, an amplifier connected to amplify said amplitude modulated wave, said amplifier having an output circuit connected to a circuit interconnecting a plurality of local controllers, each said local controller having filtering means, amplifying means and controlling means.

3. In a remote control signal transmission system in which interference pickup of power line frequencies is within the range of the fundamental and harmonic frequency of a plurality of control frequencies, signal transmission means comprising control frequency generation and selection apparatus for developing a control frequency inversely proportional to traffic volume on a thoroughfare, a carrier frequency generator to supply a constant frequency carrier, mixer circuit means connected to receive and mix said control frequency and said carrier frequency, a differentiator circuit connected to said mixer circuit means to receive the mixed frequencies and apply them to an amplifier, an amplifier connected to said differentiator circuit for amplifying the output thereof, an outgoing circuit connected to apply the output of said amplifier to a plurality of local controllers, and utilization apparatus at each local controller including traffic cycle duration determining apparatus energized therefrom.

4. In a signal transmission system in which static power line frequencies are within the range of a group of control frequencies, said system comprising control frequency generation and selection means for developing a control frequency inversely proportional to traffic volume on at least one lane, a generator to supply a fixed base frequency, a circuit connected to receive and mix said control frequency and said base frequency, a differentiator circuit connected to said circuit to receive the mixed frequencies and apply them to an amplifier, an amplifier connected to amplify the output of said differentiator circuit, output channel means for applying the output of said amplifier to a plurality of local controllers, and amplification apparatus at a plurality of said local controllers to isolate and amplify only said control frequency, and traffic cycle duration determining means a part of each local controller, said means energized by said amplified control frequency directly from said amplifier and at a plurality of local controllers not having amplifiers, said means energized over a circuit connected to an amplifier at an adjacent controller.

5. In a radio controlled traffic cycle duration determining system, including, means to measure traffic volume in at least one direction on at least one street, control frequency generation means controlled by said measuring means for developing a control frequency relative to said measured traffic volume, base frequency generation means, network means connected to said control and base frequency generation means, said network means provided for mixing said control and base frequencies and rectifying said mixed frequencies and then differentiating said rectified frequencies for developing a double sideband amplitude modulated signal, at least one stage of amplification controlled by said amplitude modulated signal, a frequency modulated radio transmitter controlled by the amplified amplitude modulated signal, and a frequency modulated radio receiver at each of a plurality of radio controlled traffic cycle timing means.

6. In a radio control signal transmission means in which interference frequencies are within the range of a plurality of control frequencies, said means comprising control frequency generation means for develop a control frequency inversely proportional to traffic volume on a thoroughfare, a base frequency generator to supply a constant frequency sub-carrier, circuit means connected to receive and mix said control frequency and said sub-carrier frequency, a differentiator circuit connected to said circuit means to receive the composite frequencies and apply them to an amplifier, an amplifier connected to the differentiator circuit for amplifying the differentiated composite frequencies, said amplifier having an output circuit connected to apply the output of said amplifier to an FM radio transmitter for frequency modulation of a radio carrier frequency and for broadcast therefrom, and at least one local controller having synchronous timing means, and means to detect and amplify said control frequency and energize said synchronous timing means therefrom.

7. In a radio controlled system for use in adjusting the timing of a plurality of local traffic control devices which are energized with variable frequency power through net-

work means controlled by an FM receiver for detecting, filtering and amplifying a variable frequency signal, including in combination, a remote control signal transmission means comprising control frequency generation and selection apparatus to develop a control frequency inversely proportional to traffic volume on a thoroughfare, a base frequency generator to supply a constant base frequency, circuit means connected to receive and mix said control frequency and said base frequency, a differentiator circuit connected to said circuit means to receive the mixed frequencies, an amplifier connected to the differentiator circuit to receive and amplify said differentiated mixed frequencies, said amplifier having an output circuit connected to apply the output of said amplifier to the input circuit of an FM radio transmitter, an FM radio transmitter adapted to receive and to broadcast the control

frequency signal to said FM receiver at said plurality of local traffic control devices.

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