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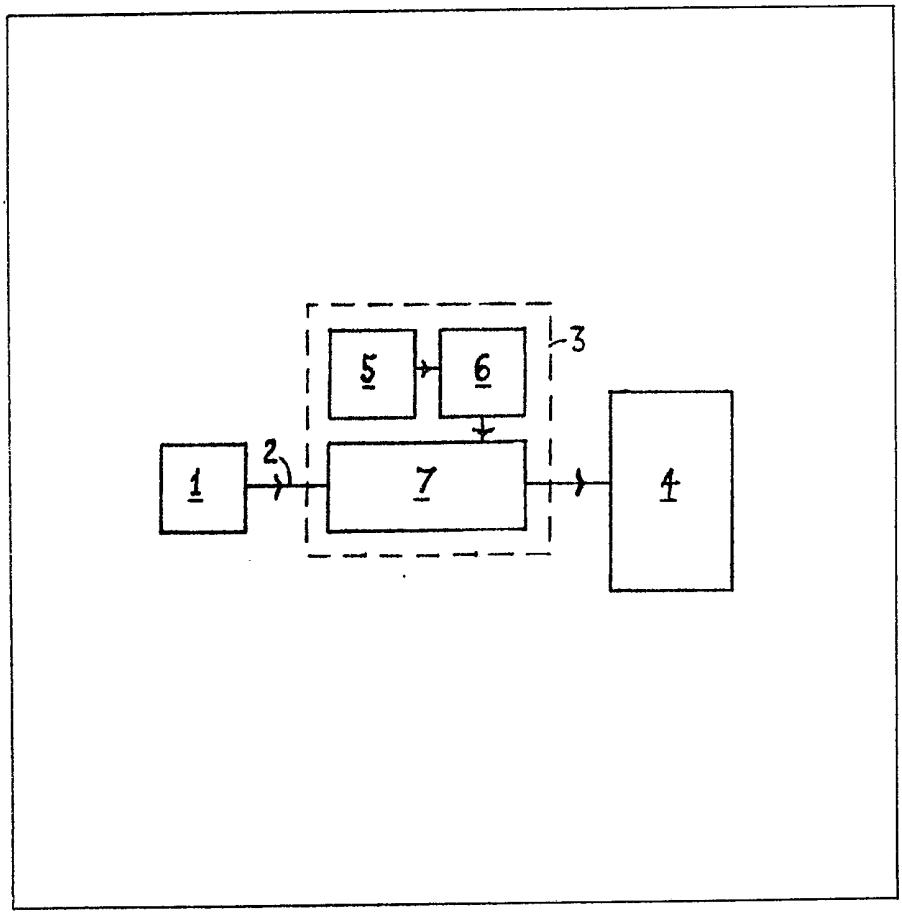
(54) **Conditioning pressure transducer outputs**

(57) The output of an operational medical pressure transducer (1) is compared with that of reference transducer (6) over a range of pressures supplied by a reference pressure source (5) to establish in an adjustment device (7) conditioning parameters or memory location associations such that the adjustment device (7) can supply a conditioned input to a recording and/or display receiver (4) in response to subsequent outputs from the operational transducer. The conditioning can be with respect to gain, linearity and zero-offset.



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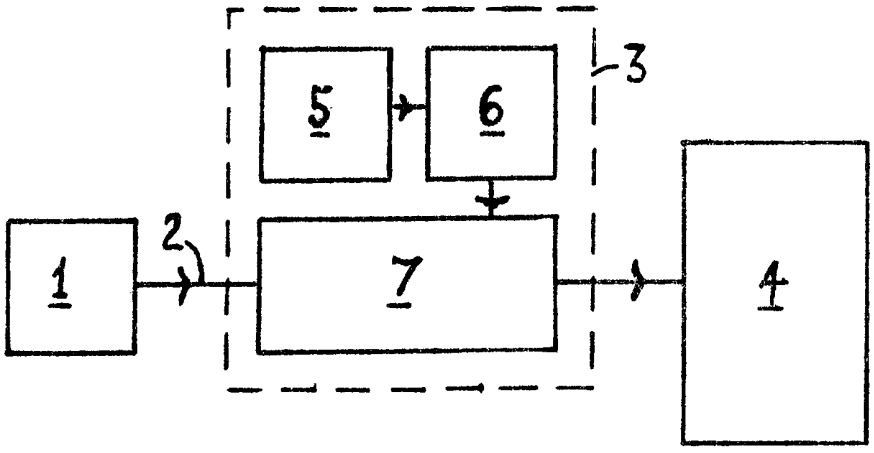
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SPECIFICATION

Signal conditioning method and unit

This invention relates to a method of and a unit for conditioning an output signal from a transducer.

The invention is of particular but not exclusive application in the medical field for conditioning the output signal of a pressure transducer prior to its reception by a receiver for example a pressure recording and/or display device in a patient monitoring system.

A pressure transducer and an associated signal conditioning unit are required to provide an electrical input for a receiver which is proportional to the pressure to which the transducer is exposed and of a magnitude compatible with the receiver input range. This input is also required to be substantially unaffected by changes in transducer temperature.

Conventionally the linearity of response and the variation of zero offset and sensitivity with temperature of the transducer output signal are determined almost entirely by the transducer specification and are set during the manufacture of the transducer. For medical applications the overall output of the transducer is also often set to a nominal value during manufacture so that any subsequent interchanging of individual transducers only requires adjustment of zero at the signal conditioning unit before use. Alternatively each transducer may have built into it an individual means of calibration reference such as a resistor which may be used by the signal conditioning unit to generate an output voltage signal corresponding to a reference pressure such as 100 mm Hg. In the absence of such a means of output calibration each transducer must be individually calibrated by the user using a known pressure, a procedure which is often very inconvenient, especially in medical applications. Since all these performance parameters are set at the time of manufacture of the transducer the overall accuracy of the system is almost entirely dependent on the maintenance after manufacture and during subsequent usage of the original performance specification.

The present invention provides a signal conditioning unit for conditioning the output signal of at least one operational pressure transducer, the unit comprising a source of a reference pressure selectively variable over a predetermined range, a reference pressure transducer, and an adjustment device arranged to be programmed in response to the outputs of the reference and operational transducers so as to supply in response to the operational transducer output an output normalized to the requirements of a receiver.

The adjustment device can comprise comparator means for comparing the operational and reference transducer outputs, conditioning means for conditioning the operational transducer output to provide a conditioned input to a receiver, a memory device for storing the conditioning parameters, and means for applying the stored parameters to condition a subsequent operational transducer output to provide a conditioned input to the receiver.

Also, the adjustment device can comprise a memory device for storing reference transducer outputs due to applied reference pressures at memory locations associated with operational transducer outputs due to the said reference pressures, and means for supplying to the receiver the stored reference transducer outputs in response to operational transducer outputs due to a pressure being monitored thereby.

The invention also provides a method of operating a pressure indicating apparatus, the method comprising the steps of comparing an output obtained from an operational pressure transducer with the output of a reference pressure transducer responsive to a reference pressure source over a predetermined pressure range, conditioning the operational transducer output so as to provide a conditioned output for reception by the receiver, and storing the conditioning parameter, the stored parameter being used to condition the operational transducer output during subsequent use of the operational transducer to provide a conditioned output for the receiver.

The invention also provides a method of operating a pressure measuring apparatus comprising an operational pressure transducer and a receiver for receiving the output of the transducer, the method comprising the steps of setting up the apparatus by applying to the operational pressure transducer and to a reference transducer a plurality of pressures in a predetermined range, storing, for each of the plurality of pressures, a value corresponding to the reference transducer output in a memory location associated with the operational transducer output at the same pressure, and subsequently operating the apparatus by supplying the stored values to the receiver in response to operational transducer outputs with which the memory locations are associated.

The important transducer characteristics to be normalised are sensitivity, linearity and zero offset.

The present invention thus enables the recording or monitoring system to receive accurately defined signals directly proportional to pressure from a wide range of operational transducers with no more inconvenience to the operator than arise from use of a transducer with accurately normalised characteristics and a conventional signal conditioning unit.

The signal conditioning unit of the present invention also has the advantage that any change in transducer characteristics within a wide range, occurring after manufacture, has negligible effect on the accuracy of the output to the monitor.

The invention is further described below, by way of example, with reference to the accompanying schematic drawing, the single figure of which shows, in block diagram form, a signal conditioning unit in accordance with the invention connected between an operational

pressure transducer and a receiver.

As shown in the drawing, the output of an operational medical pressure transducer 1, which need not be an expensive or highly accurate instrument, is supplied by an electric cable 2 to a signal conditioning unit 3, and after processing therein is supplied to a receiver which may be a chart recorder, or other recording and/or display means for providing record and/or a visual display of the pressure monitored by the transducer 1.

The signal conditioning unit 3 contains a reference pressure source 5 which provides a reference pressure selectively variable over a predetermined pressure range and which is sensed by a master or reference pressure transducer 6 whose characteristics are stable and known. The unit 3 also contains an adjustment device 7 for adjusting the electrical amplitude, zero offset, and linearity of the output of the transducer 1 so as to provide an output from the unit 3 that is matched to the input signal requirements of the receiver 4.

During an initial setting up period the output of the operational transducer 1 is compared over the same pressure range with that of the reference transducer 6 and is electrically processed in such a way as to yield a substantially linear output, directly proportional to pressure, of whatever pressure is sensed by the transducer 1.

The signal conditioning parameters such as gain, linearity correction, and zero offset, set during this period are electrically stored and held in a memory device within the device 7 during the subsequent use period of the operational transducer 1, so that the reference transducer 6 need not be continuously pressurized.

The initial setting up may be carried out at two different temperatures and if there is some transducer parameter, such as bridge resistance, which can be correlated with temperature, the adjustment of zero offset and gain needed to maintain the output within the designated tolerances throughout the working range can similarly be stored in the memory device.

Preferably, the circuit parameters controlling zero offset, gain, linearity, and variations of these with transducer temperature, are stored in digital form in the memory device, so as to be maintained unchanged for as long as they are required by the user, the unit 3 being then provided with analog to digital converters for conversion of the analog signals from the reference transducer 5 and the or each operational transducer 1 to digital form. A digital to analog converter is also provided at the unit output if the receiver 4 requires an analog input.

In a modified arrangement, the adjustment device 7 comprises a memory device in which the operational transducer 1 is allocated a table of digital memory locations corresponding with the full scale digital output of that transducer or a binary fraction thereof. In each such location, there is stored, during the 'setting up' period, a number corresponding to the pressure derived from the reference transducer 6 at the same pressure. That is, if at zero pressure the output from the operational transducer 1 is say 20, memory location Number 20 of its calibration table would hold the number zero. When pressure is applied and the output of the reference transducer 5 rises to say 50, the output of the operational transducer might rise to 60. In this case the memory location Number 60 in its table would hold the number 50. During measurement therefore, the output of the operational transducer 1 is used to determine which location within its calibration table holds the current pressure, so that this pressure figure may be accessed and read from the memory for further processing.

This conversion from a transducer output number to a pressure number is rendered very rapid and enables tracking of rapidly changing pressures in real time. The pressure numbers may be set through a digital to analog converter circuit to give a normalised pressure output voltage for a chart recorder, or recorded directly on a digital plotting printer or digital recording medium such as magnetic taper or disk. They may also be used to give a direct visual output on a V.D.U.

Alternatively the pressure numbers, averaged over pre-determined time intervals, may be stored in a computer memory so that further, more complex, processing may subsequently take place.

The electrical cable 2 connecting the operational transducer 1 to the signal conditioning unit 3 may also be used as a pressure duct giving reference to atmospheric pressure during normal operation but giving reference to the pressure monitored by the reference transducer 6 during the setting up period.

Although the specific description has referred to a single operational transducer 1, it will be evident that the unit can be arranged to deal with the outputs of a plurality of such transducers.

A signal conditioning device embodying the present invention thus allows the use of operational transducers that have not been manufactured to the highest standards of accuracy and stability, and which are consequently inexpensive, whilst ensuring high accuracy and stability of the measurements obtained thereby.

CLAIMS

1. A signal conditioning unit for conditioning the output signal of at least one operational pressure transducer, the unit comprising a source of a reference pressure selectively variable over a predetermined range, a reference pressure transducer, and an adjustment device arranged to be programmed in response to the outputs of the reference and operational transducers so as to supply in response to the operational transducer output an output normalized to the requirements of a receiver.

2. A signal conditioning unit for conditioning the output of an operational pressure transducer, the unit comprising a source of a reference pressure selectively variable over a predetermined range, a reference pressure transducer comparator

means for comparing the operational and reference transducer outputs, conditioning means for conditioning the operational transducer output to provide a conditioned input to a receiver, a memory device for storing the conditioning parameters, and means for applying the stored parameters to condition a subsequent operational transducer output to provide a conditioned input to the receiver.

3. A signal conditioning unit for conditioning the output of an operational pressure transducer, the unit comprising a source of a reference pressure selectively variable over a predetermined range, a reference pressure transducer, means for applying the reference pressure to the operational and pressure transducers over the predetermined range, a memory device for storing reference transducer outputs due to applied reference pressures at memory locations associated with operational transducer outputs due to the said reference pressures, and means for supplying to the receiver the stored reference transducer outputs in response to operational transducer outputs due to a pressure being monitored thereby.

4. A unit as claimed in claim 2 or 3 wherein the transducer outputs are analog outputs, the memory device is a digital device, and the unit includes analog to digital converter means for converting the transducer outputs to digital form.

5. A unit as claimed in claim 4 having a digital to analog converter for converting the unit output to an analog signal to provide an analog input for the receiver.

6. A unit as claimed in any preceding claim having a cable for electrically connecting the operational transducer thereto, the cable comprising a duct for selectively applying atmospheric pressure or the pressure of the reference source to the operational transducer.

7. A signal conditioning unit substantially as herein described with reference to the accompanying drawing.

8. A method of operating a pressure indicating apparatus, the method comprising the steps of comparing an output obtained from an operational pressure transducer with the output of a reference pressure transducer responsive to a reference pressure source over a predetmined pressure range, conditioning the operational transducer output so as to provide a conditioned output for reception by the receiver, and storing the conditioning parameter, the stored parameter being used to condition the operational transducer output during subsequent use of the operational transducer to provide a conditioned output for the receiver.

9. A method as claimed in claim 8 wherein the parameter comprises at least one of gain, linearity correction and zero offset.

10. A method as claimed in claim 9 wherein the parameter comprises a temperature related parameter.

11. A method of operating a pressure measuring apparatus comprising an operational pressure transducer and a receiver for receiving the output of the transducer, the method comprising the steps of setting up the apparatus by applying to the operational pressure transducer and to a reference transducer a plurality of pressures in a predetermined range, storing, for each of the plurality of pressures, a value corresponding to the reference transducer output in a memory location associated with the operational transducer output at the same pressure, and subsequently operating the apparatus by supplying the stored values to the receiver in response to operational transducer outputs with which the memory locations are associated.

12. A method of operating a pressure indicating apparatus substantially as herein described with reference to the accompanying drawing.

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