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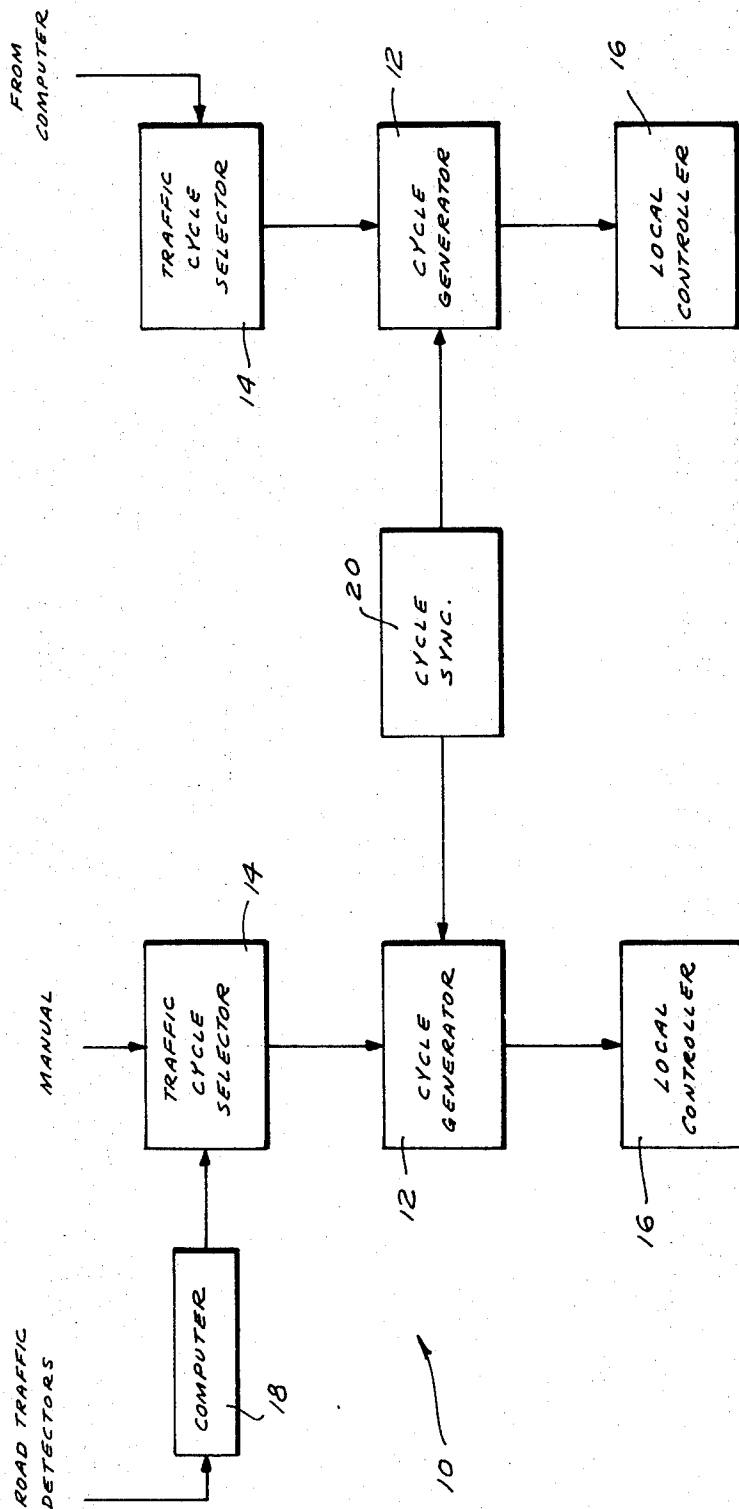
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PHASE SHIFT CYCLE GENERATOR FOR A TRAFFIC CONTROL UNIT

Filed Nov. 20, 1968

4 Sheets-Sheet 1

FIG. 1



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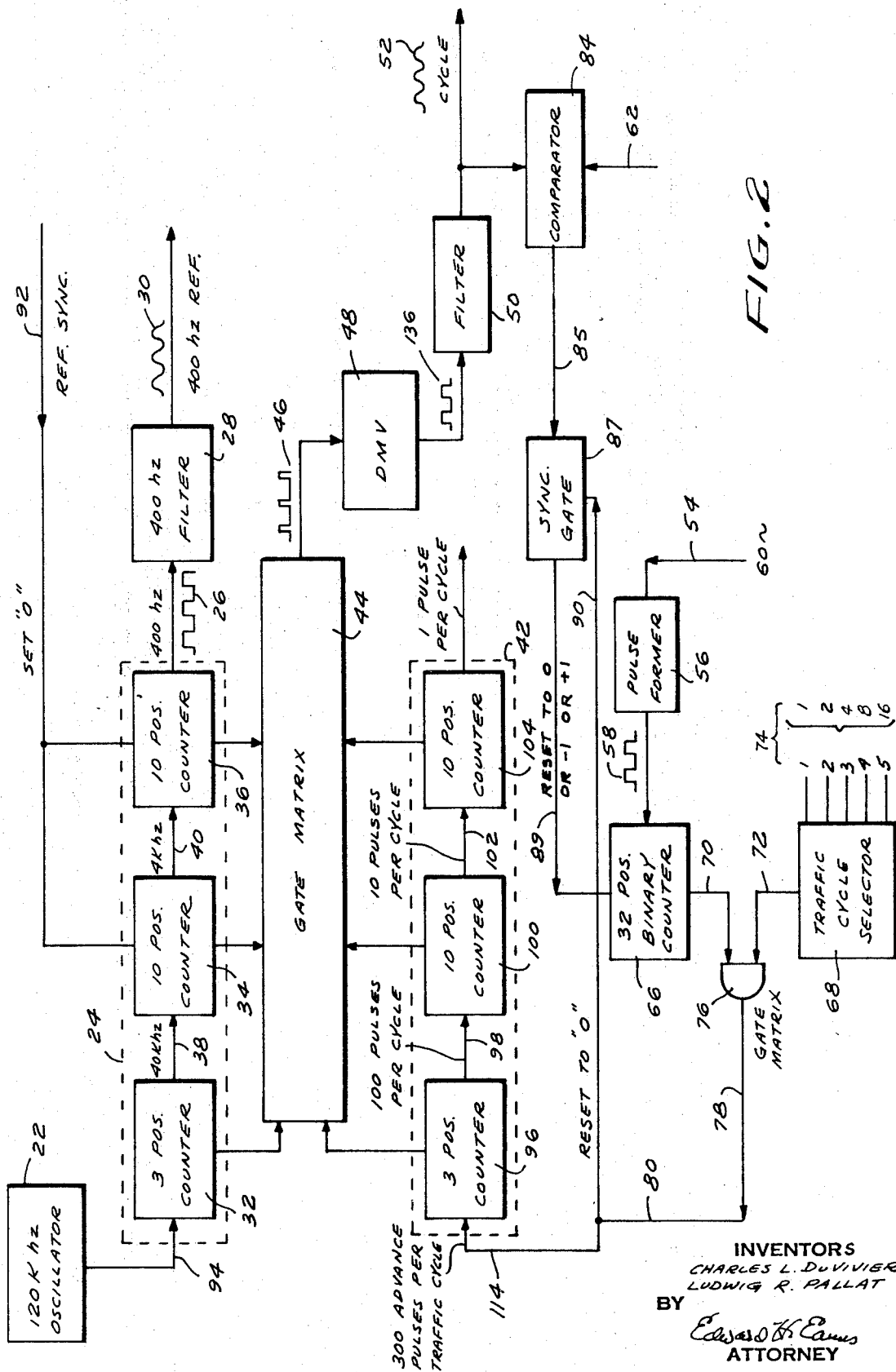
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# PHASE SHIFT CYCLE GENERATOR FOR A TRAFFIC CONTROL UNIT

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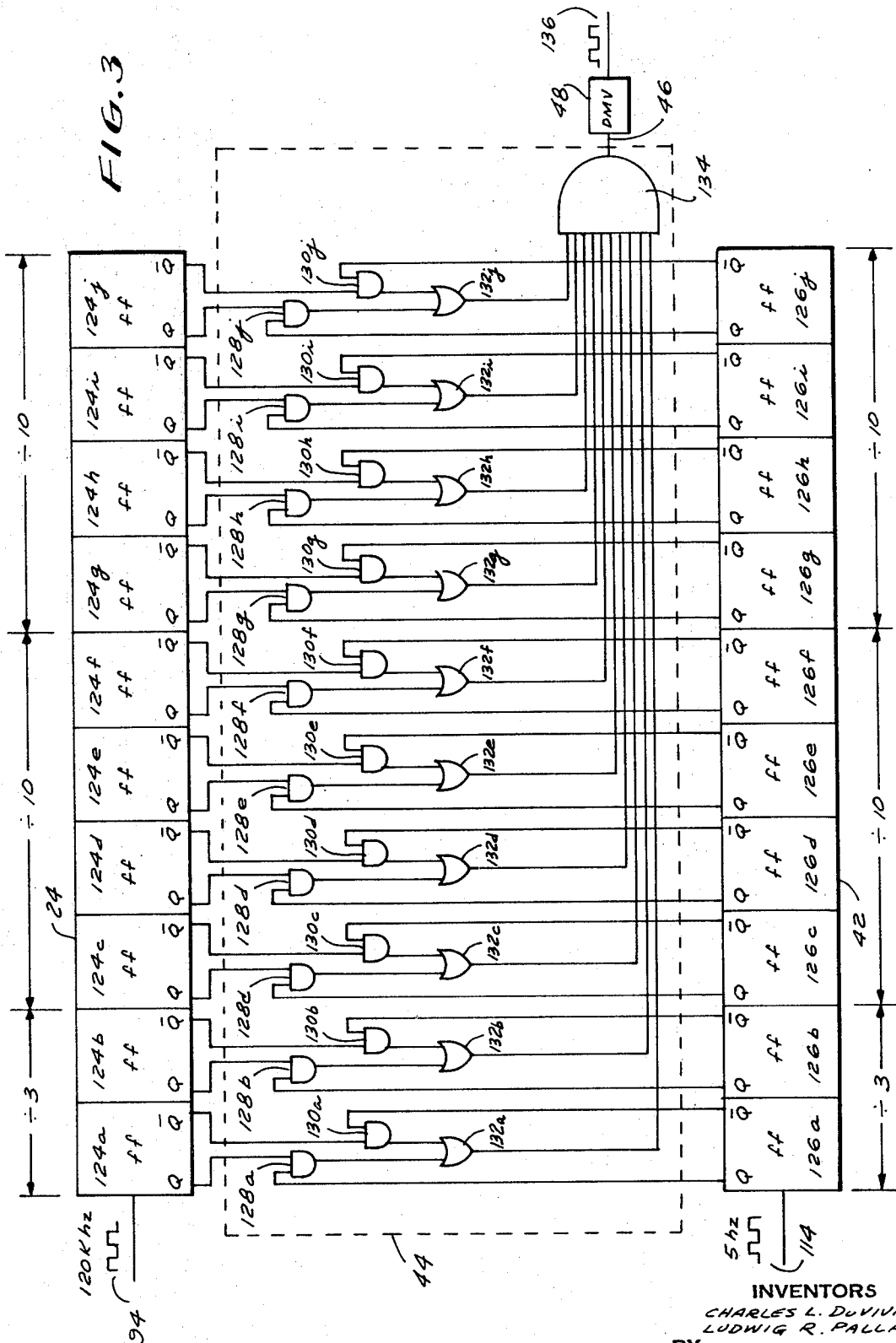
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PHASE SHIFT CYCLE GENERATOR FOR A TRAFFIC CONTROL UNIT

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4 Sheets-Sheet 3



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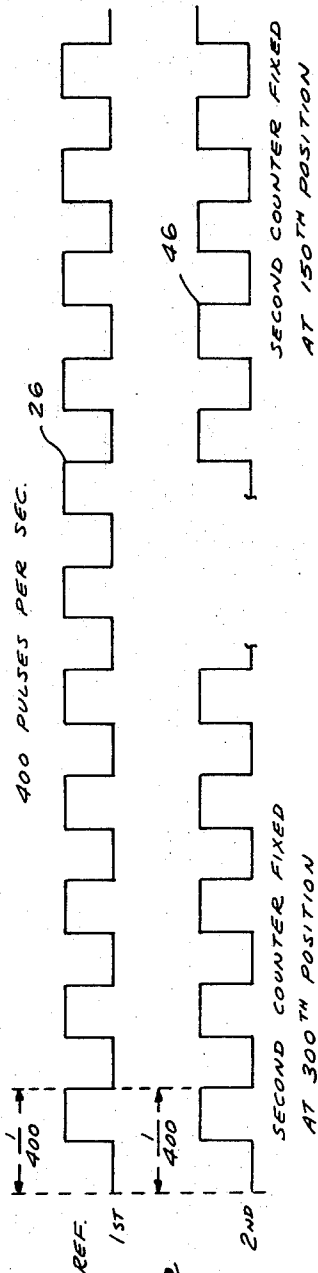
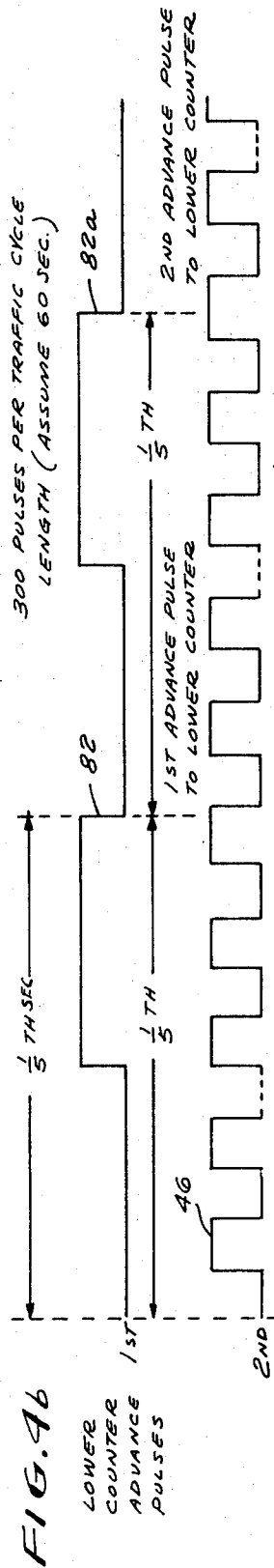
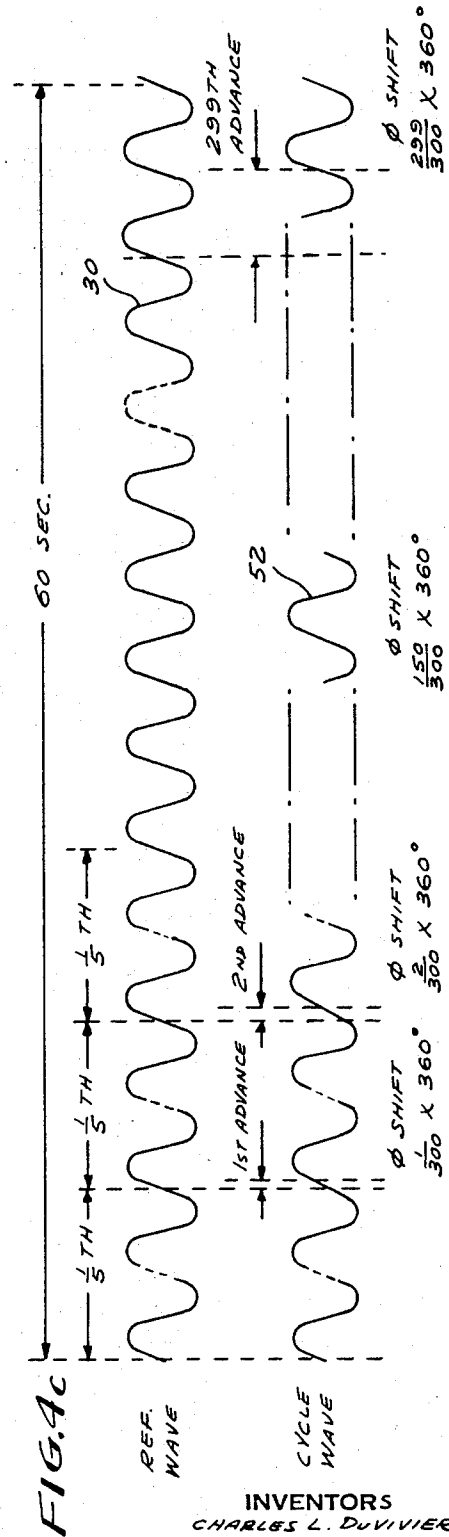
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# PHASE SHIFT CYCLE GENERATOR FOR A TRAFFIC CONTROL UNIT

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4 Sheets-Sheet 4



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3,544,911  
**PHASE SHIFT CYCLE GENERATOR FOR A  
TRAFFIC CONTROL UNIT**

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U.S. Cl. 328—155

13 Claims

## ABSTRACT OF THE DISCLOSURE

An improved cycle generator for providing a signal control traffic cycle in a traffic control system. The cycle generator is adapted to produce two single phase wave energies of identical frequencies one derived from the other wherein one wave energy is adapted to incrementally shift in phase with respect to the other. The desired traffic control cycle is obtained between adjacent coincidences of the two wave energies which is equivalent to the time required for the shiftable wave energy to pass through 360° of phase angle with respect to the reference wave energy.

## BACKGROUND OF THE INVENTION

In traffic control systems, the right of way between intersecting or otherwise conflicting paths of traffic is ordinarily sequentially accorded to one traffic path and then subsequently to the remaining path or paths before returning to the original path. The total time that elapses from the moment the right of way is first granted to an initial path until it returns to that path is referred to as the traffic cycle length and is generally of the order of 40 to 150 seconds.

Depending on the complexity of the traffic pattern being controlled, the traffic control system may utilize one or more local controllers that generate local time cycles at predetermined points in a master time cycle that is generated by a master controller. The local controllers also include apparatus for switching traffic signals at various points in time in the traffic cycle, and in this regard may be thought of as generating their own local cycle lengths during the course of a predetermined portion of the master cycle length.

It has heretofore been known to generate and time such traffic cycle lengths either in a master or local controller by measuring the time lapse between the coincidence points of two wave energies of dissimilar frequencies. Prior art generators of this type are described and disclosed in detail in U.S. Pat. No. 2,989,228 for Traffic and Other Control Systems and U.S. Pat. No. 3,241,104 for Traffic Control. In the main, such prior art cycle generators have operated on the principle that two wave energies of slightly differing frequencies will coincide in phase periodically at fixed intervals of time, the interval of time being determined by and inverse to the frequency difference between the two wave energies. Such prior art cycle generators, however, necessitate the use of multi-phase wave energies and electromechanical components to generate the desired time period.

In addition to the difficulty of accurately generating multi-phase wave energies within the accuracy required for traffic control purposes and to the inherent drawbacks in the use of mechanical devices to precisely and continuously generate a timed cycle over long periods of time, such prior art cycle generators cannot readily be synchronized with other such generators nor are they readily compatible with digital circuitry outputs such as might otherwise be used to control the selection of the period

of the traffic cycle as for example, if digital computers were utilized to alleviate traffic congestion problems. Further, there is no convenient and inexpensive means available for accurately timing the cycle lengths of such prior art generators.

## SUMMARY OF THE INVENTION

It is therefore a principal object of the present invention to provide an improved cycle generator for use in a traffic control system which utilizes all solid state equipment to generate two single phase AC wave energies, one of which gradually shifts in phase in small incremental steps with respect to the other wherein the wave energies are designed to coincide at time intervals equal to the desired traffic cycle length.

It is a further object to provide such a cycle generator wherein one wave energy is derived from the other.

It is a further object of the present invention to provide such a cycle generator which may readily be brought into phase synchronization with other similar cycle generators, which is compatible with digital circuitry components and which may be clocked and timed from a standard 60 cycle AC power line.

These and other beneficial objects and advantages are attained in accordance with the present invention by generating two single phase wave energies from a common source and having one of the wave energies shift through 360° of phase angle incrementally with respect to the other during the course of the desired traffic cycle. The two wave energies are thus coincident in phase once during the period of time corresponding to a single traffic cycle and the time between adjacent coincidences is equivalent to the length of the traffic cycle.

The first or stationary wave energy may be thought of as a reference wave and, as a basis for the derivation of the second wave energy as discussed below, this reference wave energy is generated from a fixed high frequency crystal oscillator, the output of which has been stepped down by suitable counters and filters so as to produce a sinusoidal wave energy of the predetermined desired frequency.

The second wave energy or cycle wave energy is derived from gating circuitry designed to produce an output pulse each time the counter associated with the reference wave passes through a position which is identical to the position at which a second identical counter is maintained. Thus, as the pulses from the oscillator cause the first counter to sweep through its positions, at one position the first counter will correspond to the present position of the second counter and at that time the gating circuitry will produce a pulse which is subsequently transformed into the cycle wave energy. This will occur once during each complete sweep through the first counter and since the reference wave is also defined by a complete sweep through the first counter, the reference wave and cycle wave energies will be of identical frequencies. That is, the frequency of both the reference and cycle wave energies is determined by the number of times per second the first counter goes through all its positions.

The shifting phase relationship between the cycle and reference wave is obtained by periodically advancing the second counter so that the coincidence point between the first and second counters also advances. This causes a shift in the time at which coincidence takes place since it occurs at some other position of the counters with each advance pulse to the second counter. In other words, the zero point of the cycle wave is caused to shift in time while the zero point of the reference wave is kept constant, which is in effect a shifting of the phase angle between the two wave energies. Assuming that

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the cycle and reference waves were coincident in phase when the second counter was in its first position, phase coincidence will not reoccur until the second counter goes through all its positions and returns to its initial position. Thus, since the cycle length is determined by the time between coincidences of the two wave energies, the cycle length may be controlled by controlling the rate at which the second counter is advanced through its positions. This is independent of the frequency of the reference or cycle wave energy.

The advance pulses to the second counter are produced by a clock pulse generator means. In the preferred practice of the invention a 60 Hz. AC power line is utilized as a clock pulse source and selected subdivisions of the 60 Hz. source cooperate to provide the advance pulses.

### BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a block diagram of a traffic control system utilizing a cycle generator produced in accordance with the present invention;

FIG. 2 is a block diagram of a cycle generator in accordance with the present invention;

FIG. 3 is a simplified logic diagram which shows the manner in which the cycle wave producing pulses are generated; and

FIGS. 4a through 4c schematically illustrate the pulse and wave forms developed in the cycle generator.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is illustrated in the accompanying figures wherein similar components are indicated by the same reference numerals throughout. Reference is now made in particular to FIG. 1 wherein a traffic control unit 10 utilizing a cycle generator in accordance with the present invention is depicted. The cycle generator 12 is shown receiving input information relating to the desired traffic cycle length from a selector 14 and generating a signal corresponding to the start and completion of the chosen time cycle to one or more local traffic signal controllers as exemplified by local controller 16. The local controller 16, in turn, may be positioned along a roadway or at an intersection or the like and serves to provide the sequential green, yellow, and red traffic signals which control the flow of traffic along the roadway. As shown, the input to selector 14 may be manual in which case the resultant cycle would be independent of traffic conditions along the roadway or the selector input may come from a computer 18 which in turn receives information from road detectors or other means relating to traffic conditions along a particular roadway or from several roadways.

In some instances, it may be desirable to synchronize the cycle lengths of several control units. To this end, a cycle synchronization block 20 is provided which receives information relating to the cycle length generated by one cycle generator which serves as a master unit and sends out signals to the other associated cycle generators which are to be brought into synchronization with the master unit. Such synchronization circuitry is used where it is sought to control the traffic flow along an artery extending through several intersections and it is desirable to coordinate the signals of the various local controllers along the artery. The means for affecting the synchronization of several units will be described forthwith.

Reference is now made to FIG. 2 wherein the cycle generator of the present invention is depicted in block diagram form. The cycle generator of this preferred embodiment serves to provide a first 400 Hz. sinusoidal wave energy which serves as a reference wave energy and which may be considered fixed with respect to its phase angle and a second 400 Hz. sinusoidal wave energy which serves as a cycle wave energy and constantly

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shifts in phase in discrete steps with respect to the reference wave energy. The cycle generator is utilized in a traffic control system which employs comparison means for comparing the reference and cycle wave energies and determines and responds to phase coincidences of the two wave energies. The coincidence of the wave energy is then used to define the start and completion points of the traffic cycle, for example.

The two wave energies are produced, one directly and one indirectly, from a fixed frequency crystal oscillator 22 which in this preferred embodiment has a frequency of 120 kHz. The output of oscillator 22 is shifted so as to produce what is in effect a train of spikes occurring at a frequency rate of 120 kilopulses per second. The pulses then pass through suitable logic circuitry in the form of a 300 position counter 24 which divides the input pulse train by 300 and produces a 400 Hz. square wave 26 which may be passed through a 400 Hz. bandpass filter 28 to produce the desired sinusoidal wave 30. The three hundred position counter 24 comprises a three position counter 32, a first ten position counter 34, and a second ten position counter 36 connected in series. Thus, the output 38 of the three position counter 32 is a 40 kHz. square wave which is the input to the first ten position counter 34 and the output 40 of the first ten position counter is a 4 kHz. square wave which serves as the input to the second ten position counter 36. The output of ten position counter 36 is the 400 Hz. square wave 26.

A second 300 position counter 42 which is identical to the first 300 position counter 24 is also provided and is connected to the first counter by suitable logic circuitry comprising comparator gate matrix 44 so that each time the positions of the first and second 300 position counters 24 and 42 correspond identically, a pulse is generated. Since the first counter 24 goes through all of its 300 positions, each  $\frac{1}{400}$  of a second, for any fixed position of the second counter 42, the first counter 24 will reach that position once within each  $\frac{1}{400}$  of a second period, so that a pulse output 46 of the logic circuitry 44 will also occur each  $\frac{1}{400}$  of a second. The output 46 of the logic circuitry 44 after passing through a delay multi-vibrator 48 and a suitable bandpass filter 50 will thus also be a 400 Hz. sinusoidal wave 52 (referred to as the cycle wave). It should be readily apparent that for only one position of the second counter 42 will the cycle wave 52 be in phase with the reference wave 30 and that for the 299 other possible positions of the second counter 42 the cycle wave 52 will be out of phase in varying degree relative to the reference wave 30. In this regard, the first counter 24 is designed to produce an output pulse each time it counts to 300; thus, the cycle wave will be in phase with the reference wave only when the second counter 42 is also at 300 so that the cycle wave producing pulses 46 and reference wave producing pulses 26 coincide in time.

If at some particular time the second counter 42 were set at 150, the cycle wave would lead or lag the reference wave by  $180^\circ$ , since the cycle wave producing pulses will occur when the first counter 24 reaches 150 while the reference wave producing pulses will not occur until the counter 24 reaches 300. Similarly, if the second counter 42 were set at 75, the cycle wave would lag behind the reference wave by  $90^\circ$  and if the counter were set at 225, the cycle wave would lag behind the reference wave by  $270^\circ$ . In FIG. 4a the relative positions of the cycle wave producing pulses are depicted for the case where the second counter 42 is fixed at 300 so that the reference and cycle waves coincide and for the case where the second counter is fixed at 150 so that the cycle wave leads or lags the reference wave by  $180^\circ$ . Thus, each time the second counter 42 is advanced by an advance pulse to its next position, the phase angle between the reference wave and cycle wave will shift by  $\frac{1}{300}$  of  $360^\circ$ . Since the cycle wave shifts through  $360^\circ$  of phase angle each time the second counter 42 goes through its entire 300

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positions and since coincidence takes place only once each time the second counter goes through all of its 300 positions (i.e., at the 300th position) the rate at which the second counter advances will determine the rate of phase shift of the cycle wave.

One convenient source of pulses to advance the second counter 42 which are accurately generated and readily available in most locations is a standard 60 Hz. power line. The 60 Hz. wave energy in order to be effectively utilized must first be transformed into a series of pulses, and to this end the 60 Hz. AC wave energy 54 is passed through a pulse former 56, the output 58 of which is a train of short duration pulses normally emanating at the rate of 60 pulses per second. Another convenient source of advance pulses is the first counter.

Assuming for the moment that the 60 Hz. wave energy 54 controls gate 60 so that 60 pulses per second are provided via former 56 then if these 60 pulses per second were passed directly to counter 42 as advance pulses, they would advance counter 42 through its entire 300 positions in five seconds. This period of time is far too short for traffic control purposes and hence the number of pulses passing to the lower counter must be reduced. A variable pulse divider circuit 64 provides pulses at the rate to advance counter 42 through its 300 positions in the desired traffic cycle. The pulse divider circuit 64 includes a 32 position binary counter 66 and a traffic cycle selector unit 68 which has inputs which may be made to correspond to any level of the counter 66 and cause it to stop at that point and reset to repeat its counting. Thus, counter 66 and selector unit 68 cooperate in defining a variable counter that counts up to a number predetermined by properly selecting the counter unit control 74. The outputs 70 and 72 of counter 66 and of the selector unit 68 are fed to AND gate 76 which allows a signal to pass only when the counter 66 has reached the position preselected in control unit 68. The output 78 of gate 76 is fed back to counter 66 and serves as a reset signal to the counter each time the desired level is reached. Thus, the selector unit 68 determines at which point in its count the 32 position binary counter 66 stops counting and advances a pulse along lead 80 to the second 300 position counter 42 and hence the variable pulse divider circuit is in effect a divide by "n" circuit where n is a number between 1 and 32 which has been preset in the selector unit 68 and the desired cycle length is five times n where the advance pulses are obtained from a 60 Hz. source.

Assume, for purposes of illustration, that a 60 second traffic cycle is desired. The second 300 position counter 42 therefore must go through all 300 of its positions in 60 seconds or at the rate of 5 positions per second. To do this, counter 42 must receive 5 advance pulses per second from the clock pulse former 56 and thus, the variable pulse divider circuit 64 must provide five pulses per second on line 80. Therefore, the 60 pulses per second provided from the clock pulse former 56 must be reduced by a factor of 12. This is accomplished by setting control 74 so that selector unit 68 corresponds to the 12th position of the 32 position counter 66 and thus a signal will pass AND gate 76 only when counter 66 has counted to 12. Thus, each 12th clock pulse will pass to the second 300 position counter 42 and will then advance counter 42 at the rate of five positions per second. As was stated the output 78 of AND gate 76 also serves to reset the 32 position counter 66 so as to enable it to start counting to 12 again after each advance pulse passed to the 300 position counter. It should be remembered that between each advance pulse to counter 42 there will be 80 cycle or reference producing pulses since for the example chosen the advance pulses occur at  $\frac{1}{5}$  second interludes and the cycle and reference wave producing pulses occur at  $\frac{1}{400}$  second intervals.

Since the second 300 position counter 42 is caused to advance at the rate of 5 pulses per second, it will go

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through its entire 300 positions in 60 seconds which is the desired traffic length. Also, since the accuracy with which power companies usually generate 60 cycle AC power is very great, the degree of accuracy with which the cycle line shifts will likewise be great.

Reference is now made to FIG. 4 and particularly to FIGS. 4b and 4c which respectively depict the second counter advance pulses 82 and the cycle wave producing pulses 46. Assume that the cycle wave producing pulses 46 on line 2 of FIG. 4b are originally in phase with the reference wave producing pulses 26 shown on line 1 of FIG. 4a. When the first advance pulse 82 to the second counter 42 is received, it will cause the counter 42 to advance so that coincidence between the first and second counters will occur when the first counter reaches its first position whereas before coincidence occurred at the zero position. The cycle wave producing pulses will thus shift  $\frac{1}{300}$  of  $360^\circ$  with respect to the reference wave producing pulse. When the next advance pulse 82a is received, the second counter 42 will advance to its second position and coincidence will occur when the first counter reaches its second position thus causing an additional shift of another  $\frac{1}{300}$  of  $360^\circ$  with respect to the reference wave producing pulses. Between advance pulses 82 and 82a there will be 80 cycle wave producing pulses since there is a time duration of  $\frac{1}{5}$  second. With each additional advance pulse 82 to the second counter, the phase of the cycle wave producing pulses relative to that of the reference wave producing pulses will shift by another  $\frac{1}{300}$  of  $360^\circ$  until the 300th advance pulse is received at which time the reference and cycle wave producing pulse will occur at the same time (and remain the same until the next advance pulse occurs  $\frac{1}{5}$  of a second later). In FIG. 4c the sinusoidal wave forms for the reference wave 30 and cycle wave 52 which represents the square waves of lines 4a and 4b properly filtered are shown. Because the second counter 42 advances in discrete steps the phase relationship between the cycle and reference waves will also shift in discrete steps.

As was previously mentioned, it is often necessary to synchronize the traffic cycle generated by one traffic control cycle generator with that generated by another similar traffic controller cycle generator. To this end a comparator circuit block 84 is provided as shown in FIG. 2 and adapted to receive inputs comprising the cycle wave energies desired to be brought into phase synchronization, namely, the present cycle wave energy 52 and the cycle wave energy 62 from the other controller. The comparator circuit 84 compares the two wave energies and is designed to vary the present cycle wave energy 52 by speeding up or slowing down the rate of clock pulses to the second 300 position counter 42 by varying the starting position of the 32 position counter 66. Thus, in the event the comparator circuit 84 determines that the rate of phase shift of the present cycle wave energy 52 must be increased to bring it into phase synchronization with the cycle wave energy 62 from the similar cycle generator, it will pass a suitable signal along lead 85 to the synchronization gate 87 which in turn will signal the binary counter 66 to shift the counter starting point to its first position rather than its 0 position. This causes counter 66 to advance through its positions at a faster rate than it normally would since the counter starts counting from position 1 rather than from position 0 thereby causing advance pulses to the second 300 position counter 42 to emanate at a more frequent rate resulting in an increase in the rate of phase shift of the cycle wave energy 52. Conversely, if the rate of phase shift of the cycle wave energy 52 must be decreased to bring it into synchronization with the cycle wave energy 62, the synchronization gate 87 will cause the starting position of counter 66 shift its "—1" position. Actually, the counter will begin each count at 31 rather than at 0, thus causing counter 66 to advance to its final position in a longer time period than if the starting position was 0. This results in less frequent advance pulses to counter 42

causing a reduction in the rate of phase shift of the cycle wave energy 52.

Thus, the rate of phase shift of the cycle wave energy 52 with respect to the reference wave energy 30 is determined by the rate of advance of the 32 position binary counter 66 by the 60 Hz. power source 54. This rate may be modified by shifting the starting point of the counter ahead one position or behind one position in accordance with the output of the synchronization gate 87 which in turn is governed by the output of the comparator circuit 84 so as to bring the cycle generator into phase synchronization with another similar cycle generator.

In a similar fashion, the reference wave energy 30 may be brought into synchronization with the reference wave generated by some other cycle generator and in this regard a reference signal 92 may be used to set to 0 the 10 position counters 34 and 36 of the first 300 position counter 34. This will synchronize the reference wave energies to an accuracy within 1%. If an even greater accuracy is required, the three position counter 32 may also be set to 0 by the reference synchronization signal 92 in which case an accuracy of  $\frac{1}{3}$  of 1% may be obtained in bringing the two reference waves into synchronization.

Reference is now made to FIG. 3 wherein the comparator circuit comprising gate matrix 44 is illustrated. As shown, the first 300 position counter 24 comprises a series of 10 flip flops 124a through 124j. Similarly, the second 300 position counter 42 also comprises a series of 10 flip flops 126a through 126j so that for each flip flop 124 of the first counter there is a corresponding flip flop 126 for the second counter. Each flip flop 124 and

126 has a Q and a "not Q" ( $\bar{Q}$ ) output representing the two possible states of the flip flop. The comparator gate matrix 44 comprises a series of AND gates 128a through 128j which compare the Q outputs of the corresponding flip flops 124 and 126 and a series of AND gates 130a

through 130j that compare the  $\bar{Q}$  outputs of the corresponding flip flops 124 and 126. The outputs of each of the corresponding AND gates 128 and 130 (a through j) feed into an OR gate 132 (a through j) so that when two corresponding flip flops 124 and 126 are in the same

state (be is Q or  $\bar{Q}$ ), a signal will appear on the output of OR gate 132. The outputs of OR gates 132a through 132j comprise the inputs to AND gate 134 and the output 46 of AND gate 134 comprises the input to the delay multi-vibrator 48. Thus, whenever each of the corresponding flip flops 124 and 126 are in the same state, whether

that state be Q or  $\bar{Q}$ , there will be an output signal 46 from AND gate 134. If any corresponding pair of flip flops are not in the same state their associated AND gates 128 and 130 will not transmit a signal to the related OR gate 132 thus preventing AND gate 134 from transmitting a signal to DMV 48.

The signal 46 transmitted by AND gate 114 comprises a short duration pulse and since the flip flops 124 and 126 will be in identical corresponding positions 400 times per second, 400 such pulses will be transmitted. The cycle generator must convert these pulses to a sinusoidal wave energy which may be compared with the sinusoidal wave energy comprising the reference wave energy 30. The method of converting the pulses of the comparator circuit into a sinusoidal wave energy utilizes a delay multi-vibrator (DMV) 48 the output 136 of which is in effect a square wave. In this regard a DMV which produces an output pulse the time duration of which is one-half the duration between adjacent input pulses must be chosen. The output 136 of the DMV may then be passed through a 400 Hz. filter 50 producing the sinusoidal cycle wave energy 52 in a manner identical to that in which filter 28 produces the reference wave energy 30 although some slight distortion will occur each time the lower counter advances.

Thus, in accordance with the present invention a cycle

generator has been described which is adapted to produce two single phase wave energies of identical frequencies one wave energy being adapted to shift in phase with respect to the other. The cycle generator is designed to be used with apparatus well known in the art adapted to respond to coincidences of the two wave energies. The frequency of the coincidences may be altered by varying the rate at which the cycle wave energy shifts in phase with respect to the reference wave and the rate of shifting may readily be synchronized with other similar cycle generators.

Although the term "identical frequencies" has been used in the present application to denote the relationship between the reference wave energy and the cycle wave energy, it should be appreciated that during the course of one complete traffic cycle the cycle wave energy will have lost one complete wave, as compared to the reference wave energy, and thus the average frequencies are not literally identical.

Having thus described our invention what we claim is:

1. A cycle generator for generating a timed period determined by the coincidence of two single phase wave energies comprising in combination: means for generating a first single phase wave energy; means for generating a second single phase wave energy including means for shifting the phase of said second wave energy in incremental steps relative to said first wave energy; and means for controlling the rate at which the phase of said second wave energy shifts relative to said first wave energy.

2. The invention in accordance with claim 1 wherein said means for generating said first wave energy comprises: a pulsating energy source the output of which advances a recycling multi-position counter; a first recycling multi-position counter adapted to reduce the rate of pulses from said pulsating energy source by utilizing said pulses to advance the position of said counter and generating an output signal only when a particular position of said counter is reached and filter means for receiving the output signal from said multi-position counter and filtering the same to produce a wave energy the frequency of which is equivalent to the rate at which pulses emanate from said counter.

3. The invention in accordance with claim 1 wherein said second wave energy is derived from said first wave energy.

4. The invention in accordance with claim 2 wherein said means for generating said second wave energy comprises: a second multi-position counter having a number of positions identical to that of said first multi-position counter; a comparator circuit adapted to generate an output signal each time said first and second multi-position counters are in corresponding positions; and filter means adapted to filter said comparator circuit output signal so as to produce a wave energy the frequency of which is equal to the rate at which said output signals are generated by said comparator circuit.

5. The invention in accordance with claim 4 wherein said means for shifting the phase of said second wave energy relative to said first wave energy comprises means for advancing the position of said second counter and thereby advancing the position in said counter at which coincidence between said first and second counter will occur thereby delaying in time the point at which said second wave producing signal will be generated relative to the time at which said first wave producing signal will be generated.

6. The invention in accordance with claim 5 wherein said means for controlling the rate of phase shift further includes means to generate advance pulses at a variable rate to said second counter.

7. The invention in accordance with claim 6 wherein said last named means includes a preset periodic pulse source.

8. The invention in accordance with claim 7 wherein said preset source is a 60 Hz. AC power line.

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9. The invention in accordance with claim 7 further comprising means for controlling the number of pulses from said preset periodic pulse source that advance said second counter.

10. The invention in accordance with claim 9 wherein said control means comprises a third multi-position counter adapted to receive said periodic pulses, to advance in position with each such periodic pulse, and to pass an advance pulse to said second counter when said third counter reaches a predetermined position; variable means for selecting the predetermined position of said third counter; and feed back means for returning said third counter to 0 after said predetermined position is reached by said third counter and an advance pulse is transmitted to said second counter.

11. The invention in accordance with claim 2 further comprising means for synchronizing the phase of said first wave energy with the phase of the corresponding first wave energy of another similar cycle generator wherein said synchronization means includes means for resetting said first counter to 0 when a signal is received from said similar cycle generator indicating that the first counter of said similar cycle generator is set at 0.

12. The invention in accordance with claim 7 further comprising means for synchronizing the phase of said second wave energy with the phase of the second wave energy of another similar cycle generator including means for comparing the phase of the present cycle generator with the phase of the other cycle generator and means for

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varying said periodic advance pulses in accordance with the output of said comparator means whereby the rate of said periodic pulses is increased if the phase of said other cycle generator leads the phase of the present cycle generator and the rate of said periodic pulses is decreased if the phase of said other cycle generator lags the phase of the present cycle generator.

13. The invention in accordance with claim 1 wherein said cycle generator is adapted to provide a signal control traffic cycle in a traffic control system.

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