Sept. 1, 1953 H. E. VAN VALKENBURG ET AL 2,651,012

TRANSDUCER CONTROL

Filed June 12, 1952 2 Sheets-Sheet 1

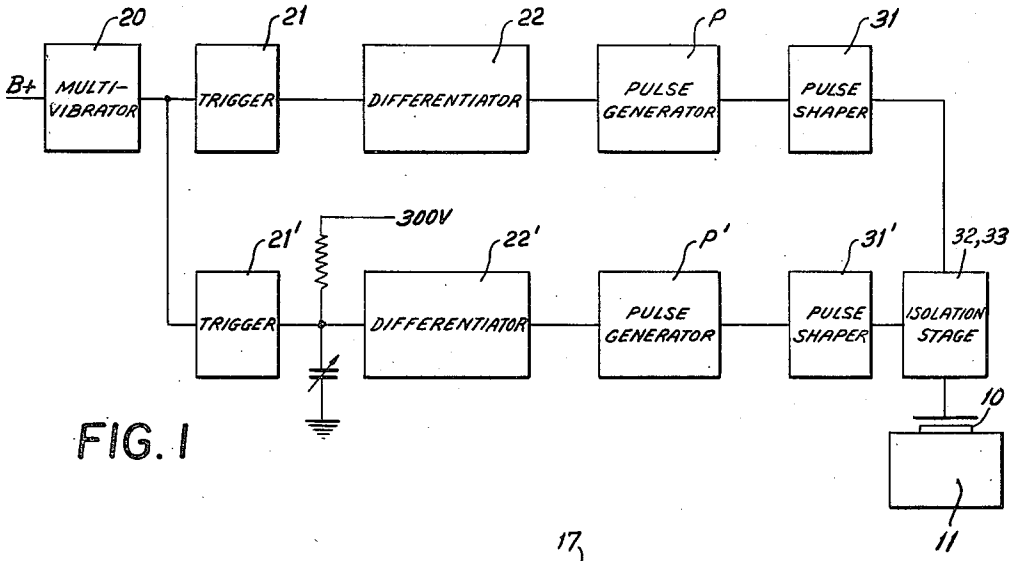


FIG. 1

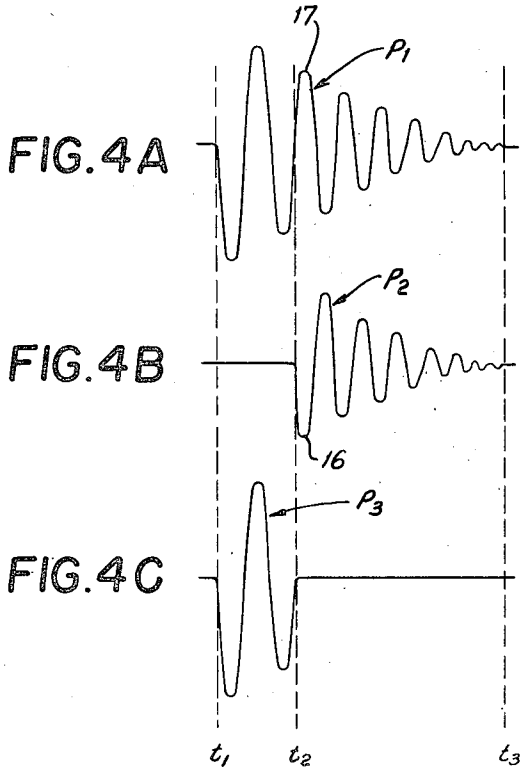


FIG. 4A

FIG. 4B

FIG. 4C

INVENTORS.
HOWARD E. VANVALKENBURG.
EDWARD G. COOK
BY
Joseph H. Lipschutz
ATTORNEY

Sept. 1, 1953 H. E. VAN VALKENBURG ET AL 2,651,012

TRANSDUCER CONTROL

Filed June 12, 1952 2 Sheets-Sheet 2

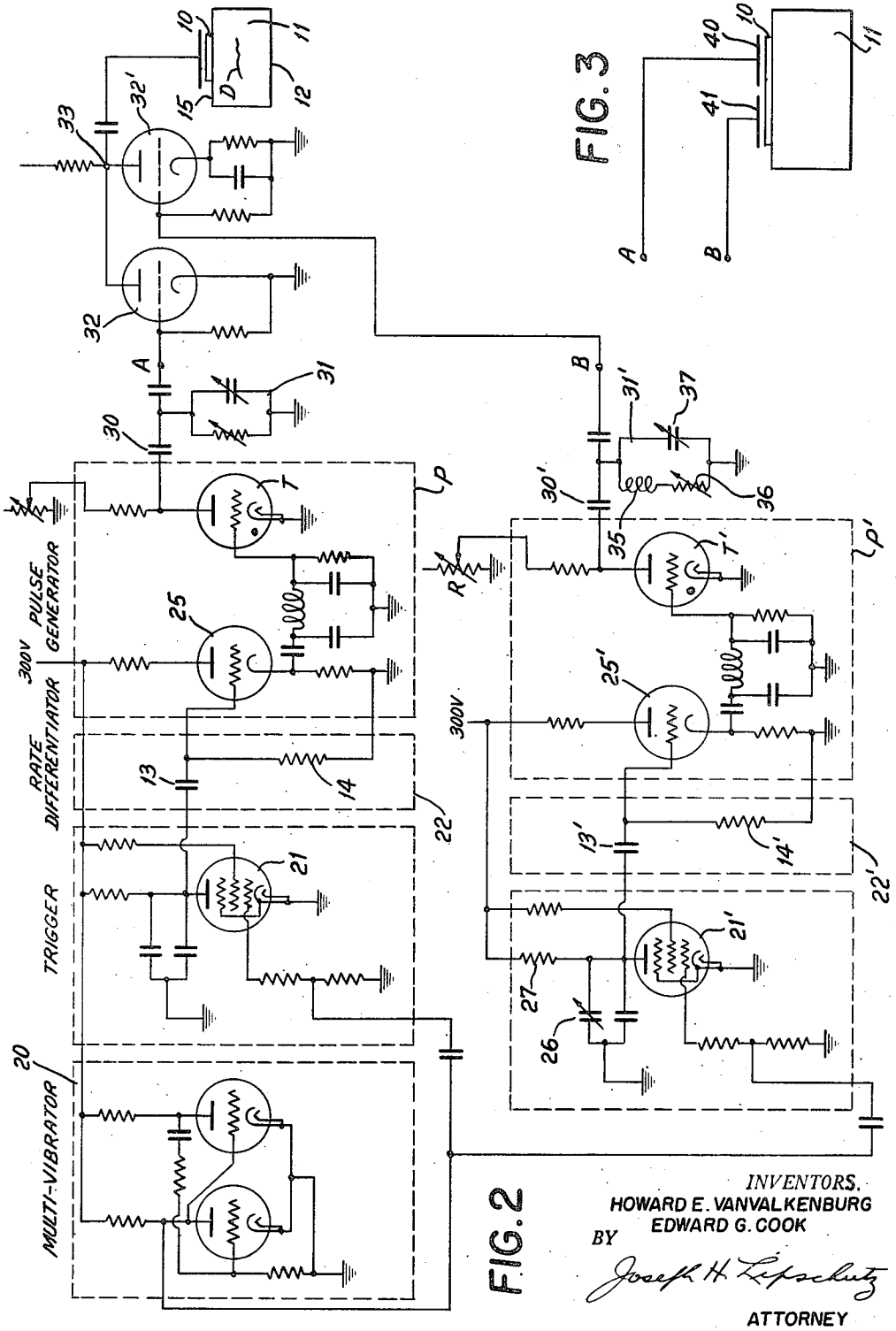


FIG. 2

FIG. 3

INVENTORS.
HOWARD E. VANVALKENBURG
EDWARD G. COOK
BY
Joseph H. Lipschutz
ATTORNEY

Patented Sept. 1, 1953

2,651,012

UNITED STATES PATENT OFFICE

2,651,012

TRANSDUCER CONTROL

Howard E. Van Valkenburg, Candlewood Isle, and Edward G. Cook, Stratford, Conn., assignors to Sperry Products, Inc., Danbury, Conn., a corporation of New York

Application June 12, 1952, Serial No. 293,228

4 Claims. (Cl. 318—116)

1

This invention relates to pulse generators and has for its principal object the provision of a method and means for causing a transducer to generate a wave train of short duration. The usual wave train which is generated by a transducer, such as a piezo-electric quartz crystal, is characterized by an exponential amplitude decay. It is highly desirable in many applications that these mechanical vibrations generated by the quartz crystal be stopped sharply after a desired number of oscillations. For example, in the testing of objects by transmitting ultrasonic energy into the object and measuring the time interval between transmission of the energy and reception of its reflection from the first reflecting surface within the object, it will be seen that unless the wave train generated by the transducer is short and sharply cut off it is not possible to inspect the region of the object close to the entering surface. This is due to the fact that if the wave train is relatively long, reflection of the initial portion of the wave train from a reflecting surface near the entering surface of the object will be received before the transmission of the remainder of the wave train has ended. In an effort to accomplish the above result several methods have heretofore been employed. One of these consisted in mechanically loading the faces of the crystal, but this did not stop the oscillations soon enough. Another method which has been proposed is to apply a critically damped electric energizing wave train to the transducer crystal. This resulted in a sharp electrical energization of the crystal for a short period, but nevertheless caused the crystal to generate after this energization an exponentially decaying vibration, although it did reduce the duration of this vibration.

It is the principal object of this invention to provide a method and means for terminating the vibration generated by the transmitting face of the quartz crystal after any desired number of oscillations which may be predetermined at will.

Further objects and advantages of this invention will become apparent in the following detailed description thereof.

In the accompanying drawings,

Fig. 1 is a block diagram embodying one form of this invention.

Fig. 2 is a view similar to Fig. 1 but disclosing the wiring details.

Fig. 3 is a diagrammatic representation of a modification of the Fig. 2 form of the invention.

Figs. 4A, B, and C are a series of graphs illustrating the principle of the invention.

2

Referring first to Fig. 4A it will be seen that the typical wave train P1 generated by the transducer is characterized by an exponential decay wherein the oscillations of the vibration gradually lose amplitude from maximum to zero in a time interval t_1 to t_3. This is the type of oscillation which results normally when a quartz crystal is energized by a short electric wave train. As stated in the introduction hereto, the quartz crystal 10 will transmit the mechanical vibrations corresponding to the oscillations of such wave train into an object 11 with which the crystal is in engagement. The wave train will travel into the object 11 until it strikes a reflecting surface, which may be either the rear surface 12 or an internal reflecting surface such as defect D, whereupon the wave train will be returned to the crystal. It will be seen that if the transmitted wave train is of relatively long duration, reflections will start coming back from a reflecting surface such as D lying near the entering surface 15 before the transmitted wave train has terminated at the crystal. This will render it difficult to detect returning reflections, and therefore an instrument such as the ultrasonic reflectoscope which depends upon indicating the time interval between the transmission and reception of a wave train could not operate efficiently to detect such defects. It is therefore desirable that the transmitted wave train be as short as possible, while at the same time having the oscillations of sufficient amplitude to provide the necessary power for traversing the object.

To accomplish the above it is desirable to provide a system which will, after a brief time interval t_1 to t_2, eliminate further oscillations of the transmitting face of the crystal, as shown in Fig. 4C. One method of accomplishing this result would be to apply to the crystal electrical energization, which would tend to vibrate the transmitting face of the crystal in a direction opposite to the direction in which said crystal face is being vibrated by the original electrical wave train at time t_2. Such an electrical impulse would cause the transducer to generate an oscillation P2 as disclosed in Fig. 4B wherein it will be seen that the wave train applied to the crystal tends to produce, for example, a cycle 16 of similar shape and opposite sign to the cycle 17 previously generated by the transmitting face of the crystal. Since the pulse B tends to vibrate the transmitting face of the crystal with a force equal and opposite to the force which energizing wave train A tends to vibrate said crystal face beginning at time t_2, it will be seen that all

further tendency of the transmitting face of the crystal to vibrate after time t_2 is substantially eliminated. The problem therefore is to provide a method and means whereby after the time interval t_1 to t_2 a wave train is applied to the crystal which tends to vibrate the transmitting face of the crystal equally in magnitude but opposite in direction to the tendency of said crystal face to vibrate in response to the wave train which is previously applied to the crystal at time t_1.

In order to accomplish the foregoing result we provide the arrangement disclosed in block form in Fig. 1 and in detail in Fig. 2. In this form of the invention a multivibrator **20** is energized from a suitable source (here shown as 300 volts), and the wave train thus generated is applied to the grids of two normally conductive trigger tubes **21** and **21'**. The outputs of the trigger tubes are differentiated by differentiators **22** and **22'** in the grid circuits of two cathode followers **25** and **25'**, which are in turn in the grid circuits of two thyratron tubes T and T' of wave train generators P and P'. Each differentiator comprises a capacitor **13**, **13'** and a resistor **14**, **14'**, and only the positive pulse outputs of the differentiators are effective to trip the follower tubes and the thyratron tubes. The differentiator output in the circuit of the auxiliary thyratron T' acts through a time delay which may comprise a capacitor **26** and a resistor **27**, one of which is adjustable. By means of this time delay the trigger of the auxiliary thyratron may be delayed for any desired time interval t_1 to t_2 after discharge of thyratron T.

When the main thyratron T fires it will permit a capacitor **30** to discharge through a pulse shaping circuit **31** whose output is applied to an amplifier tube **32** whose output is applied to the crystal **10**. This wave train will set the transmitting face of the crystal vibrating to cause it to transmit a mechanical wave train into object **11**, said wave train being of the exponential decay type P shown in Fig. 4A. After a time delay set as described hereinbefore to correspond to the time interval t_1 to t_2, the auxiliary thyratron T' will fire to permit a capacitor **30'** to discharge into pulse shaping circuit **31'** whose output is applied to amplifier tube **32'** from the output of which the wave train is applied to the transmitting face of the crystal **10**. The two tubes **32** and **32'** have their outputs connected at **33** and therefore serve to isolate the two pulse shaping circuits from each other so that each pulse shaping circuit may act independently on the crystal **10** without affecting the other pulse shaping circuit. The two tubes **32** and **32'** as connected therefore serve as pulse separation circuits to permit each wave train to act independently of the other on the transmitting face of the crystal.

Since the mechanical wave train P2 begins to be generated only after time interval t_1 to t_2, it will be seen that if it can be made of the same shape but opposite in phase to the mechanical wave train which is generated by the transmitting face of the crystal at the particular instant, the transmitting face of the crystal will be stopped from vibrating. Therefore the pulse shaping circuit **31'** is provided with an inductance coil **35**, adjustable resistor **36**, and adjustable capacitor **37**, by which adjustments the frequency and the wave form of the electrical pulse may be controlled to provide whatever shape of mechanical pulse is necessary to be equal and opposite to the oscillation existing on the transmitting face of the crystal by reason of electrical pulse P at that particular instant. In this manner, by applying two separate electrical pulses to the transmitting face of the crystal after a time delay, and the later pulse shaped so that the wave generated by the transmitting face of the crystal is equal and opposite to the oscillation of the crystal face as a result of the first electrical pulse, the crystal face may be brought to a complete stop.

In a modified form of the invention disclosed in Fig. 3 the same result may be achieved by eliminating all of the circuit after points A and B in Fig. 2 and causing the outputs of the shaping circuits to be applied directly to independent and separate energizing electrodes **40** and **41** of the single crystal **10**. By this modification the necessity of employing separating tubes **32** and **32'** is eliminated and the same result of completely separating the two electrical wave trains acting on the transmitting face of the crystal is achieved.

Having described our invention, what we claim and desire to secure by Letters Patent is:

1. The method of producing by a crystal transducer a wave train of mechanical energy of a controlled number of cycles, which consists in generating a voltage wave train, applying the wave train to the transducer to cause the transducer to vibrate mechanically, generating a second voltage wave train which is electrically independent of said first wave train, shaping the second wave train, and applying the second wave train to the transducer a predetermined time interval after the first wave train has been applied to the transducer to cause mechanical vibrations produced by the face of the transducer equal and opposite to the mechanical vibrations existing at the face of the transducer at the instant of application of the second wave train.

2. The method of producing by a crystal transducer having a plurality of energizing electrodes a wave train of mechanical energy of a controlled number of cycles, which consists in generating a voltage wave train, applying the wave train to one of the transducer electrodes to cause the transducer to vibrate mechanically, generating a second voltage wave train which is electrically independent of said first wave train, shaping the second wave train, and applying the second wave train to another transducer electrode a predetermined time interval after the first wave train has been applied to the first transducer electrode to cause mechanical vibrations produced by the face of the transducer equal and opposite to the mechanical vibrations existing at the face of the transducer at the instant of application of the second wave train.

3. A device for producing a wave train of ultrasonic energy of a controlled number of cycles, comprising a crystal transducer, a voltage wave train generator, a second voltage wave train generator electrically independent of the first generator, means for energizing the wave train generators, delay means for delaying energization of the second wave train generator, means for shaping the wave train generated by the second wave train generator after a predetermined time delay means whereby the generators apply their wave trains to the transducer to cause mechanical vibrations generated by the face of the transducer equal and opposite to the mechanical vibrations existing at the face of the transducer at the instant of application of the second voltage wave train.

4. A device for producing an ultrasonic wave

train of energy of a controlled number of cycles, comprising a crystal transducer having a plurality of energizing electrodes, a voltage wave train generator, a second voltage wave train generator electrically independent of the first generator, means for energizing the generators, delay means for delaying energization of the second wave train generator, means whereby the first generator applies its wave train to one of said transducer energizing electrodes, means for shaping the wave train generated by the second wave train generator after a predetermined time delay means whereby the second generator applies its wave train to another of the transducer energizing electrodes to cause mechanical vibrations generated by the face of the transducer equal and opposite to the mechanical vibrations existing at the face of the transducer at the instant of application of the second voltage wave train.

HOWARD E. VAN VALKENBURG.
EDWARD G. COOK.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,416,337	Mason	Feb. 25, 1947