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[54] **ACOUSTIC ANTENNA**

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[52] **U.S. Cl.** ..... **310/9.1;** 310/8.2; 310/8.7; 340/8 FT

[51] **Int. Cl.²** **H01L 41/10**

[58] **Field of Search** ..... 310/8.2, 8.3, 8.5, 8.6, 310/8.7, 9.1, 9.4; 340/8 FT, 8 S, 6 R, 16 R; 181/33 E, .5 AG, .5 T, .5 ED, .5 J; 179/138, 181; 73/67.8, 67.9

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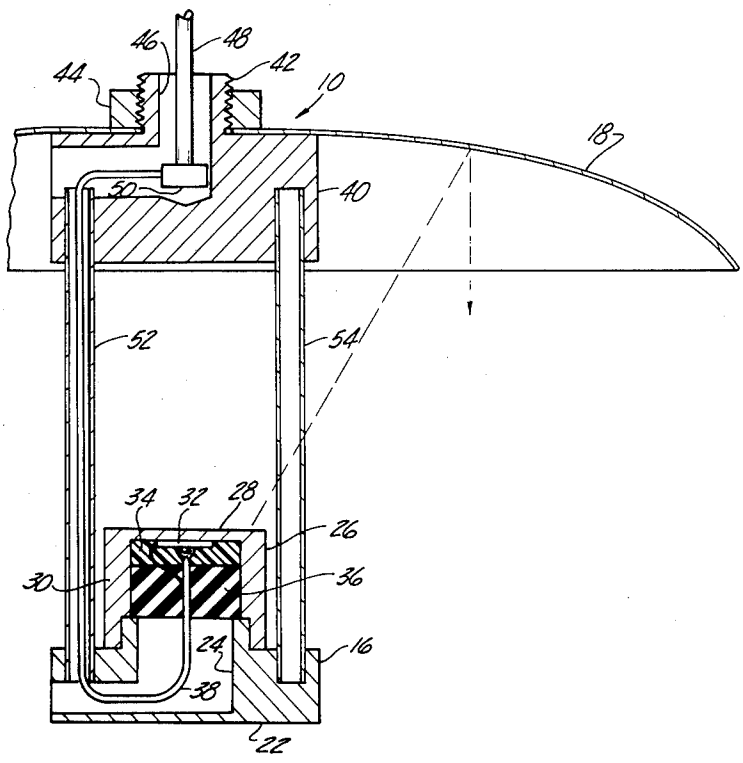
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[57] **ABSTRACT**

An acoustic projector comprising a piezoelectric crystal source mounted in a mechanically tuned metal housing and disposed at the focal point of an acoustic reflector of generally parabolic configuration. A support block is secured within the reflector and is mechanically connected to the transducer assembly by means of cylindrical hollow posts.

5 Claims, 3 Drawing Figures



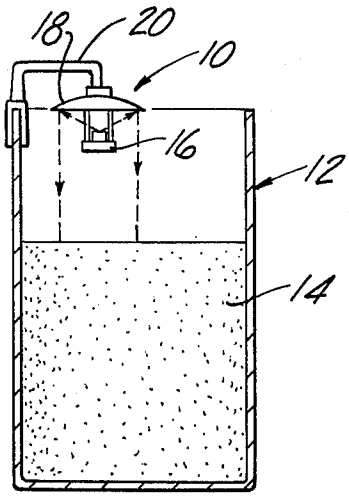


Fig - 1

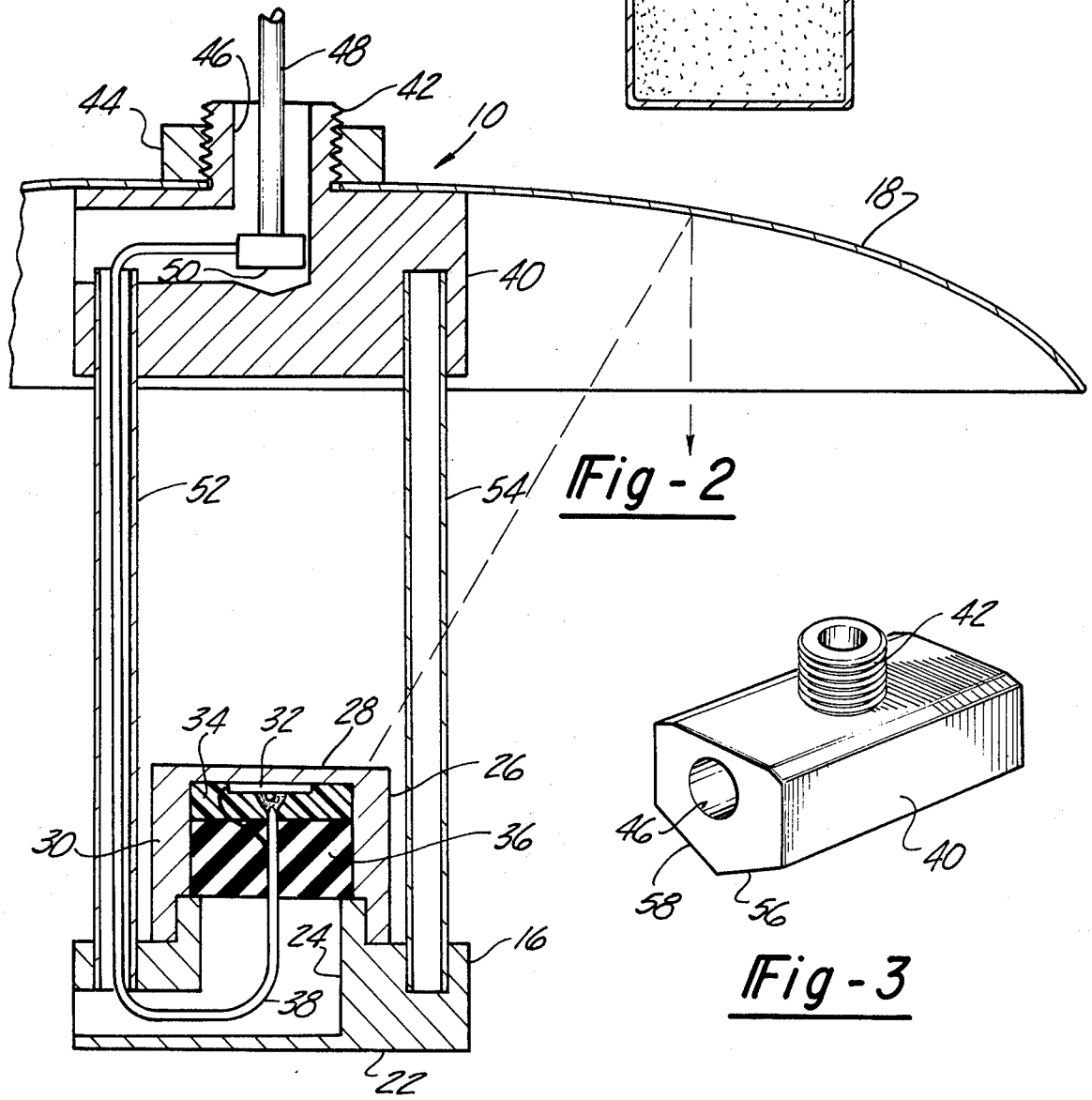


Fig - 2

Fig - 3

ACOUSTIC ANTENNA

INTRODUCTION

This invention relates to apparatus for producing and transmitting a narrow beam of acoustic energy with negligible sidelobes for use in level sensing and control systems.

BACKGROUND OF THE INVENTION

It is well known to monitor the level of material in a container such as a tank or silo by means of an acoustic energy transceiver disposed near the top of the container. The measurement principle is similar to that of the well known radar system; i.e., level is detected as a function of the round-trip transmission time of an acoustic signal transmitted from the antenna to the material surface and reflected back to the antenna. One of the shortcomings of prior art devices is the relatively wide beam pattern and sidelobes which are produced. A wide beam pattern containing substantial sidelobes can cause reflections of the acoustic wave off of container walls giving rise to an undesirable reflected wave which arrives at the material level some time after the direct wave. If the indirect wave arrives at the material level during the interval of pulse transmission, phase cancellation can occur with a resulting reduction of strength in the returned signal. This produces a corresponding reduction in detection range. A similar problem can exist with respect to signal receipt, phase cancellation occurring at the transducer. Therefore, the effect of reflections is compounded by the typical two-way transmission which is involved with the use of devices of this type.

Another difficulty in prior art devices is the impedance mismatch between the acoustic transducer and the air load. Severe impedance mismatches produce low efficiencies and a substantial reduction in the distance or level range which can be measured.

BRIEF SUMMARY OF THE INVENTION

The present invention provides an acoustic wave generator and projector or antenna which produces a very narrow beam pattern having negligible sidelobes and having a highly effecient impedance match between the transducer and the surrounding materials thereby to provide a sonic projector or antenna having increased range, increased efficiency, and greater applicability to deep silo and similar environment where reflective walls are present and substantial range is required. In general, this is accomplished by the combination of an acoustic generator or source and means for mounting the source at the focal point of a modified parabolic reflector. The acoustic source, in accordance with the preferred embodiment of the invention, comprises an electrically driven flexural piezoelectric disc mounted in facial contact with a flexural surface of a mechanically tuned housing having a mechanical resonant condition at twice the natural frequency of the flexural disc thereby to provide mechanical amplification of the acoustic signal. The objectives of the invention are further accomplished by means of a novel projector structure including a modified parabolic reflector.

The various features and advantages of the present invention will be best understood from the following description of the specific embodiment to the invention. This description is to be taken with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified side view of a container showing an illustrative embodiment of the invention mounted therein for the measurement of material level in the container;

FIG. **2** is a side view partly in cross section of the illustrative embodiment of the invention; and,

FIG. **3** is an end view of one of the components of the assembly of FIG. **2.**

DETAILED DESCRIPTION OF THE SPECIFIC EMBODIMENT

Referring to the drawings and especially to FIG. **1** there is shown an acoustic projector **10** disposed at a fixed level at or near the top of a silo **12** containing a liquid or particulate material **14.** Projector **10** comprises an acoustic wave generator **16** disposed at the focal point of a modified parabolic reflector **18** which is mounted adjacent a sidewall of the silo **12** by means of a support bracket **20.**

The acoustic generator **16** is electrically energized or excited to produce an acoustic wave which is projected outwardly to the reflector **18** and thence downwardly in a narrow beam pattern toward the top surface of the material **14** in the silo **12.** Encountering the interface between the material **14** and the surrounding air, at least a portion of the acousitc wave is reflected back to the projector **10** for detection during a transmit-receive cycle. The overall theory of transmit-receive operation and distance measurement as a function of pulse transmittal time is well known to those skilled in the art and will not be repeated here. It is, however, important to note that the level of material **14** in silo **12** is monitored and controlled as a function of the round-trip transmittal time of the acoustic signals between the reflector **18,** the interface of the material **14** and the transducer **16.**

Referring now to FIGS. **2** and **3,** the physical and functional characteristics of the specific embodiment of the invention will be described in detail. The generator assembly **16** comprises a molded plastic end block **22** having a hollow opening **24** formed longitudinally therein and machined aluminum housing **26** having a thin, circular end wall **28** and a somewhat thicker cylindrical sidewall **30.** The housing **26** is hollowed out and open-ended to mate with block **22** and to receive a piezoelectric crystal transducer **32** having a major plane surface in bonded contact with the inner surface of the circular end wall **28** of the aluminum housing **26.** Piezoelectric crystal **32** is set in a urethane potting compound **34** backed by a thicker layer of silicon rubber encapsulant **36.** The crystal transducer **32** is electrically connected across opposite surfaces thereof to separate conductors of a coaxial cable **38** through which the electrical excitation signal is applied.

Acoustic generator **16** further comprises a molded plastic parabolic reflector **18** having secured thereto a plastic support block **40** having the surface characteristics illustrated in FIG. **3.** Block **40** has a threaded tubular arm portion **42** which extends through an aperture in the center of the reflector **18** and which receives a nut **44** to secure the entire assembly **10** together. Support block **40** has formed therein a channel-like opening **46** through which an electrical conduit **48** is disposed. The conduit **48** ends in a connector **50** which is electrically connected to the coaxial cable **38** as shown

The acoustic generator **16** is mechanically disposed at the focal point of the reflector **18** by means of two hollow, rigid support struts **52** and **54** which are set into sockets in the blocks **40** and **22,** respectively. Cable **38** extends through tubular strut **52** as shown. Support block **40,** as best shown in FIG. **3,** is provided with a "water shed" external surface configuration having reflective non-coplanar surfaces **56** and **58** to divide the acoustic wave front from the source transducers **32** and direct it outwardly into the interior of parabolic reflector **18.** The amplitude distribution of the acoustic wave measured outwardly from the center line of the support block **40** exhibits a degree of taper or decreasing amplitude at the outer reaches of the reflector **18.**

It is apparent in FIG. **2** that the piezoelectric crystal **32** is in close contact with the thin wall section **28** of the housing **26** flexes along with the transducer **32** at the excitation frequency so as to produce a longitudinally directed acoustic wave which emanates from the circular surface of end wall **28** toward the reflector **18** and, of course, toward the surfaces **56** and **58** of the support block **40.** As the end wall **28** flexes, a degree of compensating mechanical flexure in the sidewalls **30** is necessarily undergone by the housing **26.** The expansion and contraction of the sidewalls **30** naturally occurs at twice the frequency of the transducer disc **32.** Accordingly, housing **26** is constructed to exhibit a natural flexure resonance in the manner described at twice the resonant frequency of disc **32** thereby to mechanically amplify the flexure of the disc **32** and end wall **28** to produce a high operating efficiency and high signal strength.

In a specific embodiment, the longitudinal dimension of the support block **40** is just under 3 inches while the diameter of the reflector **18** is 12 inches. The narrow dimension of the support block **40** taken laterally in FIG. **3** is approximately one and one-half inches and the distance between the rim of the reflector **18** and the outer surface of end wall **28** is 5 inches. This combination produces a beam width of approximately one and one-half degrees suitable for use in a silo having a 4 foot radius and a 150 foot depth. Electrically an input excitation signal of 115 volts at 60 cps is contemplated.

It is to be understood that the foregoing description is illustrative in character and is not to be construed in a limiting sense.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An acoustic energy projector for use in level detection systems comprising: an acoustic wave source and a reflector spaced from the source along an axis of acoustic projection and having a focal point for collection energy from the source and directing such energy along a narrow beam path, the reflector being shaped to provide amplitude tapering for side lobe reduction, mounting means for disposing the source in spaced relation to and substantially at the focal point of the reflector and oriented to direct the acoustic wave produced thereby toward the reflector, said source comprising a housing having a flexural planar wall portion and an electrically excitable flexural transducer disposed in contact with said wall portion, said reflector being substantially parabolic in shape, the projector further comprising divider means disposed centrally within the reflector and having an acoustically reflective multiplanar surface for distributing the acoustic energy from the source outwardly into the parabolic reflector, said divider means further comprising a support means secured to the reflector, the mounting means comprising at least one hollow strut connected between the support member and the source, and electrical conductor means extending through the strut to the source for carrying an excitation signal thereto.

2. Apparatus as defined in claim **1** wherein the source comprises a hollow end member and a cylindrical housing having an open end contiguous with the end member, a piezoelectric crystal transducer disc mounted on the end wall of the housing and facing the reflector to produce an acoustic wave directed toward the center of the reflector when flexurally active, and an insulative, compliant material encapsulating the disc within the housing.

3. Apparatus as defined in claim **2** wherein the natural flexural resonant frequency of the housing sidewall is twice the resonant frequency of the disc.

4. Apparatus as defined in claim **2** wherein the support member, the end member, and the reflector are plastic.

5. Apparatus as defined in claim **1** wherein the source further comprises a hollow end member having an opening contiguous with the open end of said housing, the projector further comprising a support member mounted on and carried adjacent said reflector, and hollow tubular support struts extending between the support member and the end member, one of the struts forming an open channel from the reflector to the housing, and conductor means in the channel and electrically connected to the transducer for exciting the transducer to produce the acoustic wave.

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