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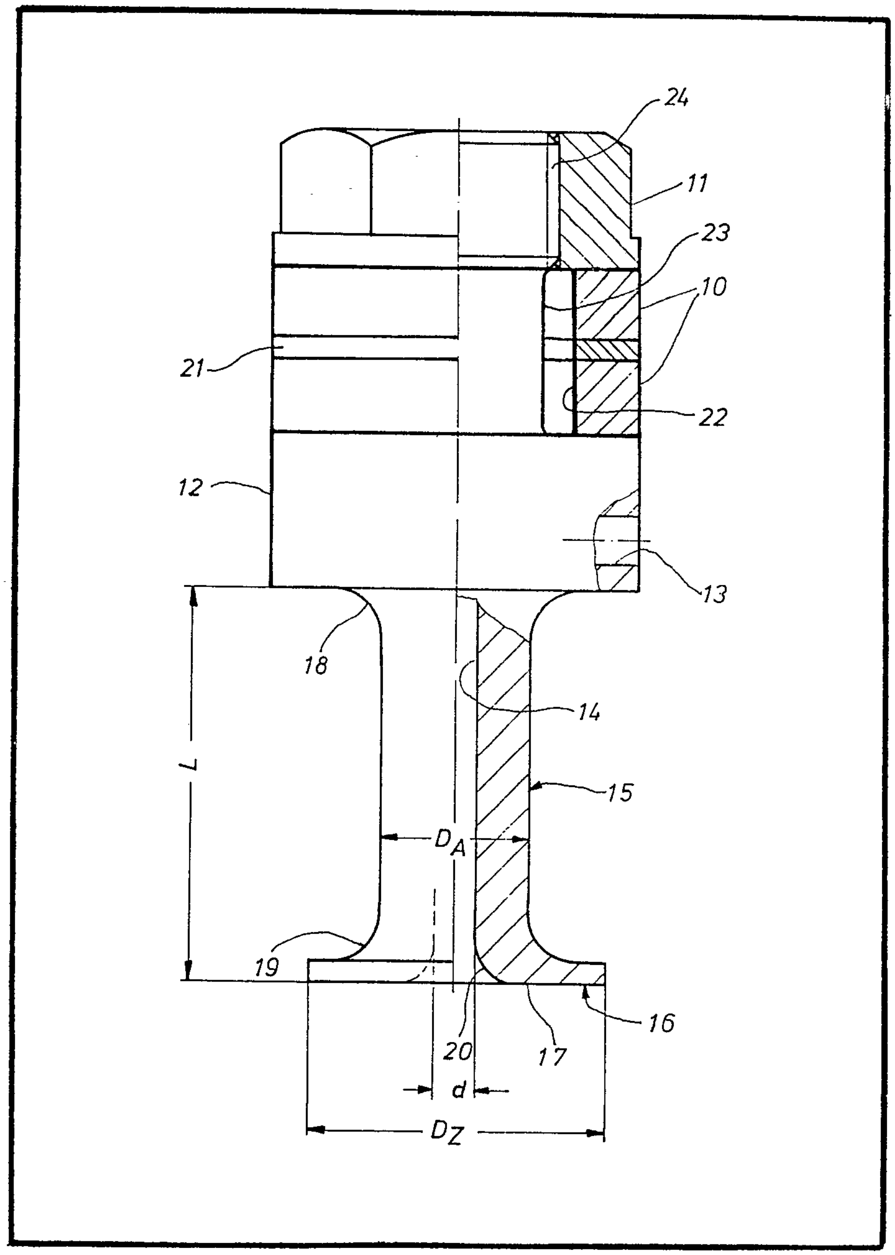
(54) Ultrasonic liquid atomiser

(57) An ultrasonic liquid atomiser has a piezo-electric transducer (12) mechanically coupled to an amplitude transformer (15), and an atomising plate (16) disposed on the free end of the amplitude transformer, the dimensions of the atomising plate (16) and the amplitude transformer (15) being matched each to the other so that the vibrating system comprising the atomising plate (16) and the amplitude transformer (15) has the same resonance frequency as the transducer (12) preferably around 60 kHz.



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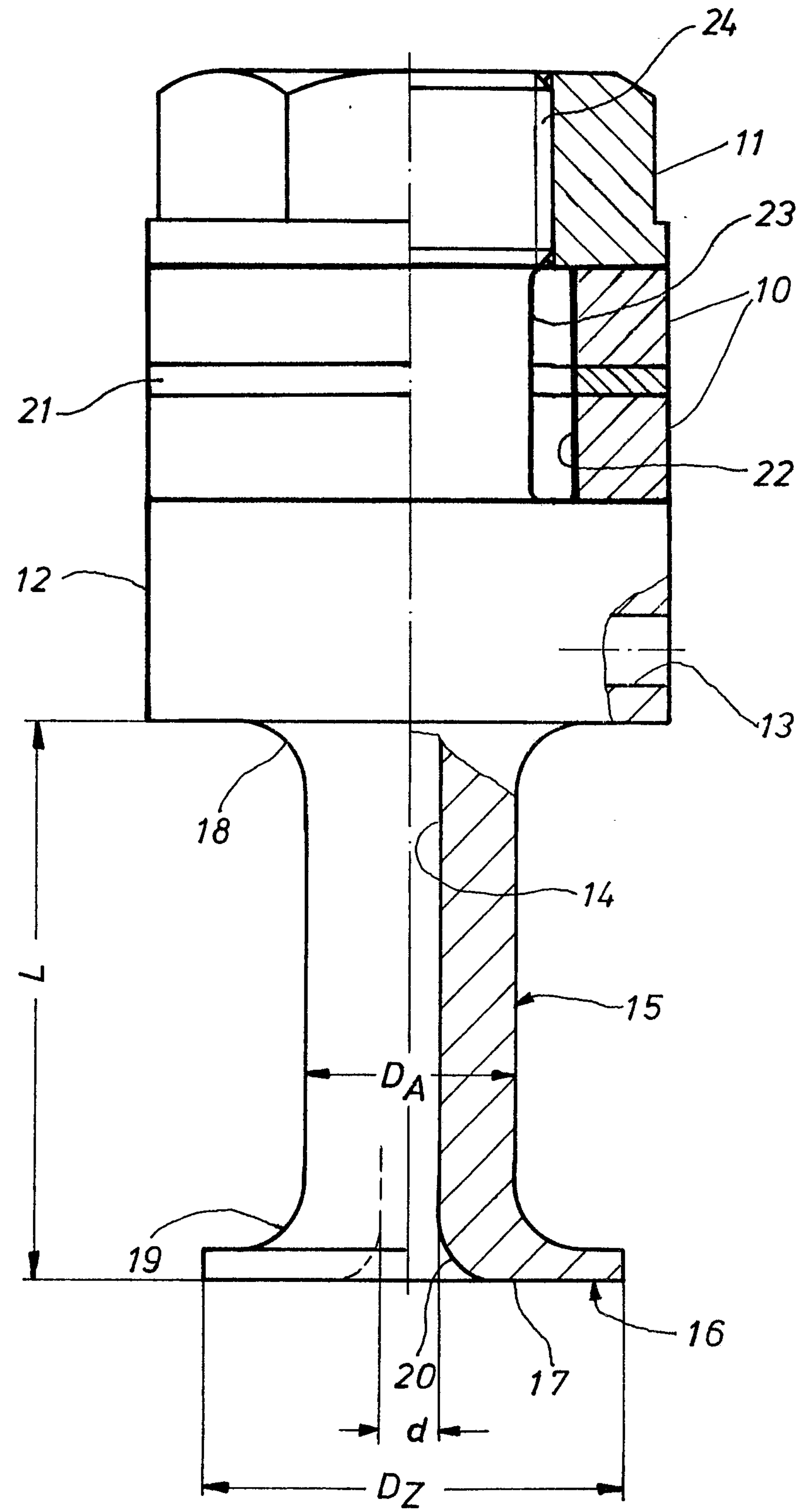

SPECIFICATION

Ultrasonic liquid atomiser

This invention relates to an ultrasonic liquid atomiser, having a piezo-electric transducer mechanically coupled to an amplitude transformer (also known as a "horn" or "snout"), and an atomising plate disposed on the free end of the amplitude transformer.

There are known piezo-electric ultrasonic vibrators for the atomisation of liquids. The prior art is described for example in the November 1978 issue of the periodical "Technische Informationen Für die Industrie", published by VALVO in Hamburg. The ultrasonic liquid atomisers in question consist of a piezo-electric transducer, which in the conventional embodiments is mechanically rigidly coupled to an amplitude transformer (known as a "horn"). In the transducer, electrical energy is converted to mechanical energy, while the "horn" brings about amplification. In order to attain the maximum possible amplitudes, it is also essential to operate the atomiser near its harmonic resonance.

Other ultrasonic liquid atomisers of the same type are described in U.S. Patent Specification 3 400 892 and German Patent Specifications 2 831 553 and 2 137 083.

The known ultrasonic atomisers operate with amplitude transformers of length at least $\lambda/4$ (as in, for example, U.S. Patent Specification 3 400 892) up to an integral multiple of $\lambda/4$ (as in German Patent Specifications 2 831 553 and 2 137 083). The vibration wave-length in question is that of the atomising plate.

The prior art ultrasonic liquid atomisers have certain unsatisfactory features, particularly in the following respects:

a) their life is too short by reason of local stress peaks. The problem lies in the appropriate dimensioning of the ultrasonic liquid atomiser;

b) the known ultrasonic liquid atomisers have too low a specific liquid throughout capacity. In this respect, the problem lies in the fact that the amplitude transformer vibrates as a whole and not as a bending member with outwardly increasing bending amplitudes. As a result, it has hitherto been necessary to provide comparatively large vibrators;

c) the known ultrasonic liquid atomisers characteristically form spray as a result of cavitation. In this respect, the problem lies in the large amplitudes of the stepped-snout amplitude transformer in the region of liquid feed. This causes the disadvantageous spray phenomenon.

According to the above account, ultrasonic liquid atomisers should satisfy the following primary requirements:

1. They should have a long useful life.
2. Their specific liquid throughput capacity should be high.
3. They should not be subject to cavitation effects.

In order that the ultrasonic liquid atomisers in question should have the widest and most versatile fields of application, they should retain the above characteristics not only at room temperature but also at very high temperatures, as typically required in oil burners for example.

The known commercial ultrasonic liquid atomisers fail entirely or at least adequately to meet the above requirements. Although they have good vibration characteristics, they are obviously attained at the cost of indisputably short life (terminated by bending failure). A similar situation can be deduced for the ultrasonic liquid atomiser of published German Specification 29 04 861.

The object of the present invention is to provide an ultrasonic liquid atomiser which not only has good vibration characteristics but moreover also attains the necessary long life.

According to the present invention, an ultrasonic liquid atomiser of the type initially described is characterised by matching the dimensions of the atomising plate and the amplitude transformer each to the other so that the vibrating system comprising the atomising plate and the amplitude transformer has the same resonance frequency as the transducer, preferably around 60 kHz, while furthermore the changes in cross-section between the transducer and the amplitude transformer in the first place and between the amplitude transformer and the atomising plate in the second place are designed to minimise stress peaks.

Outstanding results can be achieved when the amplitude transformer inclusive of the atomising plate has a length between 1/10th minimum and 9/10th maximum of the vibration wavelength $\lambda/4$, where λ=c/f, c being the velocity of sound and f the frequency of the vibrations.

One important property of the ultrasonic liquid atomiser of the invention consists in that the atomising plate executes bending vibrations without a nodal circle or circles and of such a form that the vibration amplitude increases sharply towards the rim of the plate while retaining a certain minimum value at the centre. The minimum value for the vibration amplitude at the plate centre is defined as that at which the liquid still adheres but does not yet undergo atomisation. As a result of these advantageous affects achieved by the invention, spray formation in the feed region of the atomising plate is avoided and yet a good distribution of the liquid over the entire plate surface is maintained.

Preferably, the desired minimum-stress-peak adaptation of the vibrating system comprising the amplitude transformer and the atomising plate can be optimised by practical means characterised in that the changes in section between the transducer and the amplitude transformer in the first place and between the amplitude transformer and the atomising plate in the second place have comparatively large radii, relative that is to the diameters of the amplitude transformer and the atomising plate respectively.

A typical embodiment of an ultrasonic liquid atomiser will now be described, by way of example only, with reference to the accompanying drawing which is half in longitudinal section and half in side elevation.

A piezo-electric transducer is shown, which converts vibratory electrical energy into vibratory mechanical energy. The piezoelectric transducer consists of two ceramic discs 10 between which there is an electrode disc 21 which is connected externally (by means not shown) to an external source of electricity. The discs 10 and 21, which have an axial cylindrical bore 22, lie concentrically with respect to a pin 23, which has a thread 24 on its free top end. Lower down, the pin 23 widens out to form a transducer 12 which provides an axial abutment for the two piezo-electric discs 10 and the electrode disc 21. At the top, axial fixing of the discs 10 and 21 is effected by means of a nut 11, which is screwed on to the thread 24.

The transducer 12 has a lateral connecting bore 13 through which the liquid to be atomised is fed into an axial bore 14 in an amplitude transformer 15.

The method of introducing the liquid shown in the drawing is merely one typical example. Further methods are possible within the scope of the present invention for introducing the liquid into the central bore 14 in the amplitude transformer 15. For example, axial liquid feed can be adopted.

Similarly, there are many different possible ways (not shown here) for supporting the ultrasonic liquid atomiser shown in the drawing. For example, the ultrasonic liquid atomiser can be provided with a flange secured to a suitable support.

The amplitude transformer 15 is integral with the components 12, 23 and 24. At its end remote from the screwthread 24, the amplitude transformer 15 leads integrally into an atomising plate 16. The bore 14 already referred to continues axially and centrally through the components 15 and 16. The liquid to be atomised is thus supplied to the face 17 of the atomising plate 16, where it is finely atomised by virtue of the high-frequency vibrations of the atomising plate 16.

The effective length L shown in the drawing, for the vibrating system comprising the amplitude transformer 15 and the atomising plate 16, is between 1/10th and 9/10th of the vibration wavelength $\lambda/4$. The length L amounts to 16 mm and the amplitude transformer 15 has a diameter D_A of 6 mm.

The external changes in section 18 and 19 between the transducer 12 and the amplitude transformer 15 in the first place and between the amplitude transformer 15 and the atomising plate 16 in the second place have the comparatively large radii of 2 mm (at shoulder 18) and 1.5 mm (at shoulder 19) respectively, which ensure that stress peaks will not develop at the section changes 18 and 19. This avoids bending failures and assures correspondingly long lives.

The atomising plate 16 has an overall diameter D_Z of 12 mm. A comparatively large-radius shoulder is also provided at the junction 20 between the liquid supply bore 14 and the face 17 of the atomising plate 16. If the diameter *d* of the liquid supply bore 14 is 1.5 mm for example, the radius of the shoulder 20 can be 1.5 mm for example, so that at the face 17 of the atomising plate 16 the final diameter of the liquid supply bore 14 can be 4.5 mm. The transition from the amplitude transformer 15 and the atomising plate 16 has a gradually decreasing cross-section, the transition being bounded by the radii 19 and 20.

Claims

1. An ultrasonic liquid atomiser, having a piezo-electric transducer mechanically coupled to an amplitude transformer, and an atomising plate disposed on the free end of the amplitude transformer, characterised by matching the dimensions of the atomising plate and the amplitude transformer each to the other so that the vibrating system comprising the atomising plate and the amplitude transformer has the same resonance frequency as the transducer, and by providing changes in cross-section between the transducer and the amplitude transformer on the one hand and between the amplitude transformer and the atomising plate on the other which minimise stress peaks.

2. An ultrasonic liquid atomiser as in Claim 1, wherein the resonance frequency of the amplitude transformer and the transducer is about 60 kHz.

3. An ultrasonic liquid atomiser as in Claim 1 or Claim 2, wherein the amplitude transformer inclusive of the atomising plate has a length between 1/10th minimum and 9/10th maximum of the vibration wavelength.

4. An ultrasonic liquid atomiser as in any one of Claims 1 to 3, wherein the changes in section between the transducer and the amplitude transformer on the one hand and between the amplitude transformer and the atomising plate on the other hand have comparatively large radii, relative that is to the diameters of the amplitude transformer and the atomising plate respectively.

5. An ultrasonic liquid atomiser as in any one of Claims 1 to 4, wherein the diameter of the amplitude transformer is 6 mm and that of the atomising plate is 12 mm, the thickness of the atomising plate is about 1 mm, and the length of the vibrating system comprising the amplitude transformer and the atomising plate is about 16 mm.

6. An ultrasonic liquid atomiser as in Claim 5, wherein the change in section between the transducer and the amplitude transformer has a radius of about 2 mm, while the change in section between the amplitude transformer and the atomising plate has a radius of about 1.5 mm.

7. An ultrasonic liquid atomiser as in any one of Claims 1 to 6, wherein a comparatively large radius shoulder is provided at the junction between the liquid supply bore of the amplitude transformer and the end face of the atomising plate.

8. An ultrasonic liquid atomiser as in Claim 7 in combination with Claim 5 or Claim 6, wherein the diameter of the bore is 1.5 mm, the radius of the shoulder is 1.5 mm, so that the final diameter of the bore at the end face of the atomising plate is 4.5 mm.

9. An ultrasonic liquid atomiser as in any one of Claims 1 to 8, wherein the transition from the amplitude transformer to the atomising plate has a gradually decreasing cross-section.

10. An ultrasonic liquid atomiser substantially as hereinbefore described with reference to the accompanying drawings.

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