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REFERENCE

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METHOD OF MAKING SHAPED APERTURES BY USING FOCUSED PATTERN OF ULTRAHIGH FREQUENCY SOUND WAVES

Filed Aug. 20, 1965

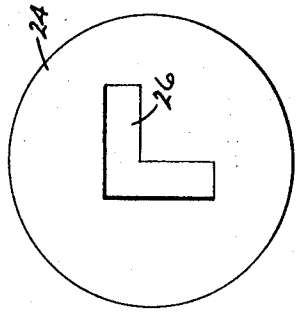



Fig. 2

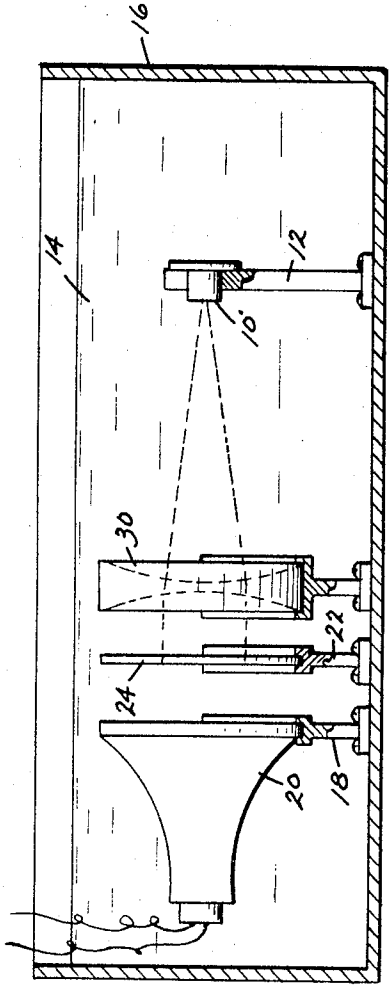



Fig. 1

3451296
OR IN 83/13

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3,451,296

# METHOD OF MAKING SHAPED APERTURES BY USING FOCUSED PATTERN OF ULTRAHIGH FREQUENCY SOUND WAVES

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U.S. Cl. 83—13 4 Claims

## ABSTRACT OF THE DISCLOSURE

A method of making very small non-circular holes in a spinneret for spinning artificial filaments involves focusing a pattern of ultrahigh frequency sound waves on the spinneret while it is immersed in a liquid medium.

This invention relates to a method of making a shaped aperture or a plurality of shaped apertures in an object and more particularly to a method of making extremely small non-circular apertures or holes. It is contemplated that the invention will find its greatest utility in making non-circular orifices in the face of a spinneret or jet for the spinning of artificial or synthetic filaments.

Generally speaking artificial and synthetic filaments are formed by extruding a solution or a melt through tiny holes or orifices in the face of a spinneret. Uusually, the spinneret is formed of metal, often platinum, but sometimes of other hard material such as a ceramic. Normally the orifices are circular to produce filaments having a circular cross section but not infrequently it is desired to extrude the filament forming material through orifices which are other than circular, e.g. square, L-shaped, H-shaped, etc. Circular orifices, even extremely small ones are of course not too difficult to make but extremely small orifices of non-circular shape present great difficulty and while the present invention is useful for making circular orifices the greatest benefits are derived when making shaped orifices, apertures or holes which are non-circular.

It is an object of this invention to provide an improved method of making shaped apertures rapidly and accurately.

A more specific object of the invention is to employ acoustics for making minute apertures of non-circular shape.

The invention will be described in connection with apparatus for carrying it out as shown schematically in the accompanying drawing wherein:

FIG. 1 is a side elevational view of the apparatus; and

FIG. 2 is an elevational view of a wave patterning shield constituting one of the elements of the apparatus.

In general, the method of the present invention, involves converging or focusing a pattern of sound waves of ultrahigh frequency and therefore relatively short wavelength on the object through which the patterned or shaped aperture is to be made. As indicated above, it is contemplated that the aperture will be quite small and that the object in which it is to be made will be a hard material such as used for spinnerets or jets for spinning artificial filaments. The spinneret or the like is submerged in a liquid medium and the elastic sound waves are created in the medium by any suitable means such as a piezoelectric transducer. These waves, or those portions thereof forming a pattern corresponding to the desired shape of the aperture, are passed through a sonic lens which focuses them on the face of the spinneret. The focused and concentrated waves contain a large amount of energy and where they strike the spinneret a hole is



formed by heat and cavitation, as will presently be explained in more detail.

In the drawing, the spinneret is indicated at **10** and is mounted in a bracket **12** within a liquid medium **14** contained in a tank **16**. The liquid medium is preferably gas-free water in which plane longitudinal sound waves travel with a velocity of about 1460 meters per second, which is high with respect to the velocity in air wherein sound waves travel at about 345 meters per second. Instead of water, other gas-free liquids capable of transmitting sound waves at a relatively high velocity may be employed.

Mounted on a bracket **18** within the tank is a piezoelectric transducer **20** which is arranged to direct planar coherent ultrahigh frequency sound waves toward the face of spinneret **10**. In order to produce a well-defined aperture in the spinneret, the wavelength of the sound waves in the liquid medium should be not greater than about one-tenth of the smallest dimension of the aperture. Since, as mentioned, it is contemplated that the invention will be employed for making very small apertures, the output of the transducer must be in the ultrahigh frequency range, preferably above ten million cycles per second. For example, in water, sound waves having a frequency of ten thousand cycles per second and a velocity of 1460 meters per second have a wavelength of 14.6 centimeters whereas at a frequency of ten million cycles the wavelength is 0.0146 centimeter and at one hundred million cycles the wavelength is only 0.00146 centimeter. Thus the smaller the orifice, the greater should be the frequency in order to produce the desired short wavelength.

Mounted on a bracket **22** in front of transducer **20** is a shield **24** having therein a wave patterning opening **26**. Opening **26** is correlated in shape with the shape of the aperture to be made in the spinneret or other object but is substantially larger than the aperture. Shield **24** is made of a material wherein sound waves have a very low velocity and are dissipated quickly whereby effectively only those waves aligned with opening **26** pass through the shield. The shield may be made of vulcanized rubber wherein the velocity of sound is only about fifty-four meters per second or of wood which is also a good sound barrier or may be laminated structure with the face directed toward the transducer reflecting a portion of the wave and a second layer absorbing the unreflected portion. At this point it should be mentioned that the inside of tank **16** is coated with a sound absorbing material such as vulcanized rubber whereby stray waves are not reflected from the sides of the tank.

Mounted on bracket **28** and located between shield **24** and the spinneret is a converging sonic lens **30** which may be a double concave metal lens formed of a low energy loss material such as aluminum or magnesium. Lens **30** focuses or images the pattern of waves passing through the shield opening **26** onto the face of the spinneret which is located at the real focus of the lens whereby the wave energy is concentrated in a much smaller area on the spinneret than the area of the shield opening. This concentrated energy heats the spinneret face in a pattern corresponding to opening **26** and at the interface between the spinneret and the liquid medium the phenomenon known as cavitation takes place. Caviation is a rupture of the liquid caused by a sudden increase in velocity of the sound waves as they enter a hard object. The velocity of planar longitudinal sound waves in platinum is about 2690 meters per second and in a ceramic material may be twice this or more. As mentioned, the velocity of sound in gas-free water is about 1460 meters per second. This sudden increase in velocity of the sound waves causes tiny vacuums to form in the liquid and the metal of the spinneret is torn away in the area of the vacuums. This cavitation phenomenon is well known as is taken advan-

tage of in ultrasonic cleaning procedures wherein it is the cavitation phenomenon which removes the unwanted matter but very little if any of the material actually forming the body being cleaned is removed because the sonic waves are not sufficiently concentrated. However, according to the present invention the sonic wave are deliberately concentrated by the lens **30** whereby a large amount of energy is focused on the area where the aperture is to be made. Shield **24** is not affected by cavitation because it is made of a material in which the waves slow down so that vacuums are not formed in the liquid at the interface.

The material of the spinneret in the immediate vicinity of the patterned image is also affected somewhat so that if it is desired to make an aperture having the exact shape of particular opening **26** for example, the shape of the opening must be modified. Thus if it is desired to produce an aperture having sharp corners, the corners of the opening in shield **24** will in practice be slightly concave. It will be apparent that shield **24** may be provided with a plurality of openings whereby a plurality of apertures may be formed simultaneously in the spinneret.

Having thus described the invention, what is claimed is:

**1.** A method of making a shaped aperture in an object formed of a hard material comprising positioning the object in a gas-free liquid medium, directing planar coherent ultra high frequency sound waves through the liquid medium toward the object in a pattern correlated with but substantially larger than the pattern of the shaped aperture to be made in the object, and focusing the patterned sound waves by means of a converging sonic lens on the object located at the real focus of the lens.



**2.** The method set forth in claim **1** wherein the wavelength of the sound waves in the liquid medium is not greater than about one-tenth of the smallest dimension of the shaped aperture to be made in the object.

**3.** The method set forth in claim **1** comprising generating the sound waves by means of piezoelectric transducer, and providing between the transducer and the sonic lens a shield which is apertured to permit only those waves of the desired pattern to strike the lens.

**4.** The method set forth in claim **3** wherein the frequency of the sound waves is at least about ten million cycles per second.

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U.S. Cl. X.R.

51—59; 77—1; 83—701; 116—137; 134—1; 156—2, 6; 310—8.1