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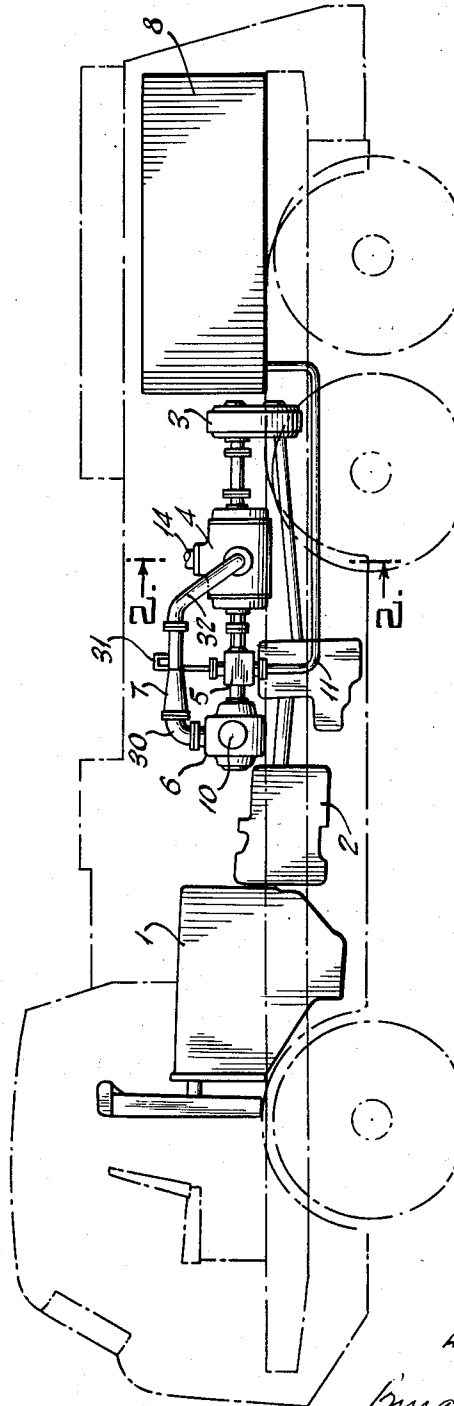
2,936,835

APPARATUS FOR MAKING FIRE EXTINGUISHING AIR FOAM

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3 Sheets-Sheet 1

Fig. 1-



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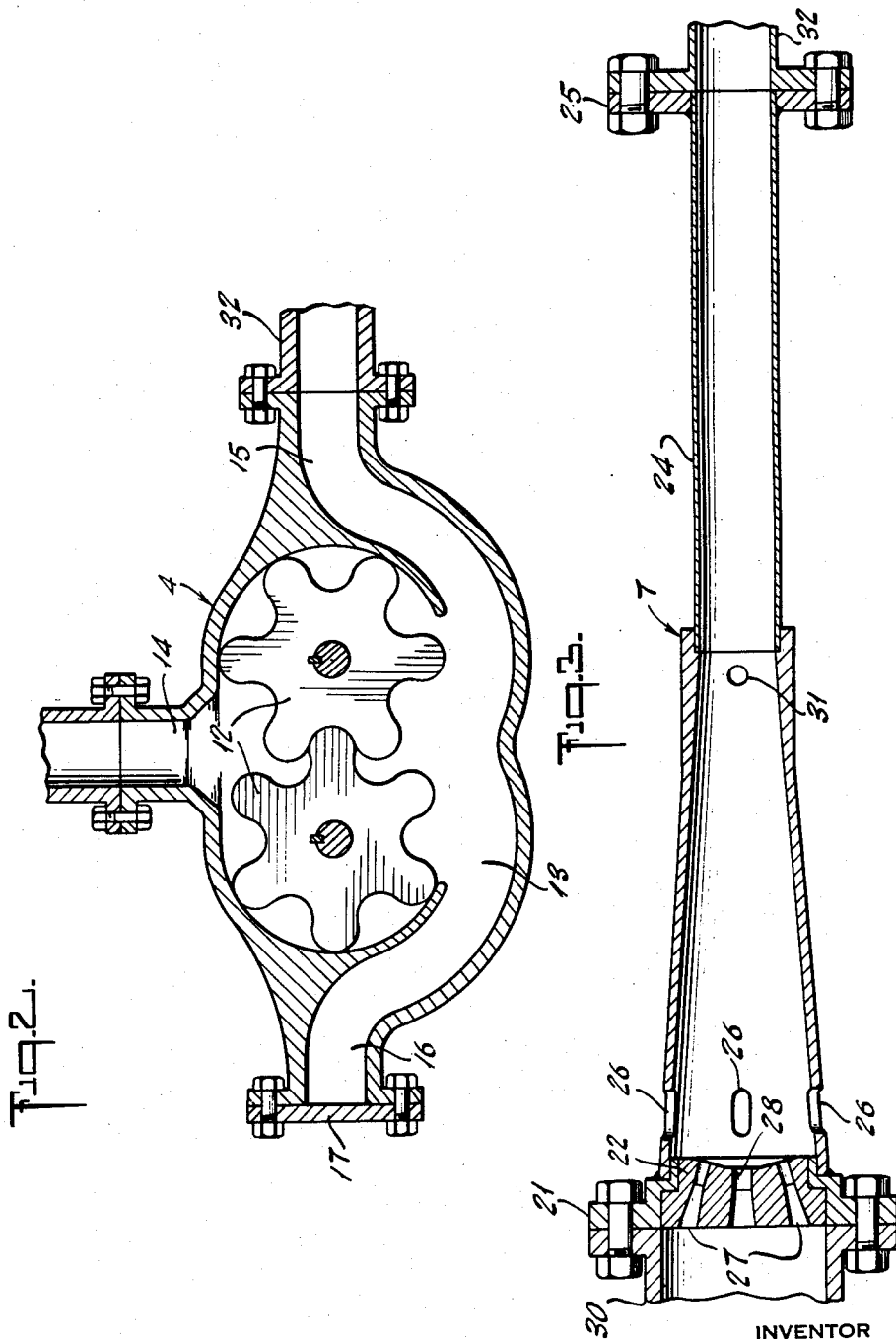
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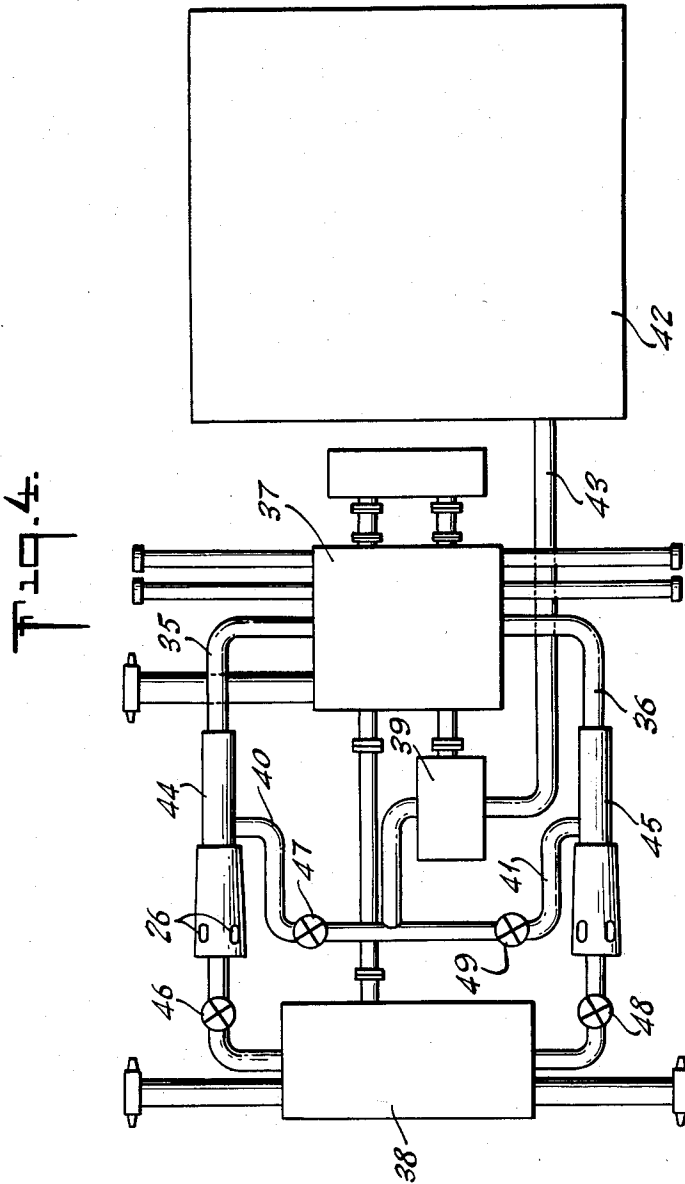
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3 Sheets-Sheet 3



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APPARATUS FOR MAKING FIRE EXTINGUISHING AIR FOAM

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4 Claims. (Cl. 169-14)

This invention relates to the making of fire extinguishing air foam. The system can be used to advantage in various forms and types of installation but, as will presently be apparently, is especially useful in the field of automotive fire apparatus.

The principal object of the invention is to provide apparatus for making and projecting good quality air foam at high pressures.

Another important object of the invention is to provide a system which is flexible, in the sense of requiring a minimum of manual adjustment of controls to vary the discharge rate, over a wide range, while maintaining the desired quality of foam, namely, a homogeneous, stable, fine-bubble foam. Such quality, of course, requires the maintenance of substantially constant proportions of the supplies of essential ingredients (water, air foam liquid and air) or a substantially constant expansion, as it is termed (meaning the ratio of foam volume discharged to liquid volume supplied) and the resulting foam must have good drain-off characteristics.

A particular advantage of the invention is that the foregoing objects are achieved with great economy of power. While this power economy is advantageous in all types of apparatus, it is of particular advantage in automotive apparatus in that the foam-making potential of a motor vehicle equipped only with a commercially available type of engine is enormously increased.

The present invention utilizes as the essential foam maker a positive displacement pump of what will be referred to as the rotary gear type, which consists of meshing gears or lobes rotating in opposite directions in a closely fitting housing. This type of pump, as is well known, is highly effective as a liquid pump but extremely inefficient as an air compressor and this latter characteristic has precluded its use heretofore as a high pressure foam discharge pump, due to the high air content of such foam (say, three times the volume of the liquid components).

In its broadest aspect, the invention turns on the discovery that the rotary gear pump can be caused to function as an extremely effective, high pressure foam maker, and with unexpected power economy, if the discharge capacity of the pump is so correlated to the feed of the foam components to it (water, airfoam liquid and air) as to maintain a positive pressure, or "back-pressure" as it will be termed herein, on the suction i.e. inlet, side of the pump.

Other objects, advantages and features of the invention will become apparent from the following description of the accompanying drawings of a preferred form of the invention. In the drawings:

Fig. 1 is a phantom view, in side elevation, of a fire truck equipped with one form of the invention;

Fig. 2 is a transverse section on the line 2-2 of Fig. 1;

Fig. 3 is a longitudinal section of one of the components; and

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Fig. 4 is a schematic plan view of a modified arrangement.

Referring, first to Fig. 1, the power plant can be assumed to be a standard, commercial engine 1. The road transmission is indicated at 2 and, at 3, the transmission for the foam making apparatus 4, 5, 6, 7. A tank for air foam liquid is designated 8.

As stated above, one of the essentials of the system is a rotary gear pump, such as 4. It will sometimes be referred to herein as the foam pump because it serves both to churn the components into a fine bubble, homogeneous foam and also to expel the resulting foam (without further treatment). The water and air foam liquid components are both supplied to the foam pump by positive displacement pumps and all three pumps may be coupled in line and driven from transmission 3 so that the relative proportions which they deliver will be maintained over the entire operating range. Rotary gear pumps 5, 6 are preferred. Pump 6 has one or more water supply connections 10 and pump 5 an air foam liquid supply connection 11, in this instance assumed to extend to tank 8. In a typical case, the deliveries of these two pumps may be in the ratio of approximately 15 to 16 volumes of water to 1 of air foam liquid, forming what is usually referred to as a 6% solution. In the Fig. 2 section, the lobe rotors of pump 4 are marked 12, what is usually termed the suction chamber is marked 13, and the discharge outlet 14. Two inlets to the suction or inlet chamber are shown, marked 15, 16, but for present purposes it may be assumed that inlet 16 is blocked off by closure plate 17.

Means are provided for supplying air under suitable pressure to the chamber 13 of the foam pump. In lieu of an air compressor, this preferred form of the invention makes use of what is generically termed in the art a "forcing foam maker," which is a device in which high velocity liquid jets are caused to aspirate and entrain a large volume of air. The preferred form of the invention utilizes a special form of forcing foam maker. Unlike the known forcing foam makers, it is especially constructed so that it not only entrains a large air volume but also advances the liquid-air mixture at a high velocity and is capable of so doing even against a substantial back pressure and without any back flooding of the aspirator.

As shown on a larger scale in Fig. 3, the foam maker (generally designated 7) consists of an apertured head and a tubular body. The head, to which the body is secured, consists of a flange 21 in which is seated an orifice plate 22. The tubular body (also secured to the flange) consists of a tapering section 23, i.e. tapering in the direction of flow, merging into a cylindrical section 24 flanged at its remote end, as at 25. At the large end of the tapering section, its wall is provided with a number of air admission openings 26.

The orifice plate, to the outer side of which liquid under pressure is supplied, has a number of restricted or jet openings 27 with their axes converging in the direction of flow to form a series of impinging jets or streams of liquid and a center opening 28 directing an axial stream at the point where the other streams impinge.

The total cross sectional area of the orifice plate openings is only a fraction of that of the liquid supply to the plate, with the result that the liquid enters the tubular body in the form of high velocity jets. The impingement of the converging streams serves to break up the flow into a mass of particles, whereas the center stream serves the dual purpose of flaring or fanning out this mass of water particles and also, by a ram effect, driving it forward at high velocity. This latter effect is

enhanced by making the center opening larger than the other openings, as indicated. Thus fanned out to fill the cylindrical section of the body, the high velocity stream of particles develops suction behind it and draws in a large volume of free air through the openings 26, the resulting stream consisting of an intimate mixture of air and liquid, well suited for later conversion to foam. It is found that the cylindrical section of the body serves to keep this stream "solid," at is were, so that there is no return flow of air or air and water to flood the air openings even when, as is contemplated, the air-water stream encounters a back pressure at the foam pump.

As indicated in Fig. 1, the foam maker 7 is connected by line 30 with the discharge side of water pump 6. The air foam liquid can be introduced directly into line 30 or into the cylindrical section 24 by a connection 31, the section 24, in turn, being coupled to the suction inlet 15 of foam pump 4 by line 32.

The air supply means, of whatever type, is arranged to take in a volume of air at atmospheric pressure equal to that required to convert the liquid components to foam of the prescribed expansion ratio. The foam pump, on the other hand, is deliberately designed to take advantage of the compressibility of the air ingredient, being of restricted capacity in the sense that, at any given speed, it displaces substantially less than the full number of cubic feet of air at atmospheric pressure necessary to so convert the volume of liquid which it is displacing at that given speed. In consequence, a positive pressure is established and maintained on the suction side of the foam pump and the latter displaces a restricted volume of compressed air which, when discharged to atmosphere, expands again to the full volume required for the prescribed expansion ratio.

It has been discovered that, by resort to this arrangement, the characteristics of the rotary gear foam pump can be changed to an extraordinary degree and, particularly, in that the power normally required when such a pump is utilized to compress atmospheric air can be radically reduced. This substantial saving in required horsepower results from the fact that the volume of air which must be displaced per minute by the intermeshing teeth or lobes of the pump can be very much reduced.

As illustrating the capabilities of the described system, let it be assumed that the engine 1 is of, say 230 H.P. and that it is desired to deliver 2000 gallons per minute of air foam, at an expansion of four to one, under a pressure of 150 lbs. per square inch. Unless otherwise indicated, all pressures referred to are gauge. These requirements have been selected because, so far as is known, there has not been available heretofore any system or apparatus capable of meeting them with a power supply such as the indicated 230 H.P.

For such requirements, the water pump is designed to deliver 470 gallons per minute at 150 lbs. per square inch at a prescribed engine throttle setting and the air foam liquid pump to deliver 30 gallons per minute. The forcing foam maker can readily be designed to aspirate 1500 gallons per minute of atmospheric air, so that the total component requirements (2000 gallons per minute of water plus air foam liquid plus air) are supplied. The foam pump is designed so that its displacement (at the prescribed throttle setting) is not 2000 gallons per minute but only some 1000 gallons per minute; that is, the full 500 gallons per minute of liquid but only about 500 gallons per minute of air (or about one third of the 1500 gallons of the aspirated atmospheric air). In the result, the velocity head of the liquid plus air stream supplied to the foam pump is converted to back pressure in the suction chamber of that pump, such pressure in the illustrative case amounting to approximately 29 lbs. per square inch. The foam pump churns the ingredients to foam and, when the foam is discharged to atmosphere, the compressed air content expands to its original 1500 gallons

and the total delivery is the required 2000 gallons per minute.

By contrast with the foregoing, it is demonstrable that, if the foam pump is sought to be operated at a discharge capacity of 2000 gallons per minute and the necessary 1500 gallons per minute of air attempted to be drawn in by the foam pump itself, at atmospheric pressure, the work required to be done necessitates an engine of some 400 H.P. (as against some 225 H.P. by the system of this invention).

Since the major problem usually encountered in air foam production is the provision of adequate capacity (without undue power consumption) the foregoing exemplification of the principles of the invention has been directed to large capacity apparatus. However, flexibility is another important requisite of such apparatus and in this respect, also, the described system has outstanding advantages.

Thus, the described system is equally advantageous and effective over the entire range of discharge pressures, namely, from virtually zero up to and even in excess of the 150 lbs. per square inch mentioned in the specific illustration. Also, there is nothing critical about the water supply. The system is indifferent to whether it is a high pressure or a high draft (negative pressure) supply. Accordingly, the system has a wide field of application both for automotive apparatus and stationary installations.

Furthermore, the system can be adapted to provide a wide range of output volumes by using two or more forcing foam makers in place of one, arranging them in parallel so that their particular capacities can be used individually or collectively. Such an arrangement is illustrated schematically in Fig. 4.

In this instance, there are two supply lines 35, 36 to the suction side of the foam pump, marked 37, the lines being connected to the discharge side of water pump 38. In each supply line there is incorporated a forcing foam maker, both being supplied with air foam liquid by pump 39, through lines 40, 41. The latter pump is shown connected to air foam liquid tank 42 by line 43. Still assuming a 2000 gallon per minute capacity, foam maker 44 can be designed for a liquid capacity of, say 200 gallons per minute and 45 for 300 gallons per minute. Used together, of course, the foam output is the same as with the single 500 gallon per minute foam maker; but by simply shutting off one or the other by the closure of valves 46, 47 or valves 48, 49 and adjusting the engine throttle accordingly, other ranges of foam capacities are made available. As will be understood, the 200 gallon foam maker is designed to aspirate 600 gallons per minute of air and the 300 to aspirate 900, giving theoretical foam discharge rates of 800 and 1200 gallons per minute, respectively. Actually, it has been found that such a system can be operated over the full range, of say, 750 to 2000 gallons per minute of foam output, without any significant variation in the quality of the foam, merely by manipulation of the engine throttle and the forcing foam maker valves.

While, as already indicated, it is not essential that the air be introduced by means of some form of forcing foam maker, the latter is found to be advantageous (as compared, for example, with an air compressor) from the standpoint of simplicity and ease of maintenance, by reason of the fact that it effects a thorough pre-mixing of the liquid and air components into a coarse foam of irregular bubble size and also because, over a range of throttle openings, it holds more closely to the prescribed expansion ratio.

It will be understood that the various figures used in the foregoing descriptions are for purposes of illustration only and that the indicated horsepower savings will vary according to the inlet pressure or compressed air volume the foam pump is designed to handle in combination with the required volumes of water and air foam liquid.

Similarly, the expansion ratio can be varied by varying the design of the foam makers or it can be increased by incorporating a common aspirating type foam nozzle in the discharge line from the foam pump. It will now be apparent, also, that while that side of the foam pump to which the pre-mixed ingredients are supplied is sometimes referred to herein (as in common parlance) as the "suction" side, the foam pump is not in fact so operated as to establish suction or negative pressure at its inlet or "suction" side. On the contrary, as pointed out, the foam pump is adapted to displace a restricted volume of air which is already at superatmospheric pressure on the "suction" or inlet side of the pump.

As regards the type of foam maker illustrated in Fig. 3, and again for purposes of illustration only, some appropriate dimensions for a unit having a liquid capacity of 500 gallons per minute might be mentioned. Highly satisfactory results have been achieved with a unit having an over-all length of some 26", of which about one half represents the cylindrical section of the body, the internal diameter of the latter being approximately 3". In such unit, eight jet openings in the orifice plate, arranged in a circle, may be designed to impinge at an included angle of 32°, the total area of such openings plus the center opening aggregating about 1 square inch (as against an area of some 8 square inches for the liquid line supplying the foam maker). The total area of the air inlet openings (four in number) may be of the order of 4 square inches.

In the light of the foregoing description, the following is claimed:

1. Apparatus for making air foam having a prescribed expansion ratio which comprises: a rotary gear foam pump; pump means for supplying to the suction side of the foam pump predetermined proportions of water, air foam liquid and compressed air, the volume of air so supplied being sufficient, measured at atmospheric pressure, to meet the prescribed expansion ratio; and power means for operating the foam pump at a restricted capacity, relative to the volume of water, air foam liquid and air supplied to the pump, such restricted capacity being less than the capacity of the pump means for supplying water, air and air foam liquid whereby a predetermined positive pressure is maintained at the said suction side of the foam pump.

2. Apparatus for making air foam having a prescribed expansion ratio which comprises: a rotary gear foam pump; positive displacement pumps for supplying to the suction side of the foam pump predetermined proportions of water and air foam liquid; supplemental means for supplying to the suction side of the foam pump a volume of compressed air sufficient at atmospheric pressure to meet the prescribed expansion ratio; and power means for operating the foam pump at a restricted capacity, rela-

tive to the volume of water, air foam liquid and air supplied to the pump, such restricted capacity being less than the combined capacities of the said positive displacement pumps plus that volume of air at atmospheric pressure which is supplied as compressed air by said supplemental means whereby a predetermined positive pressure is maintained at the said suction side of the foam pump.

3. Apparatus for making air foam having a prescribed expansion ratio and discharging the same at variable rates which comprises: a rotary gear foam pump; two supply lines to the suction side of such pump; positive displacement pumps for supplying both said lines with water and air foam liquid in predetermined proportions; a forcing foam maker in each of said lines, each of a capacity to entrain sufficient air for the prescribed expansion of the water and air foam liquid supplied to said line; shut-off valves for controlling said lines so that one or both are operative; and power means for driving the foam pump and the said positive displacement pumps at the same speed, the capacity of the said rotary gear foam pump being less than the combined capacities of the said positive displacement pumps plus the air at atmospheric pressure aspirated by the forcing foam makers, whereby a predetermined positive pressure is maintained in the suction side of the said foam pump.

4. Apparatus for making air foam which comprises: a rotary gear foam pump and means for supplying to the inlet side of the foam pump predetermined volumes of water, air foam liquid and compressed air, the volume of air so supplied being sufficient, measured at atmospheric pressure, to meet a prescribed expansion ratio and the capacity of the said foam pump in gallons per minute being less than the sum in gallons per minute of the supplied water, air foam liquid and air, the latter measured at atmospheric pressure.

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