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(54) Ultrasonic transducer array around a flexible tube

(57) A tubular probe carries round its circumference a transducer arrangement 3 of ultrasonic transducer segments T1-T12 capable of transmitting ultrasonic pulses and receiving echoes. The transducer segments are connected to a multiplexer/ demultiplexer and to an image processer device. The probe may be in the form of a catheter for use within blood vessels or it may be used inside pipes. In other arrangements, the transducer segments may be formed by a toroid of piezoelectric material with inner and outer electrodes or by a solid annulus of such material scored along lines parallel to the tube axis. The probe may be combined with another ultrasonic transducer powerful enough to destroy plaque within an artery.

Fig. 1.

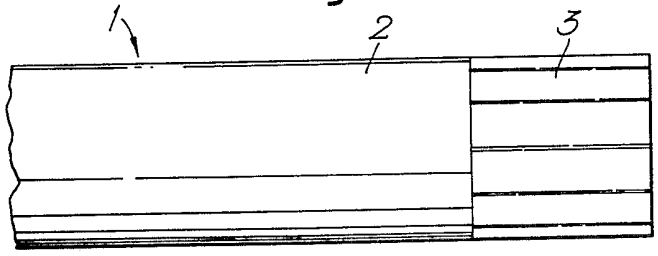

Fig. 2.

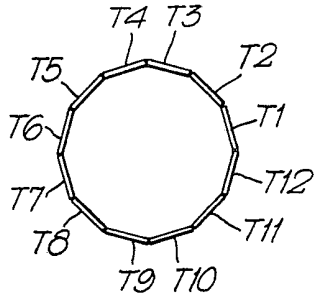

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Fig. 1.

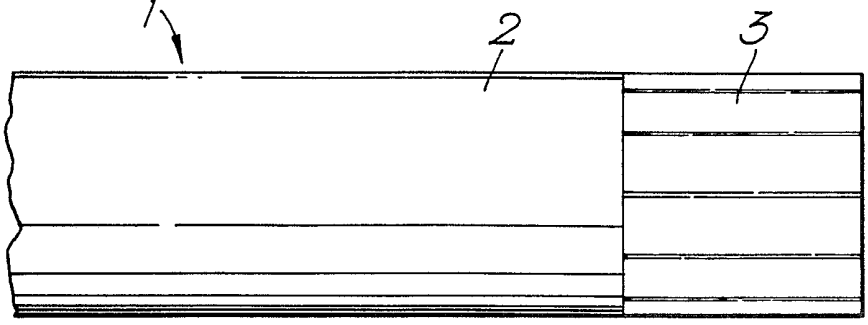


Fig. 2.

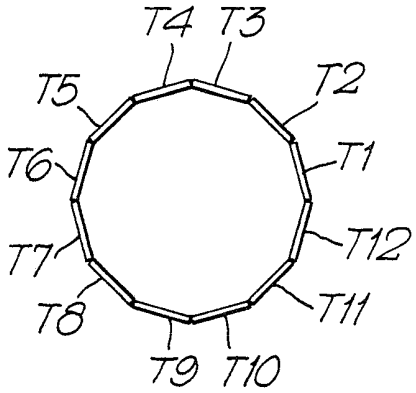


Fig. 3.

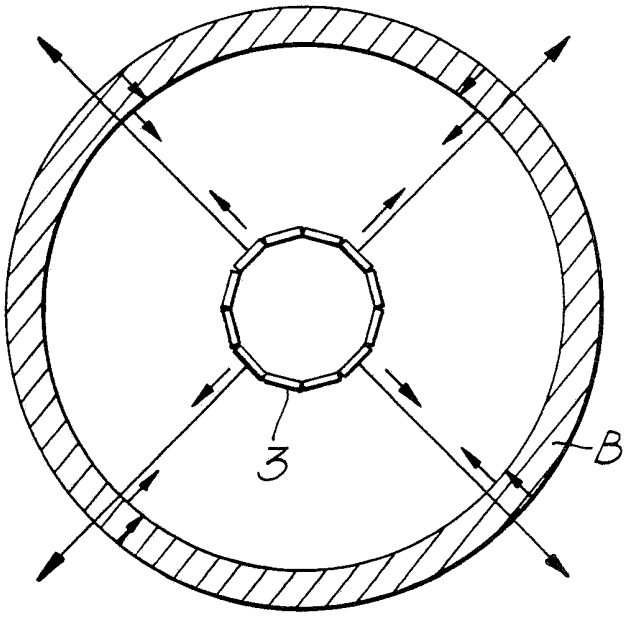


Fig. 4.

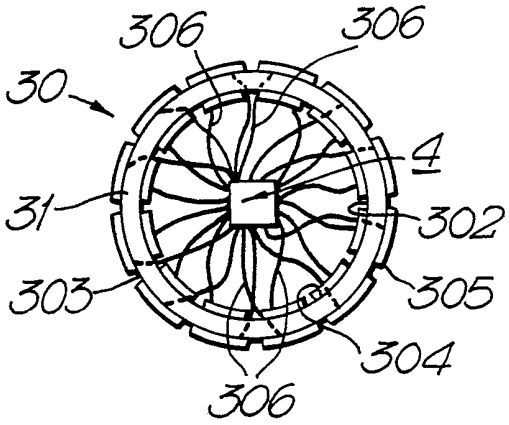


Fig. 5.

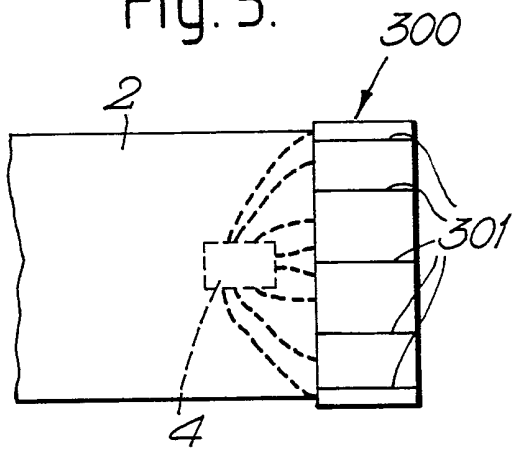


Fig. 6.

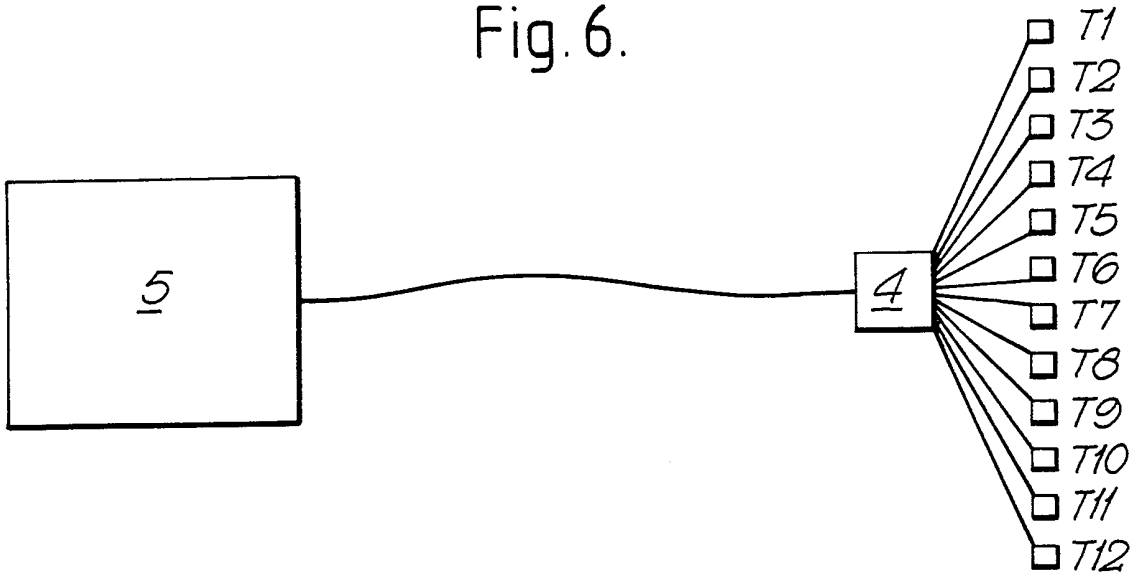
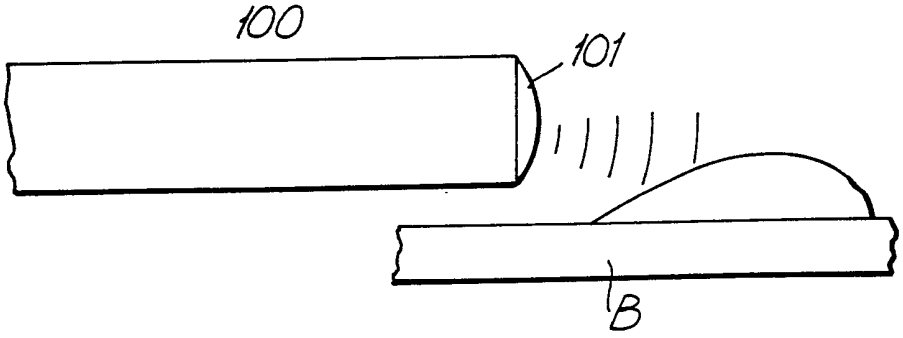


Fig. 7.



TUBULAR PROBE

This invention relates to a tubular probe and has particular application, but not exclusively, in the medical field as a catheter for insertion into, for scanning, hollow body parts such as blood vessels in order to detect abnormalities.

According to one aspect of this invention there is provided a tubular probe including a tube at least a section of which carries round its circumference a transducer arrangement comprising a plurality of ultrasonic transducer segments capable of transmitting ultrasonic pulses and receiving echoes due to reflection of the pulses within respective sectors centred on the longitudinal axis of the tube.

Preferably, the segments of the transducer arrangement subtend substantially equal sectors of the scanned area so that the latter covers a complete disc, means being provided for triggering pulse transmission by the transducers in a predetermined sequence or combinations of the latter.

Conveniently, a multiplexer/demultiplexer arrangement may be provided in the probe tube adjacent and connected to the transducer arrangement so as to time-division-multiplex the signals to and from the transducer arrangement in order to minimise the number of connections which must pass along the lumen of the probe so that the diameter of the latter can be kept to a minimum.

In use, the probe may be connected to apparatus for processing the echo signals provided by the transducer so as to provide a two-dimensional image of the cross-sectional area scanned by means of the one or more transducers.

According to another aspect of this invention there is provided a tubular probe, one end of which is provided with an ultrasonic transducer arranged for the transmission of ultrasound for breaking up an obstruction in a tubular cavity into which the catheter has been introduced.

Preferably, a probe according to said one aspect is provided with an obstruction-removing transducer to form a probe according to said other aspect.

Embodiments of this invention will now be described, by way of example, with reference to the accompanying drawings in which:-

Fig. 1 is a side view of a portion of a catheter embodying this invention;

Fig. 2 is a schematic diagram of an end view of the catheter shown in Fig. 1;

Fig. 3 is a schematic, partly sectional, diagram illustrating a use of the catheter shown in Fig. 1;

Figs. 4 and 5 are respective schematic diagrams of two alternative forms of a portion of the catheter shown in Fig. 1;

Fig. 6 is a block circuit diagram of the scanning and image processing apparatus associated with the catheter shown in Fig. 1; and

Fig. 7 is a side view of a surgical catheter in a further embodiment of this invention.

Referring to the drawings, a scanning catheter 1 comprises a flexible tube 2, one end of which is provided with a transducer arrangement 3 comprising a ring of individual ultrasonic transducers

T1 to T12 arranged around the circumference of the end portion of the catheter. The twelve transducers are connected to a multiplexer/demultiplexer 4 arranged within the catheter adjacent the transducer arrangement. Preferably, a smooth sheath of substantially ultrasonically-transparent material covers the transducer arrangement 3 to facilitate the passage of the catheter into and through the cavities to be scanned.

In use, the catheter is inserted into a hollow part B (Fig. 3) of a human or animal body such as an artery or colon and trigger signals are supplied to the transducers in a sequence determined by the multiplexer/demultiplexer 4 in order to stimulate the emission of ultrasonic pulses from the transducers in turn towards the inner wall of the hollow body part B. After such pulse emission, each transducer is immediately enabled to receive echo signals due to the reflection of the emitted pulses from acoustic interfaces (i.e. surfaces, e.g. artery walls, at which a relatively abrupt change takes place in the acoustic impedance of the medium surrounding the transducer). The echo signals are transmitted in turn via the multiplexer/demultiplexer 4 to an image processing device 5 which is arranged to form a two-dimensional image of the cross-sectional area scanned by the transducer arrangement 3.

The reception and processing of ultrasonic images has already been rendered possible in other ultrasonic scanning arrangements not employing a catheter and, since only minor straightforward modifications will be required in such an image processing device to produce an appropriate two-dimensional image

which will show up the presence of irregularities and obstructions in the tubular body part B to assist in diagnosis of medical problems, the device 5 will not be described further.

Referring to Fig. 4, there is shown an alternative transducer arrangement 30 in which a single toroid 31 of piezo-electric material is provided on its inner and outer cylindrical faces 302,303 with electrically conductive layers 304,305. A plurality of segments corresponding to the individual transducers of the transducer arrangement 3 is then provided by electrical connections 306 distributed around the circumference of the toroid.

Referring to Fig. 5, there is shown a further alternative form of segmented transducer arrangement 300 in which a solid annulus of piezo-electric material has been scored along lines 301 in a direction parallel with the axis of the catheter so as to enable segmented transmission and reception of signals in a similar manner to that described for the transducer arrangement 30.

Clearly, the arrangements shown in Figs. 4 and 5 provide greater scope for enhancing resolution than the transducer arrangement 3 since the resolution increases with the number of transducer segments.

Referring to Fig. 7, there is shown a catheter 100 having at one end an ultrasonic transducer arrangement 101 arranged for the transmission of ultrasound at a frequency and power calculated to destroy plaque within arteries of the human or animal body. Such an arrangement may be combined with the catheter 1 shown in Fig. 1 in

conjunction with the transducer arrangement 3 (or 30 or 300) to provide both a diagnostic and surgical instrument (as indicated in Fig. 1 by the broken line portion 11). By appropriate alteration of the frequency and power of the energy transmitted by the ultrasonic transducer arrangement 101 (or 11), obstructions of various kinds can be softened and/or broken up in various types of tubular body parts.

Although the tubular probes described above have been described as catheters in relation to their use in medical diagnosis and treatment, they could, possibly with adaptation, also be used in any application where access is required into an otherwise inaccessible cavity, for example for scanning and/or clearing pipes of various kinds of apparatus where other methods of scanning and/or obstruction clearance would present problems.

The operational frequency of the transducers used in the medical applications described above would probably lie in the range 1 to 20 MHz, whereas for the alternative applications in relation to pipes and other devices the operational frequency might be as low as 50 KHz or even lower in some cases.

Also, while the tubular probe 1 described above has been described as having twelve transducers in its transducer arrangement, the number of such transducers may vary and be less than or more than twelve. Clearly, the higher the number of transducers the better the resolution of the probe.

CLAIMS:

1. A tubular probe including a tube at least a section of which carries round its circumference a transducer arrangement comprising a plurality of ultrasonic transducer segments capable of transmitting ultrasonic pulses and receiving echoes due to reflection of the pulses within respective sectors centred on the longitudinal axis of the tube.

2. A tubular probe, one end of which is provided with an ultrasonic transducer arranged for the transmission of ultrasound for breaking up an obstruction in a tubular cavity into which the catheter has been introduced.

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