Dec. 8, 1970 W. D. CRAGG ET AL 3,546,619

TONE SIGNALLING DEVICE USING PIEZOELECTRIC REED OSCILLATORS

Filed Oct. 3, 1968 3 Sheets-Sheet 1

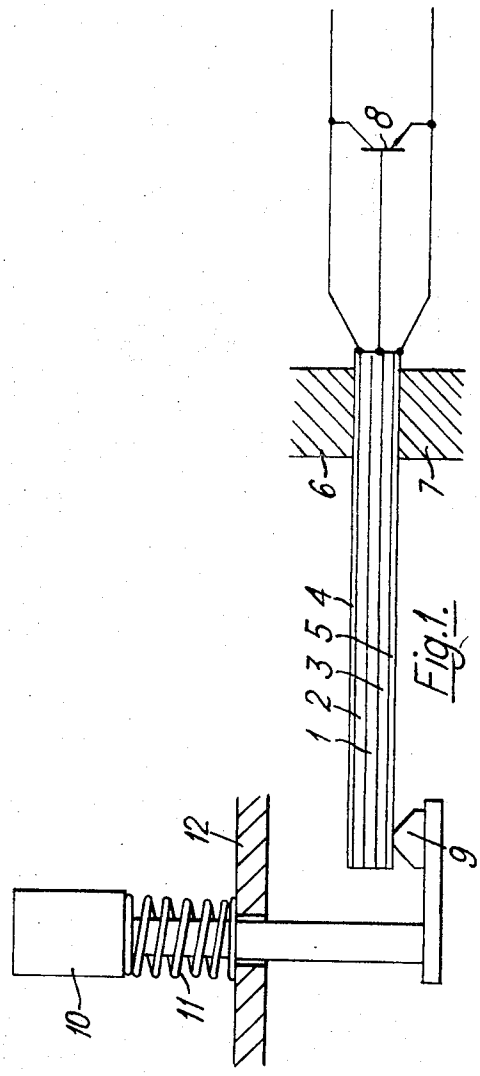


Fig. 1.

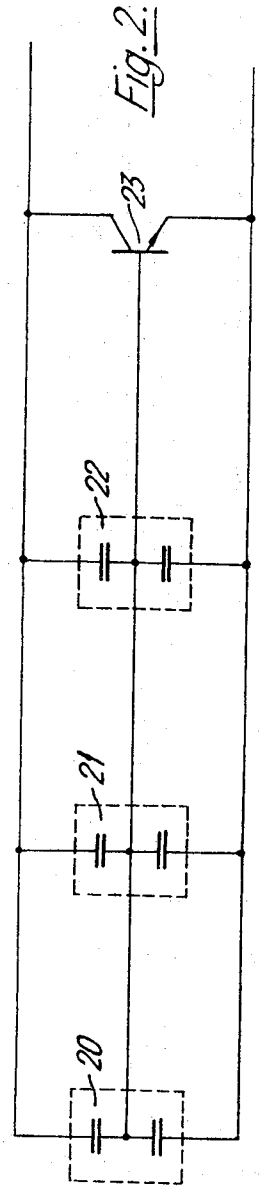


Fig. 2.

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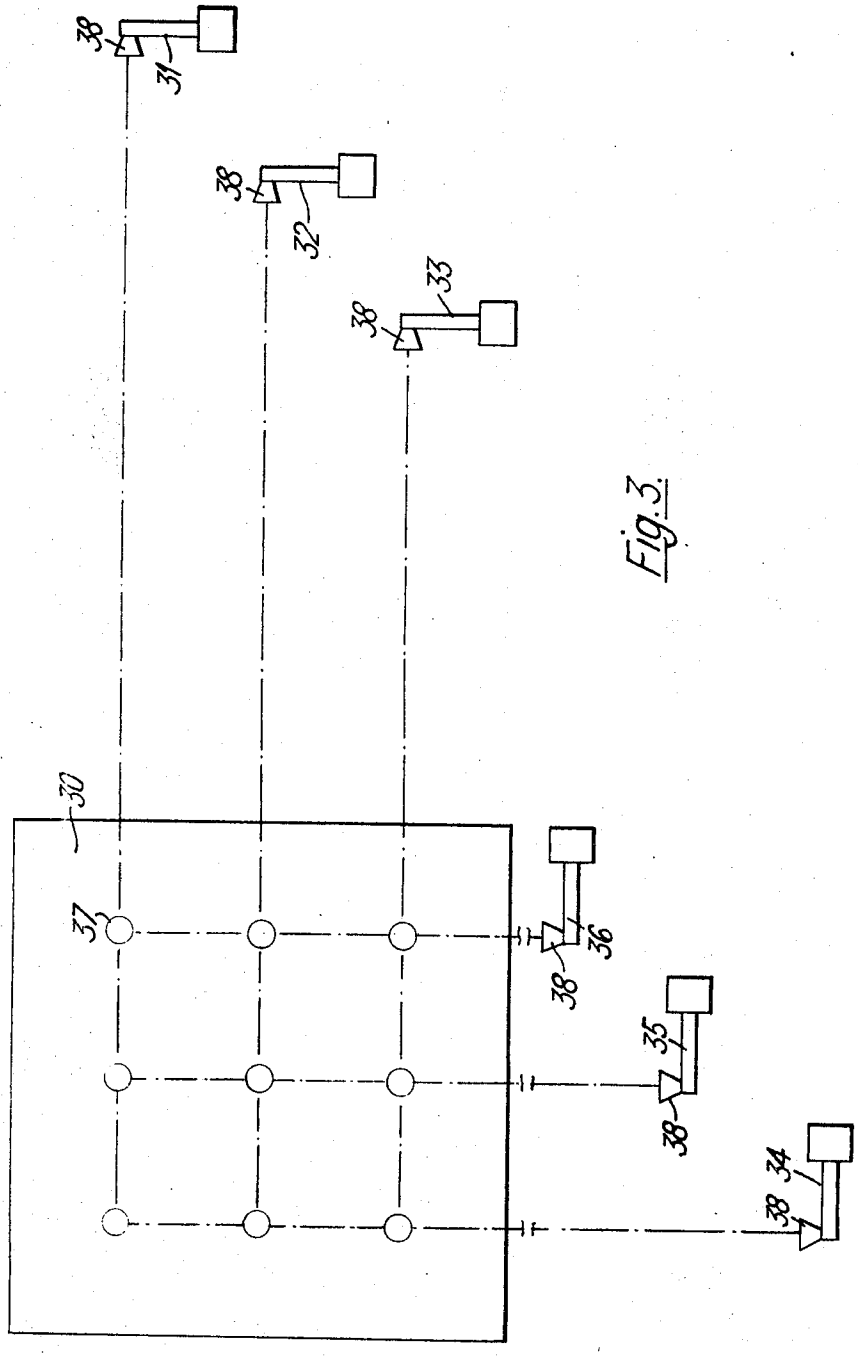


Fig. 3.

Dec. 8, 1970 W. D. CRAGG ET AL 3,546,619

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Filed Oct. 3, 1968 3 Sheets-Sheet 3

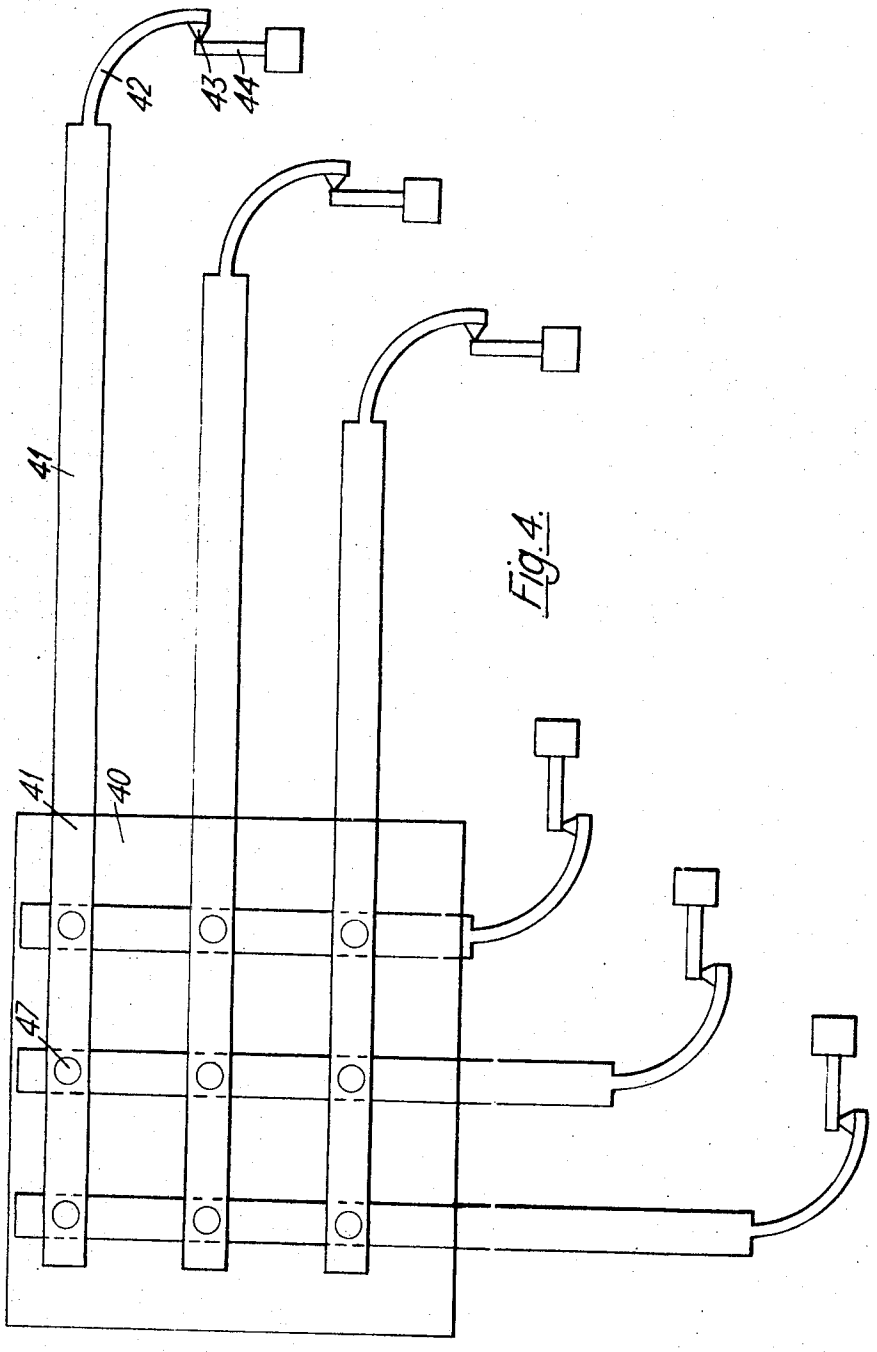


Fig. 4.

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TONE SIGNALLING DEVICE USING PIEZO-ELECTRIC REED OSCILLATORS

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U.S. Cl. 331—49
9 Claims

ABSTRACT OF THE DISCLOSURE

A contactless form of tone signalling device in which the oscillators are vibrating piezo-electric reds. Positive feedback is applied to the reeds from transistors, but the gain is only sufficient to excite the reeds into self-oscillation when dampers are removed from their associated reeds.

This invention relates to tone signalling devices and finds particular but not exclusive application in telephone networks and calculating machines, and provides a method of signalling which need not involve the make and break of electrical contacts in any circuits. The avoidance of such contacts, with their attendant problems of arcing and wear, opens the possibility of obtaining improved operational life for such signalling devices.

According to the invention there is provided a tone signalling device including one or more electromechanical transducers connected in circuits including an amplifier each of which circuits is adapted to have sufficient gain to excite its transducer into self oscillation only when a damper associated with that transducer is removed from contact with it, wherein signalling is effected by the removal of a selection of one or more dampers from contact with their associated transducers.

The features of the invention will be evident from the following description of preferred embodiments of the invention. The description refers to the accompanying drawings in which:

FIG. 1 is a diagram of a single tone signalling device comprising push-button, damper, vibrating reed and amplifying circuit,

FIG. 2 is a circuit diagram showing the connection of three reeds to a transistor,

FIG. 3 is a diagram of a tone signalling device with a 3×3 array of push-buttons interconnected to six dampers, and

FIG. 4 is a diagram of the tone signalling device of FIG. 3 equipped with a hydraulic linkage between the keyboard and the dampers.

A preferred embodiment of a tone signalling device includes an electromechanical transducer in the form of a reed clamped at one end. With reference to FIG. 1 the reed is composed of a five layer sandwich of an electrically conductive carrier layer **1** forming a common first electrode between two layers **2** and **3** of piezo-electric material, themselves included between two counter-electrode layers **4** and **5**. The carrier layer **1** is conveniently a metal layer such as a hard brass. The piezo-electric layers **2** and **3** may be made of any of the known materials which, in longitudinal compression expansion, produce a voltage difference between their major surfaces, such as lead zirconate titanate, and all three layers may be typically of the order of .015" thick, while the counter-electrode layers which may be of silver can be significantly thinner and can be deposited by sputtering. The reed is clamped at one end between jaws **6** and **7** of a clamp, and electrical connections made between the layers **1**, **4** and **5** to the terminals of a transistor **8** such that the voltage generated across one piezo-electric layer caused by the bending of the reed is amplified and fed back to the other piezo-electric layer with such a polarity as to tend to increase the bending of the reed. An oscillator is thus formed whose frequency is determined by the fundamental resonance of the reed. The resonance of the reed however can be damped by a damper **9**, and the gain of the transistor **8** is chosen so as to be insufficient to excite the reed into self-oscillation except when the damper **9** is removed from contact with the reed. The damper is linked by direct mechanical linkage to push-button **10** and is spring biased against the reed by means of a helical spring **11** compressed between the push button and a keyboard **12**. On depression of the bush-button **10** the reed is immediately excited into oscillation and the oscillatory signal can be detected and relayed to where it is required by auxiliary circuitry not shown.

As a development of the device described with reference to FIG. 1 a number of such devices can be assembled and operated from a keyboard of pushbuttons, and if there is no requirement for the facility of being able to generate two or more tones simultaneously, the transistor in the amplifying circuit may be made common to all transducers. FIG. 2 shows a diagram of the wiring of three separate reeds **20**, **21**, **22** to a common transistor **23**, where each reed is represented by the symbols of two capacitors connected in series.

So far it has been assumed that there is a single oscillator associated with each push-button, but it is possible to reduce the number of oscillators required for a given number of push-buttons by arranging the interconnection of push-buttons with transducers in such a way that the operation of a single push-button gives rise to the excitation of a unique selection of transducers. An example of this is given in FIG. 3 which depicts a keyboard **30** with nine push-buttons **37** in a 3 x 3 array. The push-buttons are coupled by dampers **38** to six reeds **31** to **36**. The first set of transducers **31**, **32**, and **33** are respectively coupled to the three rows of the array and the second set **34**, **35**, and **36** to the three columns, so that the depression of any button sets into oscillation two reeds, one appropriate to the row and the other the column of the button depressed. Provided there is no requirement for signalling the depression of two buttons simultaneously each set of three transducers can be wired to a common transistor as described above and depicted with reference to FIG. 2.

As an alternative to direct mechanical linkage between the push-buttons and the dampers associated with the oscillators a hydraulic arrangement can be used in which the dampers are attached to Bourdon tubing. This hydraulic linkage is illustrated in FIG. 4 which depicts the arrangement of push-buttons and transducers of FIG. 3. The keyboard **40** consists of a 3 x 3 array of push-buttons **47** underneath which are located the cross over points of a grid of six plastic tubes **41**. Each tube is filled with fluid and sealed at both ends. The ends remote from the keyboard are formed of a curved section of Bourdon tubing **42** and carry dampers **43** mounted on the inside of the curve. The keyboard is arranged such that when a push-button is depressed it locally distorts the two tubes underlying it causing an increase in pressure of the fluid contained in them. The Bourdon tubing at the ends of those two tubes, being flattened in cross-section, responds to this increase in pressure by partially uncoiling thereby removing the dampers from their associated row and column reeds **44** and hence allowing them to resonate.

Reed resonators of the type described above are stable enough over the temperature range −20° C. to 60° C. to be within the requirements for telephone tone signalling. Since the resonance frequency of the reed depends

on its dimensions, the initial adjustment to the required frequency may be made by eroding a small amount of material from the reed. Thus to raise the resonant frequency material may be removed from the end of the reed remote from its clamp; whereas if material is removed from the sides of the reed at its root near the clamp this will have the effect of lowering the resonant frequency.

It is to be understood that the foregoing description of specific examples of this invention is made by way of example only and is not to be considered as a limitation on its scope.

What is claimed is:

1. A tone signalling device comprising:

at least one electro-mechanical transducer;

a damper in contact with said one transducer;

keyboard control means;

means for coupling said keyboard control means to said damper to eliminate the contact between said damper and said transducer;

amplifier means coupled to said transducer to excite said transducer into self-oscillation when the contact between said damper and said transducer is eliminated.

2. A tone signalling device according to claim **1** wherein said coupling means includes direct mechanical linkage.

3. A tone signalling device according to claim **1** wherein said coupling means includes a hydraulically operated linkage further including Bourdon tubing.

4. A tone signalling device according to claim **1** wherein said keyboard control means are push-buttons.

5. A one signalling device according to claim **4** wherein the individual operation of each push-button provides for the removal and unique selection of dampers from the associated transducers.

6. A tone signalling device according to claim **1** wherein said transducer includes piezo-electric material.

7. A tone signalling device according to claim **6** wherein the piezoelectric material is lead zirconium titanate.

8. A tone signalling device according to claim **6** wherein said transducer is a vibrator reed having a five layer sandwich, said reed comprising:

two layers of said piezoelectric material;

an electrically conductive carrier layer formed between one surface of each of said two layers, said carrier layer forming a common first electrode; and

first and second counter electrode layers formed on the opposite respective surfaces of said piezoelectric layers.

9. A tone signalling device according to claim **8** wherein said amplifier means includes a transistor having an emitter, base and collector, said emitter and collector being respectively connected to the two counter electrodes, and said base being connected to said carrier layer.

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U.S. Cl. X.R.

310—25; 331—116, 156, 173