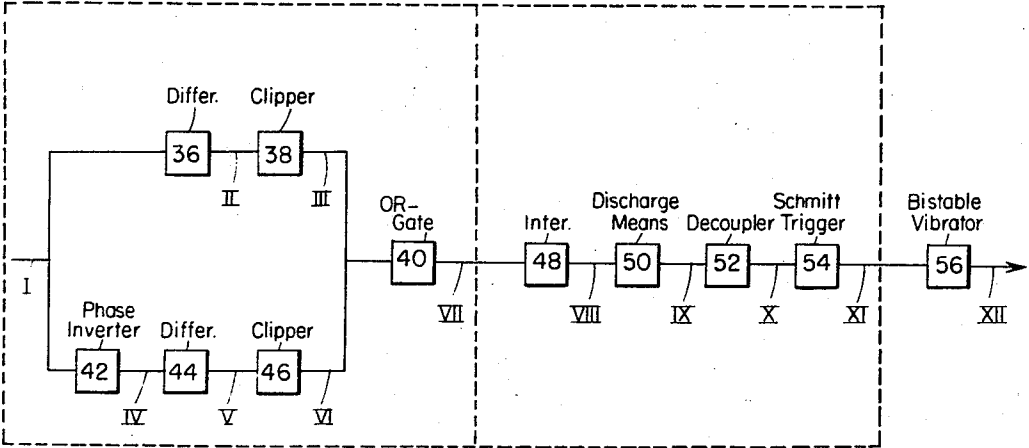


[72] Inventors **Reimar Germann;**  
**Kurt Wiederwohl, both of Graz, Austria**  
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**Division of Ser. No. 626,755, Mar. 29,**  
**1967, Pat. No. 3,471,763.**  
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[73] Assignee **Mobil Oil Corporation**  
**New York, N.Y.**  
[32] Priority **Jan. 12, 1967**  
[33] **Austria**  
[31] **A 321/67**

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*Primary Examiner—John S. Heyman*  
*Attorneys—Oswald G. Hayes, Donald L. Dickerson and Paul*  
*H. Heller*

[54] **FREQUENCY MULTIPLICATION AND**  
**DISPLACEMENT**  
**3 Claims, 4 Drawing Figs.**  
[52] U.S. Cl..... **328/55,**  
**328/20, 328/110, 328/127, 328/181, 307/290,**  
**307/237**  
[51] Int. Cl..... **H03k 5/159**  
[50] Field of Search..... **328/20, 36,**  
**38, 110, 140, 127, 181; 307/232, 233, 272, 273,**  
**290, 23 D**

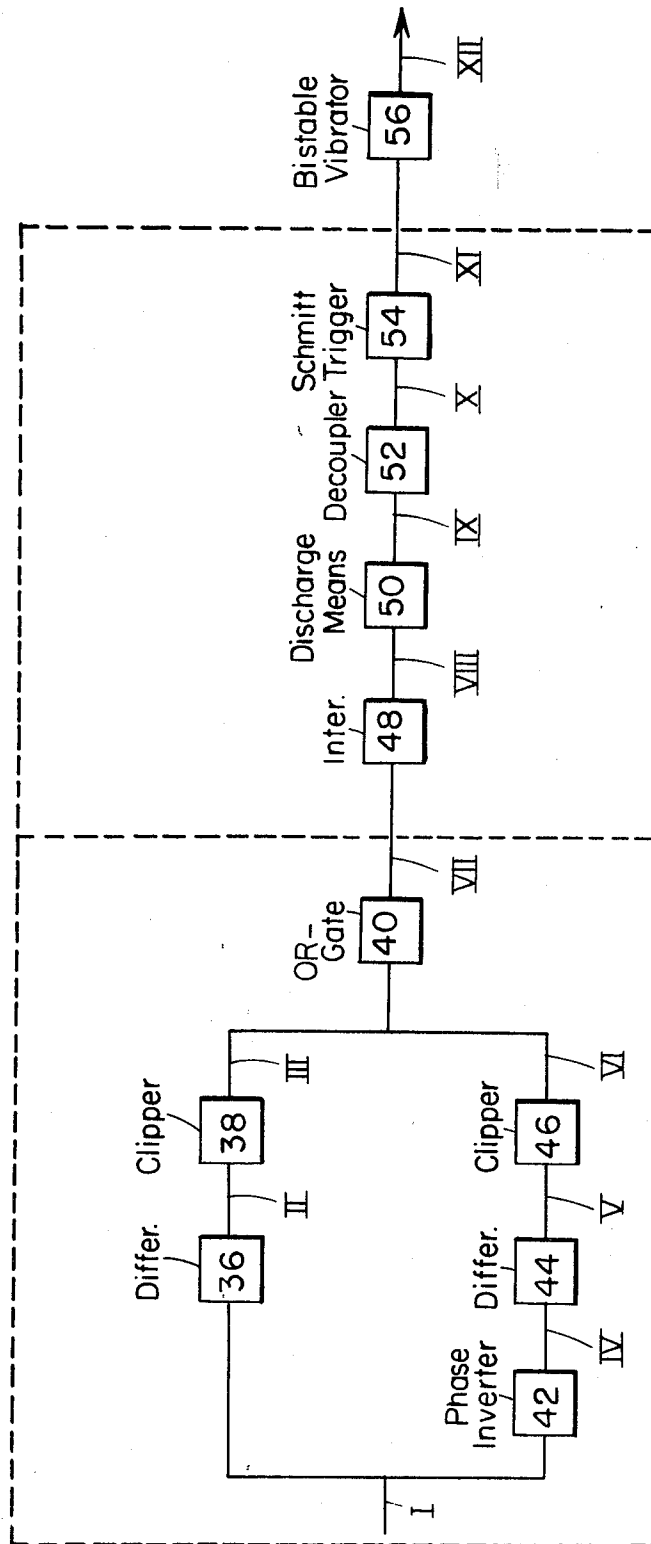
**ABSTRACT:** A circuit for displacing a signal 90° comprising a frequency doubler wherein an input square wave is differentiated and clipped. The frequency doubler also inverts the square wave, differentiates the inverted square wave and clips the differentiated inverted square wave. The two clipped signals are then added to provide a signal having a frequency twice that of the input square wave. This signal is applied to a sawtooth generator which provides an output signal to actuate a Schmitt trigger. The Schmitt trigger generates a square wave having a frequency twice that of the input square wave for actuating a bistable vibrator. The output of the bistable vibrator is a square wave displaced 90° from the input square wave.



( See FIG. 2 )

( See FIG. 3 )

FIG. 1



( See FIG. 3 )

( See FIG. 2 )

Inventors  
 Reimar Germann  
 Kurt Wiederwohl

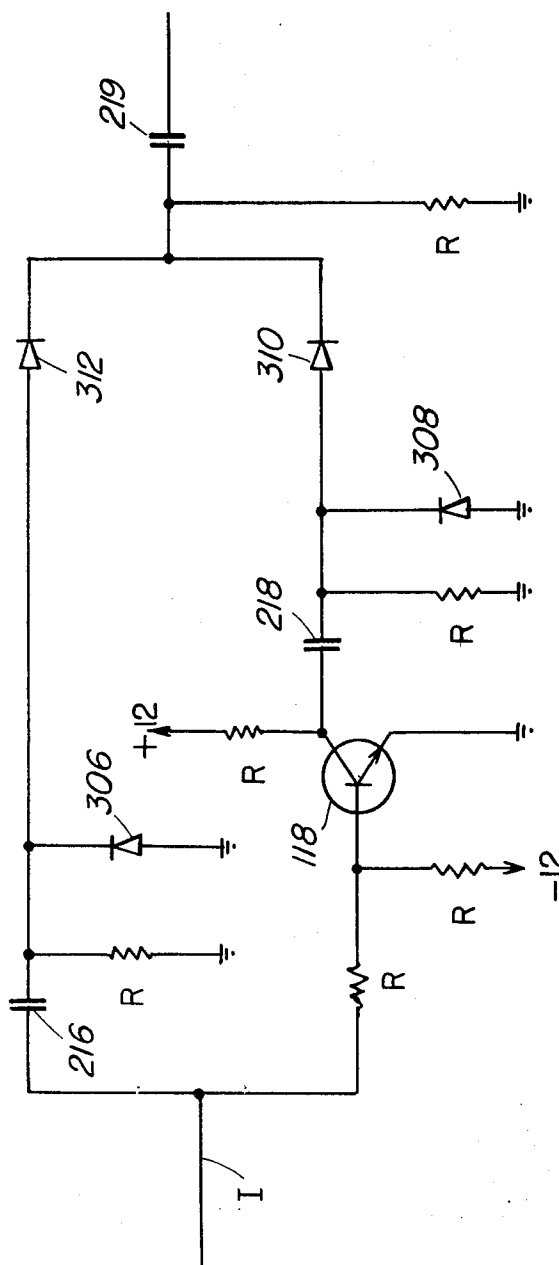


FIG. 2

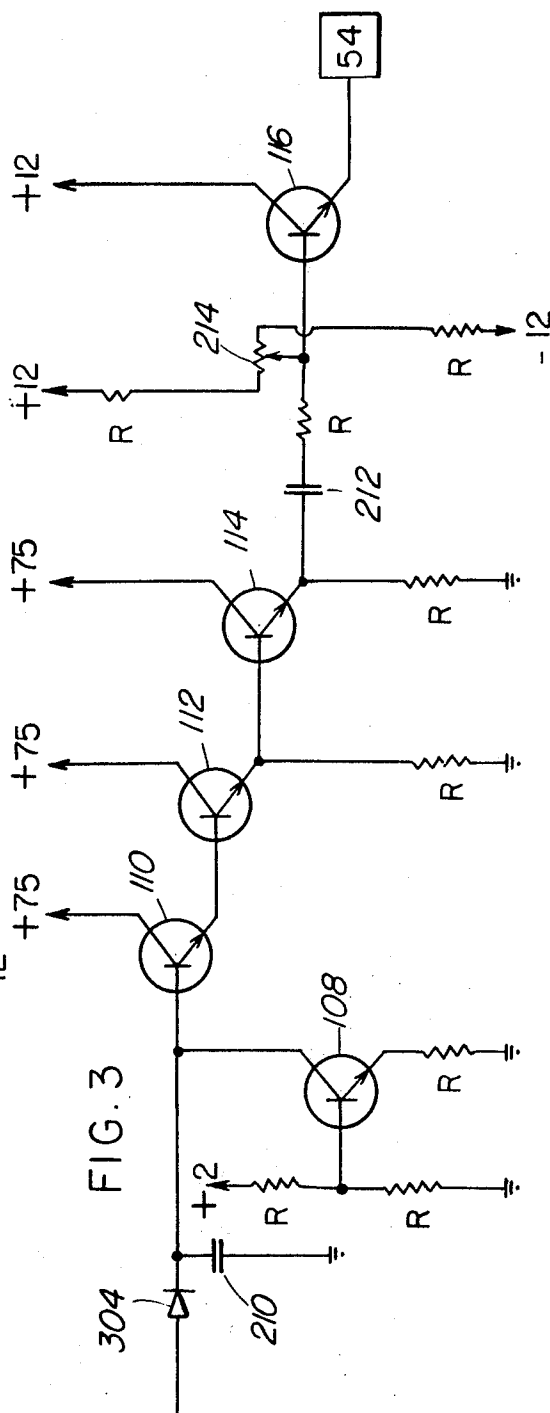
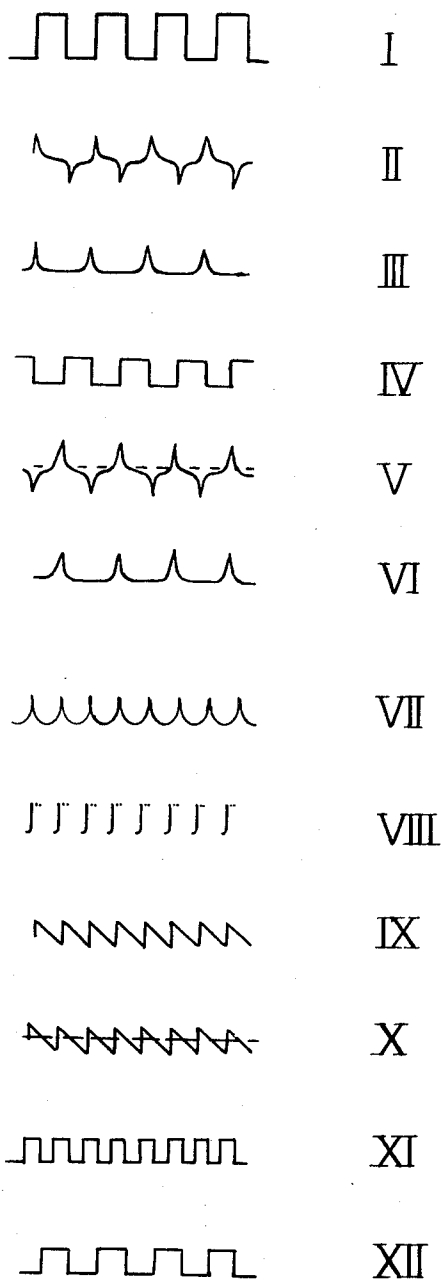


FIG. 3

Inventors  
Reimar Germann  
Kurt Wiederwohl

FIG. 4



*Inventors*  
*Reimar Germann*  
*Kurt Wiederwohl*

## FREQUENCY MULTIPLICATION AND DISPLACEMENT

### CROSS-REFERENCE TO A RELATED APPLICATION

This application is a division of application Ser. No. 626,755; filed on Mar. 29, 1967, now U.S. Pat. No. 3,471,763.

### BACKGROUND OF THE INVENTION

This invention is suitable for use with the engine analyzer synchronization system of copending application Ser. No. 587,096 Oct. 17, 1966, Germann and Wiederwohl, commonly assigned. In application Ser. No. 587,096 the pressure patterns at the fuel injection lines to the cylinders of a diesel engine are displayed on an oscilloscope. The synchronization of such a system is provided by photosensitive devices actuated by a motor driven by a signal from a transducer in one of the fuel injection lines. The motor is driven at a rate proportional to the speed of the engine or of the fuel injection pump.

The present invention is directed to an alternative system for driving the synchronous motor referred to in application Ser. No. 587,096.

### SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a circuit for displacing a signal 90° comprising means for generating a first square-wave signal having a first frequency, a first circuit portion comprising means for differentiating the first square-wave signal to generate a signal having alternating positive and negative states, and means for clipping one of the states of the differentiated square-wave signal. The circuit also includes a second circuit portion connected in parallel with the first circuit portion which comprises means for inverting the first square-wave signal, means for differentiating the inverted square-wave signal to generate a signal having alternating positive and negative states, and means for clipping the same state of the differentiated inverted square-wave signal as clipped by the first circuit portion. The circuit further includes means responsive to each of the clipped signals from the first and second circuit portions for generating an output signal having a frequency twice that of the first square-wave signal, and means responsive to the output signal for generating a sawtooth wave signal having a frequency equal to that of the output signal. A Schmitt trigger circuit is responsive to the sawtooth wave signal for generating a second square-wave signal having a frequency equal to that of the sawtooth wave signal. A bistable vibrator is responsive to the second square-wave signal for generating a third square-wave signal displaced 90° from the first square wave.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of this invention.

FIGS. 2 and 3 show portions of the circuitry use in this invention.

FIG. 4 indicates the signal produced at the various points indicated in FIG. 1.

### DESCRIPTION OF A SPECIFIC EMBODIMENT

In FIG. 1 numerals 2 and 3 refer to those figures in which detailed embodiments of the circuitry are shown. Square-wave voltage signals I are differentiated at 36 to produce signal II, which has its negative portion removed in clipper 38 as indicated by signal III. These positive peaks, representative of the leading edge of the square-wave signal I are then transmitted to an "OR" gate 40. The square-wave signals I are also transmitted to a phase inverter 42 to produce signal IV which is differentiated in means 44 to produce signal V. Differentiated signal V is clipped by means 46, and the positive peaks, signals VI, representative of the trailing edge of the square-wave signals I, are transmitted to the "OR" gate 40. The "OR" gate produces a series of positive peaks, signal VII, having twice the frequency of the initial signal I. The signal VII, which may be amplified at this point, is then directed to

an integrator 48. The positive peaks of signal VII charged the integrator 48, illustrated diagrammatically by signal VIII prior to discharge. The integrator 48 is discharged to a constant current circuit 50 to provide a sawtooth signal IX which is repositioned on a zero line by a DC decoupler 32 as indicated by signal X. This signal actuates a Schmitt trigger 54 to produce square-wave voltage signals XI. Schmitt trigger signal XI has a frequency equal to twice that of the square wave signals, I. The trailing edge of signal triggers a bistable vibrator 56 to provide signal XII. Signal XII has the same frequency as signal I, and its phase is displaced by 90°.

The electrical components described are conventional and may be found in a number of sources, such as the "Transistor Manual," General Electric Company, 6th Ed., "Reference Data for Radio Engineers," International Telephone and Telegraph, 4th Ed., and other standard works. An embodiment for several of these components is shown below, however, it will be appreciated that numerous electrical designs could be derived within the scope of the above disclosure.

FIGS. 2 and 3 present a more detailed embodiment of the system of FIG. 1. Like numbers in these figures refer to like components. The letter R refers to resistors; the values for the resistors and other components can readily be chosen by one skilled in the art to match the requirements of this system.

In FIG. 2 the square-wave signal I is differentiated by means of condenser 216 and the resistor which follows it. The negative portion of the differentiated signal is clipped by means of diode 306. In a parallel circuit the square-wave signal I is passed to transistor 118 which acts as a phase inverter. The inverted signal is differentiated by means of condenser 218 and the resistor which follows it. The negative portion of the differentiated signal is clipped by means of diode 308. The positive peaks of the differentiated signals from condensers 216 and 218 are passed in parallel to an "OR" gate comprising diodes 310 and 312. These positive signals are in effect added through the "OR" gate and appear as the composite signal VII having twice the frequency of III or VI. Signal VII passes through filter condenser 219 to a circuit shown in FIG. 3.

As shown in FIG. 3 the differentiated signal is passed to diode 304 which is part of an integrator circuit comprising a condenser 210. The charge stored on condenser 210 is discharged at a controlled rate by means of transistor 108 arranged in a constant current circuit. The sawtooth signal which is generated passes through transistors 110, 112, and 114 which serve the function of maintaining the form of the signal by matching the impedance in the circuit and by passing the signal through an emitter follower. The sawtooth signal is then decoupled of its DC component in condenser 212 from which it passes to the trigger level adjuster including variable resistor 214. The signal then passes through emitter follower 116 which is used to actuate a Schmitt trigger 54.

The signal from 54 is used to actuate a bistable vibrator 56. In a suitable bistable vibrator, for example, that shown in Transistor Circuit Design, by Texas Instruments, Inc. (McGraw-Hill Book Company, 1963), the square wave XI would be differentiated and the positive portion clipped to provide a square-wave output, XII, which is shaped by the trailing edges of signal XI.

This invention has been described in terms of specific embodiments set forth in detail, but it should be understood that these are by way of illustration only and that the invention is not necessarily limited thereto. Alternative constructions will become apparent to those skilled in the art in view of this disclosure, and accordingly modifications of the apparatus and process disclosed are to be contemplated within the spirit of this invention and the following claims.

What is claimed is:

1. A circuit for displacing a signal 90° comprising, in combination:
  - means for generating a first square-wave signal having a first frequency,
  - a first circuit portion comprising means for differentiating said first square-wave signal to generate a signal having

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alternating positive and negative states, and means for clipping one of the states of the differentiated square-wave signal,

a second circuit portion connected in parallel with said first circuit portion comprising means for inverting said first square-wave signal, means for differentiating said inverted square-wave signal to generate a signal having alternating positive and negative states, and means for clipping the same state of the differentiated inverted square-wave signal as clipped by said first circuit portion, means responsive to each of the clipped signals from said first and second circuit portions for generating an output signal having a frequency twice that of said first square-wave signal, means responsive to said output signal for generating a sawtooth wave signal having a frequency equal to that of said output signal, a Schmitt trigger circuit responsive to said sawtooth wave

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signal generating a second square-wave signal having a frequency equal to that of said sawtooth wave signal, and a bistable vibrator responsive to said second square-wave signal for generating a third square wave displaced 90° from said first square wave and having said first frequency.

2. The circuit of claim 1 wherein said output signal generating means comprises:

an OR gate responsive to each of the clipped signals from said first and second circuit portions, and means responsive to said OR gate for generating a square-wave signal having a frequency twice that of said first square-wave signal.

3. The circuit of claim 1 wherein said output signal generating means comprises:

means for superimposing said clipped signals upon one another to generate said output signal.

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