

May 23, 1961

C. H. COLVIN

2,985,019

PRESSURE RATIO TRANSDUCERS

Filed Sept. 29, 1958

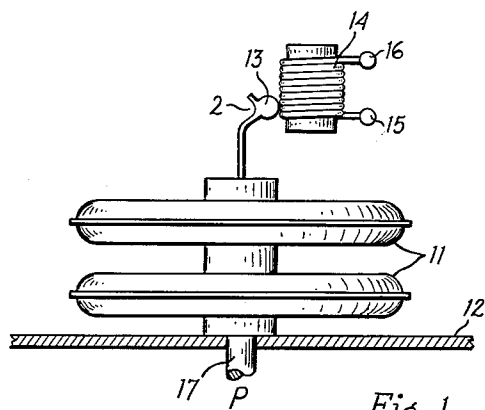


Fig. 1

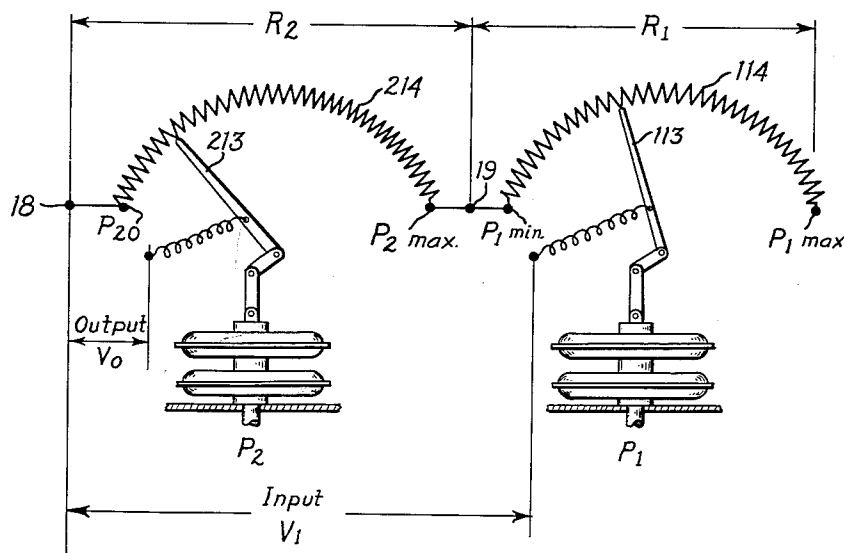


Fig. 2

INVENTOR.

CHARLES H. COLVIN
BY

Howard G. Russell
his ATTORNEY

1

2,985,019

PRESSURE RATIO TRANSDUCERS

Charles H. Colvin, Egbert Hill, Morris Township,
Morris County, N.J.

Filed Sept. 29, 1958, Ser. No. 763,992

5 Claims. (Cl. 73—398)

This invention relates to improvements in devices for producing an electrical signal, for example a voltage signal of a magnitude proportional to a physical condition, such as pressure, or any other physical condition which can be expressed in terms of pressure.

More particularly, the invention provides a transducer capable of producing a voltage signal proportional to the ratio of two variable pressures by means of an arrangement of two potentiometers supplied with a certain input voltage, the arrangement being such that an output voltage is produced which, if related to the input voltage, produces a ratio of output to input voltages which is proportional to the ratio of the two pressures.

The principles underlying the invention, its operation and its features, as well as the manner in which it may be practiced will appear more fully from the detailed description which follows accompanied by drawings showing, for the purpose of illustration, a preferred form of the invention. The invention also resides in certain new and original features of construction and a combination of elements hereinafter set forth and claimed.

Although the characteristic features of the invention which are believed to be novel will be particularly pointed out in the claims appended hereto, the invention itself, its objects and advantages and the manner in which it may be carried out may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part of it in which:

Fig. 1 is a partially diagrammatic illustration of a conventional potentiometer unit which may be used in practicing the invention; and

Fig. 2 is a diagram illustrating the combination of two potentiometers in accordance with the invention.

In the following description and in the claims various details will be identified by specific names for convenience. The names, however, are intended to be generic in their application. Corresponding reference characters refer to corresponding parts in the several figures of the drawings.

The drawings accompanying, and forming part of, this specification, disclose certain specific details of the invention for the purpose of explanation of its broader aspects, but it is understood that the details may be modified in various respects without departure from the principles of the invention and that the invention may be incorporated in other forms than shown.

Fig. 1 illustrates, partially diagrammatically, a conventional potentiometer unit which may be used in practicing the invention. The unit comprises a stack of diaphragm capsules 11 mounted at 12 and carrying a movable contact 13 slidably relatively to a resistor 14 having terminals 15 and 16. The resistor is shown as being a wire wound resistor and will hereinafter be referred to as "winding" for convenience, but it is understood that other forms of non-wire resistors are accepted in the field as equivalent and may be substituted for the wire wound unit 14. This may involve a change of the resistance

2

values to a different order of magnitude without a change in the principles underlying the invention.

Changes in the pressure inside a duct 17 leading to the inside of the capsules 11 cause the stack of capsules to expand and contract with a consequent movement of the contact 13 relatively to the winding 14.

Fig. 2 illustrates diagrammatically a combination of two pressure actuated potentiometer units in accordance with the invention.

A first potentiometer comprising a winding 114 and a movable first contact 113 is actuated in response to changes in a first pressure P_1 . A second potentiometer comprising a winding 214 and a movable second contact 213 is actuated in response to changes in a second pressure P_2 . The windings of both potentiometers lie in series and the terminal to the left of the winding may be called main terminal 18 while the terminal 19 between the winding 214 and 114 will be referred to as end terminal.

The relative arrangement of the windings, the movable contacts and the respective pressure responsive actuators is such that for the minimum pressure P_2 the resistance between the main terminal 18 and the movable contact 213 is, or would be, zero, whereas for the maximum pressure P_2 the resistance between the movable contact 213 and the end terminal 19 is zero. This is most easily accomplished by adjusting the potentiometer so that for the minimum pressure P_2 the contact 213 rests on one end of the winding 214 and that for the maximum pressure P_2 the contact 213 rests on the other end of the winding 214.

In distinction, the other potentiometer is so adjusted that in the position in which the movable contact 113 rests on the one end of the winding 114 the corresponding pressure P_1 is a minimum, but greater than zero.

An input voltage V_1 is applied between the main terminal 18 and the movable contact 113, and the output voltage signal is taken off at the main terminal 18 and the movable contact 213, respectively.

The resistance R_2 between contacts 18 and 19 is chosen arbitrarily, for example with a view of matching the data of the indicator to be used, and the resistance R_1 of winding is computed and chosen as follows:

$$(1) \quad R_1 = R_2 \frac{P_1 \max - P_1 \min}{P_1 \min}$$

If the resistances are so selected then, for any pressures P_2 and P_1 , the resistance between points 18 and 213 is equal to

$$(2) \quad R_2 \frac{P_2}{P_2 \max}$$

and the resistance between points 18 and 113 is equal to

$$(3) \quad R_2 + R_1 \frac{P_1 - P_1 \min}{P_1 \max - P_1 \min}$$

The ratio of the output voltage V_0 to the input voltage V_1 is equal to the ratio of the resistances between points 18 and 213 and between points 18 and 113, respectively, thus:

$$(4) \quad \frac{V_0}{V_1} = \frac{\text{Resistance between 18; 213}}{\text{Resistance between 18; 113}}$$

accordingly, substituting in Equation 4 the values of 2 and 3 we obtain

$$(5) \quad \frac{V_0}{V_1} = \frac{R_2 \frac{P_2}{P_2 \max}}{R_2 + R_1 \frac{P_1 - P_1 \min}{P_1 \max - P_1 \min}}$$

3

Expressing R_1 in terms of R_2 according to (1)

$$(6) \quad \frac{V_0}{V_1} = \frac{R_2 \frac{P_2}{P_2 \max}}{R_2 + R_2 \frac{P_1 \max - P_1 \min}{P_1 \min} \frac{P_1 - P_1 \min}{P_1 \max - P_1 \min}}$$

This leads to

$$(7) \quad \frac{V_0}{V_1} = \frac{\frac{P_2}{P_2 \max}}{1 + \frac{P_1 - P_1 \min}{P_1 \min}}$$

Simplifying the denominator D

$$(I) \quad D = 1 + \frac{P_1 - P_1 \min}{P_1 \min}$$

$$(II) \quad D = 1 + \frac{\frac{P_1}{P_1 \min} \frac{P_1 \min}{P_1 \min}}{\frac{P_1 \min}{P_1 \min}}$$

$$(III) \quad D = 1 + \frac{\frac{P_1}{P_1 \min} - 1}{1} = \frac{P_1}{P_1 \min}$$

Introducing the result of (III) in (7) we obtain

$$(8) \quad \frac{V_0}{V_1} = \frac{\frac{P_2}{P_2 \max}}{\frac{P_1}{P_1 \min}}$$

and

$$(9) \quad \frac{V_0}{V_1} = \frac{P_2}{P_2 \max} \frac{P_1 \min}{P_1}$$

and further

$$(10) \quad \frac{V_0}{V_1} = \frac{P_2}{P_1} \frac{P_1 \min}{P_2 \max}$$

since

$$\frac{P_1 \min}{P_2 \max} \text{ is a constant}$$

$$(11) \quad \frac{V_0}{V_1} = C \cdot \frac{P_2}{P_1}$$

Thus it is seen that the ratio of the voltages V_0 and V_1 is directly proportional to the ratio of the pressures P_2 and P_1 .

Numerical example.—It may be assumed that P_2 may vary from zero to 100 p.s.i. and that P_1 may vary from 10 to 50 p.s.i. It may further be assumed that the resistance R_2 is chosen at 1000 ohms. According to (1)

$$R_1 = 1000 \frac{40}{10} = 4000 \text{ ohms}$$

Typical figures.—It may first be assumed that P_2 equals 100 p.s.i. and P_1 equals 50 p.s.i. (maximum positions). In this case the resistance between points 18 and 213 is 1000 ohms and the resistance between points 18 and 113 is 5000 ohms. In this instance the pressure ratio

$$\frac{100}{50} = 2$$

and the resistance ratio

$$\frac{1000}{5000} = 0.2$$

The voltage ratio corresponds to the resistance ratio and is accordingly 0.2.

4

It may next be assumed that the pressure $P_2 = 100$ p.s.i. and the pressure $P_1 = 20$ p.s.i., a pressure ratio of

$$\frac{100}{20} = 5$$

The resistance ratio in this instance is

$$\frac{1000}{2000} = 0.5$$

and the voltage ratio is also 0.5.

It may then be assumed that the pressure $P_2 = 100$ p.s.i. and the pressure $P_1 = 10$ p.s.i., a pressure ratio

$$\frac{100}{10} = 10$$

The resistance ratio in this case is

$$\frac{1000}{1000} = 1$$

and the voltage ratio is also 1.

It may finally be assumed that $P_2 = 50$ p.s.i. and that $P_1 = 50$ p.s.i., a pressure ratio of

$$\frac{50}{50} = 1$$

In this case the resistance ratio is

$$\frac{500}{5000} = 0.1$$

and the voltage ratio is also 0.1. In all these examples the constant factor C was

$$\frac{1}{10}$$

Obviously, the transducer may operate an indicator, computing device or a control mechanism as known in the indicator and regulator art.

What is claimed is:

1. A pressure ratio transducing system comprising, a first member movably responsive to a first pressure; a second member movably responsive to a second pressure; a first potentiometer including a first resistance element and a movable contact connected to said first member to be moved relatively to, and in contact with, said element; a second potentiometer including a second resistance element and a movable contact connected to said second member to be moved relatively to, and in contact with, the second element, said second element extending intermediate a main terminal and an end terminal, the said first element being connected with its one end to said end terminal so as to lie in series with said second element, said second potentiometer having an element of a certain total resistance and being so arranged that at zero pressure its movable contact rests on the one end of its element and that at maximum pressure the said second movable contact rests on the other end of its element, the first potentiometer being so arranged that its movable contact rests on the one end of its element at a minimum pressure greater than zero, the total resistance of the first element being equal to the total resistance of the second element multiplied by the quotient obtained by dividing the pressure range of the first member from minimum to maximum pressure by said minimum pressure; and means for supplying an input voltage at said main terminal and said first movable contact, respectively, whereby an output voltage is produced between said main terminal and said second movable contact which, if related to the said input voltage, represents a ratio of output voltage to input voltage which ratio is proportional to the ratio of said second pressure to said first pressure.

2. In a pressure transducing system for producing an output voltage which bears a ratio to an applied input voltage which is directly proportional to the ratio of a second pressure to a first pressure, the combination of

5

two potentiometer elements in series between a main terminal at one end of one potentiometer resistance element and the opposite end of the other potentiometer resistance element; a movable output contact movable over said one element and a movable input contact movable over said other element; a first pressure responsive element movably responsive to a first pressure and connected to said input contact to move it along said other potentiometer element in dependence on changes in the first pressure from a minimum pressure greater than zero corresponding to a contact position at the one end of said other element to a maximum pressure corresponding to a contact position at the other end of the said other potentiometer element; a second pressure responsive element movably responsive to a second pressure and connected to said output contact to move it along said one potentiometer element in dependence on changes in the second pressure from zero pressure corresponding to a contact position at the one main terminal end of said one potentiometer element to a maximum second pressure corresponding to a contact position at the other end of said one potentiometer element, the total resistance of said other element being equal to the total resistance of said one element multiplied by the quotient obtained by dividing the pressure range of said first pressure responsive element by the said minimum pressure.

3. A pressure transducing system for producing between a main terminal point and one wiper arm, both below recited, a voltage signal directly proportional to the ratio of two pressures, the system comprising, in combination, two potentiometer resistance elements in series, the one end of the one element being a main terminal point, and the other end of the one element being connected to the one end of the other element; one wiper arm movable over the one element; a further wiper arm movable over the other element; a first pressure responsive member movably responsive to changes in a first pressure, said first pressure responsive member being connected to said further arm to move said further arm over said other potentiometer element from one end to the other end in response to a range of first pressures from a minimum above zero pressure to a maximum pressure; a second pressure responsive member movably responsive to changes in a second pressure, said second pressure responsive member being connected to said one arm to move said one arm over said one potentiometer element from one end to the other end in response to changes in the second pressure from zero to a maximum, the total resistance of the other element being equal to the total resistance of the one element multiplied by the quotient obtained by dividing the pressure range of said first pressure responsive member by said minimum pressure; and means for applying an input potential between the main terminal point and said further arm.

4. A pressure transducing system for producing a voltage signal directly proportional to the ratio of two pressures, the device comprising, in combination, two potentiometer resistance elements in series, the one end of the one element being a main terminal point, and the other end of the one element being connected to the one end of the other element; an output wiper arm movable over the one element; an input wiper arm movable over the other element; a first pressure responsive member mov-

6

ably responsive to changes in a first pressure, said first pressure responsive member being connected to said input arm to move said input arm over said other potentiometer element from end to end in response to a range of first pressures from a minimum above zero pressure to a maximum pressure; a second pressure responsive member movably responsive to changes in a second pressure, said second pressure responsive member being connected to said output arm to move said output arm over said one potentiometer element from end to end in response to changes in the second pressure from zero to a maximum, the total resistance of the other element being equal to the total resistance of the one element multiplied by the quotient obtained by dividing the pressure range of said first pressure responsive member by said minimum pressure; means for applying an input voltage to said main terminal and said input arm, respectively; and voltage responsive means connected to said main terminal and said output arm, respectively.

5. A pressure ratio transducing system comprising, a first member movably responsive to a first pressure; a second member movably responsive to a second pressure; a first potentiometer including a first resistance element and a first movable contact connected to said first member to be moved relatively to said element; a second potentiometer including a second resistance element and a second movable contact connected to said second member to be moved relatively to the second resistance element, said second element extending intermediate a main terminal at one side and an end terminal at the other side, the said first element being connected with its one end to said end terminal so as to lie in series with said second element, said second potentiometer having an element of a certain total resistance and being so arranged that at zero pressure the total resistance between said main terminal and said second movable contact is zero and that at maximum pressure the resistance between said second movable contact and said end terminal is zero, the first potentiometer being so arranged that at a minimum pressure greater than zero its said first movable contact rests in a position in which the resistance between said end terminal and said first contact is zero, the total resistance of the first element being equal to the total resistance between said main terminal and said end terminal which includes the second element, said total resistance being multiplied by the quotient obtained by dividing the pressure range of the first member from minimum to maximum pressure by said minimum pressure; and means for supplying an input voltage at said main terminal and said first movable contact, respectively, whereby an output voltage is produced between said main terminal and said second movable contact which bears a relation to the input voltage which is directly proportional to the ratio of the first pressure to the second.

References Cited in the file of this patent

UNITED STATES PATENTS

1,133,556	Gerdien	Mar. 30, 1915
1,285,145	Harrington et al.	Nov. 19, 1918
2,785,570	Mounteer et al.	Mar. 19, 1957
2,830,453	Jones	Apr. 15, 1958