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STEAM LEAK LOCATION

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CENTRAL ELECTRICTY GENERATING BOARD

Introduction

Steam leak noise is an ever present problem in steam raising plant. Old methods of pin-pointing the leak can vary from the use of subjective hearing directivity and visual inspection in the case of wet low pressure steam leaks, to searching with a rag at the end of a long pole in the case of high pressure superheated invisible steam leaks.

Ultrasonic listening to detect gaseous leaks is not a new technique and the use of ultrasonic sensors to locate steam leaks is therefore logical. The development of a device to locate the point of the leak accurately and from a safe distance is desirable with respect to both the environment and the operational efficiency of the plant.

Steam Leak Spectra

Before the development of an ultrasonic device for the detection of steam leaks it was important to establish the frequency spectra of steam leaks particularly at ultrasonic frequencies. A number of noise measurements were therefore carried out on steam leaks of various sizes and at different distances and the sound spectra plotted (Figure 1). From the measurements it was established that

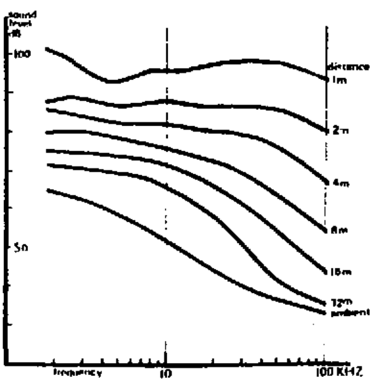

Figure 1. Steam Leak Sound Pressure Spectra

ultrasonic frequencies within the range of 10kHz to 100kHz were present.

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An ultrasonic transducer designed to operate at 40kHz was easily available and as it was both rugged and cheap it was decided to utilise it for leak location.

Transducer Characteristics

The transducer selected for the leak locator was the Massa-Hingham TR89 Type 40. Its polar directional characteristics were studied by exposing the transducer to parallel rays of 40±2kHz noise in an anechoic chamber. A clover leaf polar diagram was obtained having a main frontal lobe with a drop in sensitivity of 3dB at ±12°. Further tests were then carried out to improve the transducer's directional characteristic by the use of a beam former (Figure 2). A number of

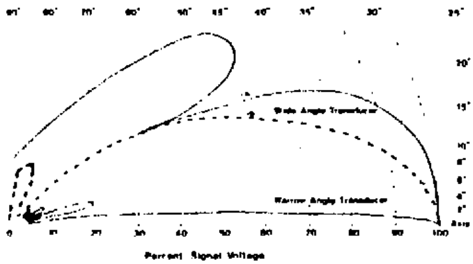

Figure 2

Polar Diagram of TR89 Transducer with different Beam Formers.

a) Wide angle TR89
b) Wide angle tube.

Narrow angle parabolic horn.

formers were constructed and tried, including a tube, a cone, a hyperbolic horn, a parabolic dish and a parabolic horn.

i) A Tube

As implied this was a parallel tube of diameter to fit the transducer (25mm). The length of the tube was varied from 5mm to 25mm. The tests showed that although the side lobes were progressively reduced the frontal lobe did not markedly change. A slight variation was then introduced in the form of the insertion of collars or bushes into a short tube. This resulted in the elimination of the side lobes and a slight broadening of the frontal lobe, for example a 20mm long tube of 21mm diameter with a 12.5mm long collar of 16mm diameter gave a single smooth frontal lobe of 3dB at ±20°.

ii) A Hyperbolic Horn

A series of horns with a throat diameter of 10mm and varying length were then tested. These very effectively eliminated the side lobes and the wider the horn mouth the narrower became the frontal lobe. A horn mouth of diameter 25mm for example gave a sensitivity drop of 3dB at ±18° and 20dB at ±30°. Whilst a 17mm mouth diameter horn of exactly the same cross section gave a sensitivity drop of 3dB at ±14° and 20dB at ±35°.

iii) A Parabolic Reflector

The principle of enhancing the signal received from a distant source and focussing it onto a transducer by the use of a parabolic dish is well known. The ultrasonic transducer was placed facing a parabolic dish of 115m focal length and 360mm rim diameter. The polar diagram of this assembly was measured and found to have a directivity dropping sharply by 3dB at $\pm 2.5^{\circ}$ and 20dB at $\pm 6^{\circ}$.

iv) A Parabolic Horn

A change in the parameters of the parabola can result into a more compact reflector which can be used as a ray collecting horn to focus rays onto a forward facing transducer placed at its focal point. The parabolic horn has a number of advantages over the parabolic dish. There is the practical advantage that the transducer is protected from physical damage by the horn itself. Also in the horn the transducer and its mounting do not obstruct any incoming rays. Such a reflector with a parabolic profile of $x^2 = 2.54y$ was tested and an effective narrow forward facing polar characteristic was obtained with a sensitivity drop of 3dB at $\pm 2.5^{\circ}$ and 20dB at $\pm 5^{\circ}$. Side lobes at $\pm 16^{\circ}$ were present but were 14dB down from maximum sensitivity.

The parabolic horn was therefore considered the most promising solution and a prototype device was constructed.

It was considered that an optimum of $\pm 2.5^{\circ}$ for a 3dB fall off in response would give good location with a target of about 1m diameter at 15m distance.

The Prototype

The requirement was to deal with a wide range (60dB) of sound pressures at 40kHz as presented by steam leaks of different sizes and at variable distances, without the need to adjust a manual gain control on the device. This was solved by a unique method in which two transducers were used on the instrument, one with a narrow field and the other with a wide field characteristic. The

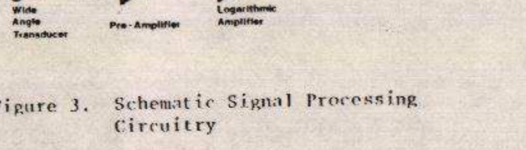

Figure 3. Schematic Signal Processing Circuitry

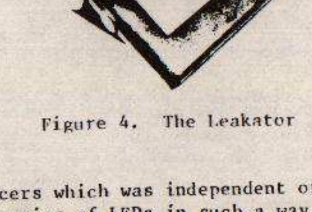

Figure 4. The Leakator

ratio of the signal received by these two transducers which was independent of sound pressure level, was arranged to energise a series of LEDs in such a way that when on target a maximum number was lit. The schematic diagram of the electronics is given in Figure 3. An additional feature was the provision of an audio signal output giving an increasing pitch as the signal was approached.

The prototype device (Figure 4) named the 'Leakator' was made up therefore of a parabolic horn for the narrow field sensor and a short tube for the wide field sensor. The indication was given visually by a column of LEDs and a plug in earphone system was provided as an optional addition for target homeing.

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