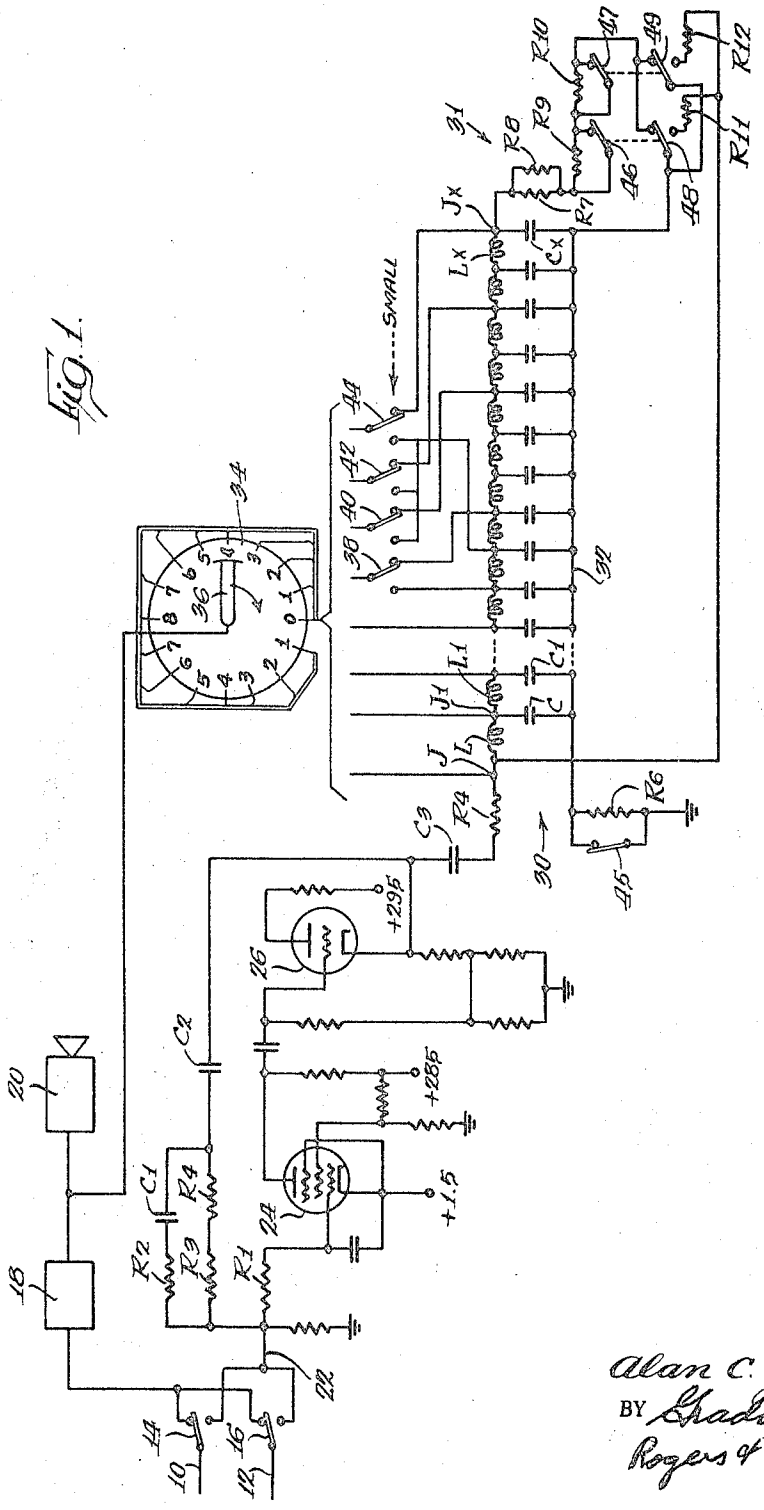
June 24, 1969 A. C. YOUNG 3,452,145

PHOTORESISTOR DELAY LINE SCANNER FOR VIBRATO

Original Filed June 18, 1962 Sheet 1 of 2



June 24, 1969 A. C. YOUNG 3,452,145

PHOTORESISTOR DELAY LINE SCANNER FOR VIBRATO

Original Filed June 18, 1962 Sheet 2 of 2

Fig. 2.

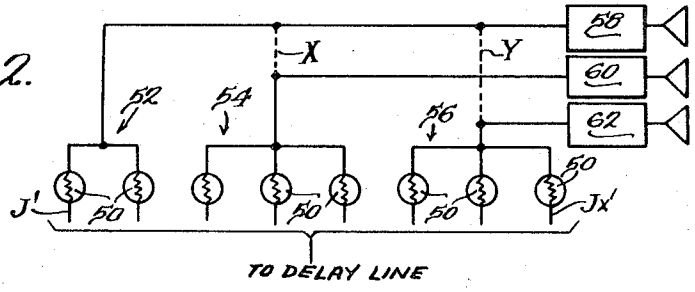


Fig. 3.

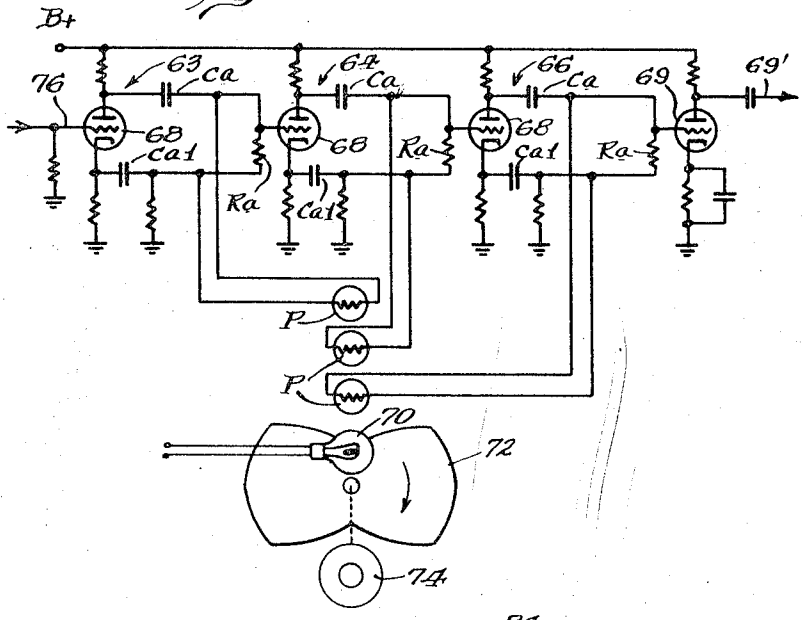
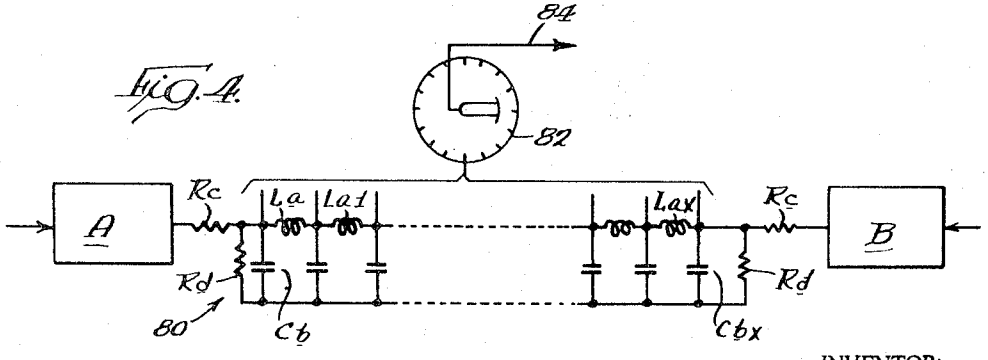


Fig. 4.



INVENTOR:
Alan C. Young
BY Gradolph, Love, Rogers & Van Sciver
Attys

United States Patent Office 3,452,145
Patented June 24, 1969

3,452,145

PHOTORESISTOR DELAY LINE SCANNER FOR VIBRATO

Alan C. Young, Park Ridge, Ill., assignor to Hammond Corporation, a corporation of Delaware

Original application June 18, 1962, Ser. No. 203,068, now Patent No. 3,258,519, dated June 28, 1966. Divided and this application Mar. 14, 1966, Ser. No. 533,918
Int. Cl. G10h 1/04
U.S. Cl. 84—1.25 7 Claims

ABSTRACT OF THE DISCLOSURE

A vibrato system for electrical musical instruments. Shown is a several stage phase shift signal delay line with a capacitative scanner for sampling junctions along the line successively to produce progressive phase shift. A celeste effect is produced by mismatching the delay line termination on any of several bases to produce controlled signal reflection in the line. There is also provision for introducing signals at both ends of the line, so that mixed signals with different degrees and directions of phase shift are picked up by the scanner. A variation uses a plurality of cyclically light scanned photoresistors connected to the delay line junctions in place of the capacitative scanner. Another variation uses a series of dynamic phase shift stages in which the degree of phase shift at each stage depends upon the value of a photoresistor element in the stage, the resistance values of which are cyclically changed by a variable intensity light source.

This invention relates in general to an arrangement for creating a vibrato effect in an electrical musical instrument such as an organ and more particularly to arrangements and methods for producing a vibrato in a more versatile and economical manner, and for related purposes. This application is a division of my copending application Ser. No. 203,068, filed June 18, 1962, now Patent No. 3,258,519.

The objects of the invention therefore include an improved arrangement for securing an improved vibrato effect in an electronic organ. Basically this is achieved in a novel and unique manner by mismatching the terminations of a standard delay line such as used for creating the ordinary vibrato effect to create electrical reflections in the line which are detected in response to a scanning action. The effect created thereby will generally be referred to as a vibrato celeste.

Other objects of the invention include an improved scanning arrangement for a vibrato delay line in order to provide certain advantages over the capacitative type scanning arrangement presently in use as typified by the concept disclosed in Patent No. 2,905,040, issued to Hanert on Sept. 22, 1959.

Still another object of the invention is to provide an arrangement in which tone signals are introduced into both ends of a vibrato delay line of a type similar to that described in the aforementioned patent for the purpose of creating a wide range of musical effects including the vibrato celeste effect mentioned above.

Yet another object of the present invention is to provide an improved and unique arrangement for controlling the percentage shift in frequency of a tone signal to which a vibrato is introduced whereby the vibrato is maintained substantially constant over a wide tone signal frequency range. This is achieved by a shift in the phase of a tone signal in a series of steps with the amount of the shift controlled by a non-linear frequency responsive circuit having a photoresistor therein whose resistance is controlled by an associated lamp so that a substantially constant percent of shift is achieved.

The manner in which the above objects are accomplished, together with others, will become apparent on examination of the following specification and claims in conjunction with the drawings, wherein:

FIG. 1 illustrates the pertinent circuit portions of a delay line arrangement for use in an organ to secure a vibrato celeste effect;

FIG. 2 illustrates one arrangement utilizing the improved scanning concept of the present invention;

FIG. 3 illustrates a plurality of cascaded phase shift circuits utilizing photoresistors for securing a substantially constant vibrato; and

FIG. 4 illustrates another arrangement for using a delay line in an organ to secure vibrato effects.

In FIG. 1 there is illustrated a pair of leads **10** and **12** respectively to which tone signals are supplied under control of the upper and lower manual keyboard respectively, for example, of an organ. A pair of switches **14** and **16** respectively enable the tone signals on leads **10** and **12** to be applied either to a conventional amplifier **18** for application to an output system **20** or to a vibrato channel **22**.

The vibrato channel **22** feeds an amplifier tube **24** through a resistor R1 and the amplifier in turn feeds a cathode follower **26**. A resistance capacitance mesh comprising the capacitors C1 and C2 together with resistors R2, R3, and R4 extends a degenerative signal from the cathode of cathode follower **26** to the input of tube **24**. The output of the cathode follower **26** is extended through a blocking capacitor C3 and a voltage dropping resistor R5 to the input terminal of a vibrator delay line **30**.

The delay line **30** comprises a group of serially connected inductances or coils L–LX terminating in a resistance network **31**. Respective terminals of the coils J–JX are connected by means of a respective capacitance C–CX to a common lead **32**. Respective junctures J–JX are also connected to respective terminals of a capacitative scanning device **34**. The device **34** has a scanning arm **36** which is connected to the output system **20** and it is rotated to sense the voltage appearing at the respective junctions J–JX for application to the output system **20**, as explained in the aforementionel patent.

A group of manually controlled switches **38–44** are provided for selectively interconnecting respective ones of the junctions J–JX with different terminals of the scanning device **34** in order to vary the amount of vibrato by controlling the total number of junctions scanned by device **34**.

A vibrato chorus effect is provided on operation of a switch **45** which disconnects a shunt on a resistor R6 tied to the delay line so that the scanning arm **36** also senses the original signal in its periodic scanning to apply the same to the output system **20** in conjunction with the phase shifted outputs of the delay line.

The resistance network **31** is connected between the termination junction JX and the lead **32**. It comprises a pair of shunt resistors R7 and R8 which provide a normally balanced termination for the line. These resistors R7 and R8 are connected in series with resistors R9 and R10 each shunted by a respective switch **46** and **47**. Switches **46** and **47**, when operated to their open position, remove the respective shunt on the associated resistors R9 and R10 to place the respective resistor in series with resistors R7 and R8 and thereby unbalance the termination of the delay line **30**.

The result is that the signals being transmitted over the delay line are then reflected back over the delay line to create additional phase shifts and/or in addition give rise to beats and nulls as the signals are either re-

inforced or cancelled. The scanner **34** detects these conditions which give rise to the unusual and interesting vibrato celeste effect. The effect, of course, is varied depending on which of the switches **46** and **47** is operated, since the respective resistors R9 and R10 are of considerably different value.

Each switch **46** and **47** also has a respective switch **48** and **49** associated therewith for the purpose of connecting a respective compensating resistors R11 or R12 between the lead **32** and the input to the delay line **30**.

In FIG. 2 there will be seen a variation of the scanning and output system seen in FIG. 1. In this case the scanning device **34** is replaced by a group of photoresistors **50** arranged in respective groups **52**, **54**, and **56**, for example, each feeding a respective output system **58**, **60**, and **62**.

Each photoresistor **50** is fed from a respective junction of a delay line such as shown in FIG. 1, as indicated by leads J' to JX', so that when the photoresistor are scanned by a cyclical light source at a vibrator rate in any well known manner, each will pass a signal corresponding to that at the respective junction of the delay line. With this system it is possible to scan the line and transmit the output to respective speakers having different formants indicated by the output systems **58**, **60**, and **62** in a sequence phased with the scanning cycle and thereby shift the formant as desired. If desired, of course, the output of the photoresistor may be connected to a single output system as indicated by the broken lines X and Y.

The arrangement shown in FIG. 3 comprises a series of cascaded dynamic phase shift circuits **63**, **64**, and **66** for securing a vibrato effect. Each circuit includes a tube **68** having a capacitor C*a* connected between its plate and a respective photoresistor element P arranged in shunt with a resistor R*a* and connected to the respective cathode through a capacitor C*a*1. The junction of the respective photoresistor P and the capacitor C*a* is connected to the grid of the tube in the succeeding stage and the output of the last stage **66** is connected to an amplifier **69** whereafter the signal is applied to an output lead **69'**.

Since the voltage between the plate and cathode of each tube **68** is substantially 180° out of phase, the voltage at the grid of the tube in the succeeding stage is dependent on the reactance of the capacitor C*a* at any particular frequency and the resistance of the photoresistor P. To vary the resistance of the photoresistor P, a light source **70** is provided and a mask **72** driven by a motor **74** is interposed between the light source **70** and the photoresistor for cyclically varying the photoresistor resistance at a vibrato rate.

Thus an input signal applied from a lead **76** to the grid of the tube **68** in the first stage is phase shifted by an amount dependent on the resistance of the photoresistor P at any particular instance and the reactance of the capacitor C*a*. Since these values may be balanced for a desired shift, a substantially constant percent of vibrato may be secured over most of the tone frequency spectrum.

The arrangement shown in FIG. 4 comprises a delay line **80** which includes a series of coils L*a*–L*ax* with the junctions being connected through capacitors Cb–Cb*x* to a common lead **81**. The junctures are scanned by a scanning device **82** for supplying a vibrato signal effect on lead **84** in a manner similar to that explained in the aforementioned patent or in connection with FIG. 1. If desired, the scanning arrangement shown in FIG. 2 may be utilized. In any event, the delay line **80** is fed at its opposite ends from respective signal sources A and B through respective resistors R*c*. Resistors R*d*, which are of lower resistance value than resistors R*c*, are provided in order to terminate the line for preventing signal reflections at either end of the line.

The signal sources A and B may actually be intermediate amplifiers fed from a common signal source, and may supply the same or different signals into the opposite ends of the line **80**. If the signals are the same, a considerable reinforcement or cancellation usually occurs at certain stages in the line **80**, and thereby a very unique vibrato effect similar in some respects to that explained for FIG. 1 is achieved. Or in the case where differing signals are fed into opposite ends of the delay line, the resultant phase shift at each junction will, of course, represent a composite effect which is of another character from that where similar signals are used, but it still creates a most unique musical effect.

The foregoing constitutes a description of various improvements in arrangements for securing a vibrato in a musical instrument which are capable of numerous modifications, and whose limitations are believed more adequately set forth in the following claims.

I claim:

1. An arrangement for securing a vibrato in a musical instrument, the improvement comprising a delay line including a group of serially connected coils and a capacitor connected between each juncture and a common lead whereby an input signal connected to a first one of said coils is shifted in phase on transmission through said coils, an arrangement for cyclically scanning respective junctures at a vibrato rate for detecting a signal of shifted phase at the respective junctures, and a plurality of termination impedances selectively connected between a last coil in said group and said common lead for unbalancing said line to create reflections of said input signal for detection by said scanning arrangement, said scanning arrangement comprising a series of photoresistors each connected to a respective one of said junctures.

2. The arrangemnt claimed in claim **1** in which said photoresistors are arranged in groups with the output of the photoresistors in each group being connected in common to a respective output system.

3. The arrangement claimed in claim **1** in which a respective compensating resistance network is connected between said common lead and the input to said line for each impedance connected to the termination thereof.

4. An arrangement for use in scanning a vibrato delay line in a musical instrument to detect signals at respective positions in said delay line, the improvement comprising a plurality of photoresistors each connected to a respective position in said delay line whereby said photoresistors are each permitted to pass a signal corresponding to that at the respective position on being scanned by a light source, and a plurality of output systems each connected to a respective group of said photoresistors for providing an output individual to the group of photoresistors.

5. An arrangement for use in scanning a vibrato delay line in a musical instrument to detect signals at respective positions in said delay line, the improvement comprising a plurality of photoresistors each connected to a respective position in said delay line whereby said photoresistors are each permitted to pass a signal corresponding to that at the respective position on being scanned by a light source at a respective rate, and a plurality of output systems each connected to a respective group of said photoresistors for providing an output individual to the group of photoresistors.

6. An arrangement for use in scanning a vibrato delay line in a musical instrument to detect signals at respective positions in said delay line, the improvement comprising a plurality of photoresistors each connected to a respective position in said delay line whereby said photoresistors are each permitted to pass a signal corresponding to that at the respective position on being scanned by a light source.

7. In an electric organ, a plurality of terminals connected to individual points in an electrical circuit in said organ, a plurality of photoresistors each connected at one electrical side to a respective one of said terminals, an output system circuit, means connecting the other electrical side of each of said photoresistors to said output system circuit, means providing a light source, and means

for scanning said light source serially across said photoresistors in cyclical fashion for serially connecting said terminals to said output system in the order of scanning and at the cyclical rate.

References Cited

UNITED STATES PATENTS

2,509,923	5/1950	Hanert	84—1.25
3,257,495	1/1962	Williams	84—1.18
3,388,257	6/1968	Eyck	84—1.25

ELI LIEBERMAN, *Primary Examiner.*

F. P. BUTLER, *Assistant Examiner.*

U.S. Cl. X.R.

84—1.25