May 26, 1964 W. PONTOW ETAL 3,134,827

STEAM CONVERSION VALVE

Filed Dec. 23, 1959 2 Sheets-Sheet 1

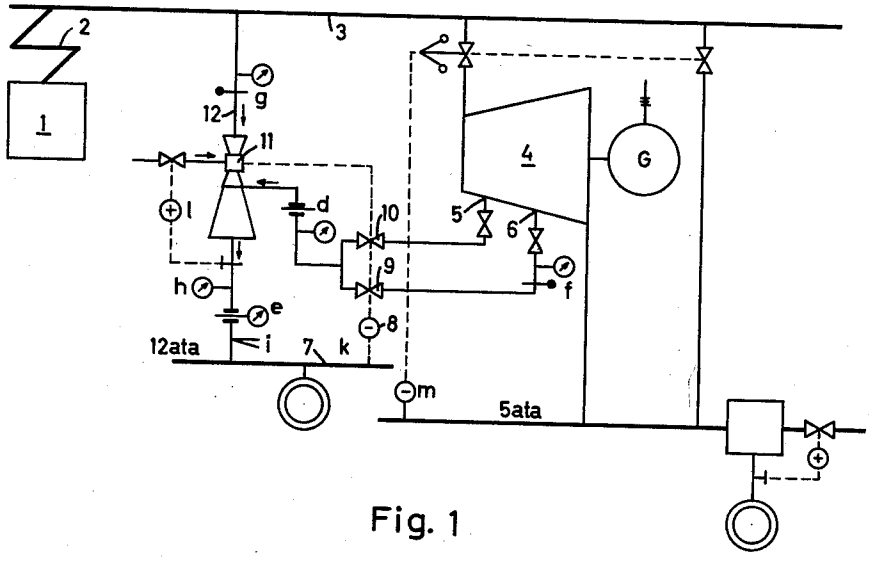

Fig. 1

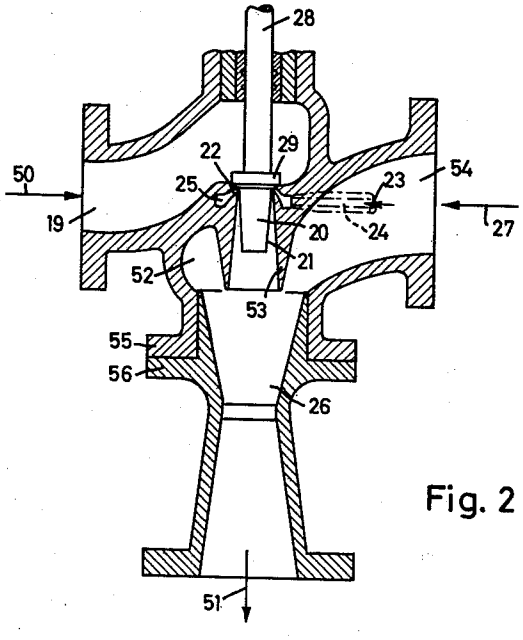

Fig. 2

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STEAM CONVERSION VALVE

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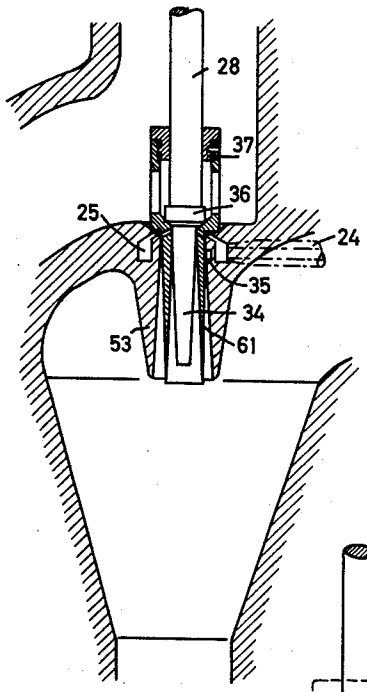

Fig. 4

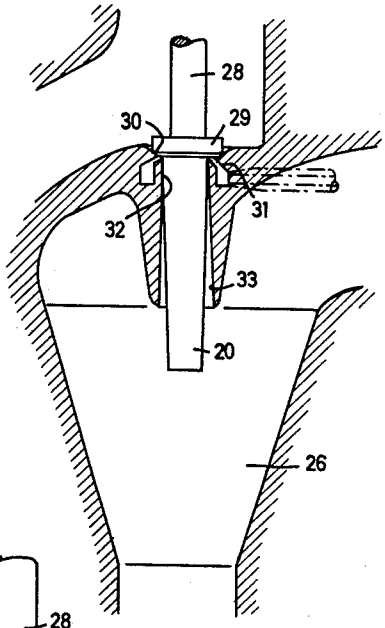

Fig. 3

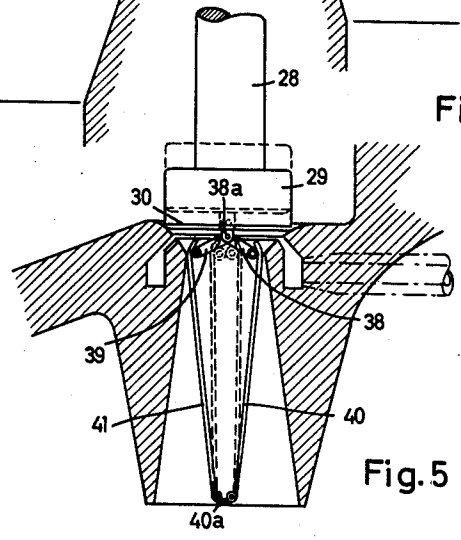

Fig. 5

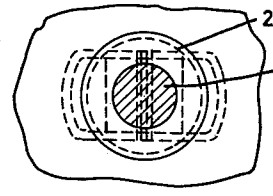

Fig. 6

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3,134,827

STEAM CONVERSION VALVE

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Our invention relates to steam conversion valves for simultaneously pressure-reducing and de-superheating steam under high pressure.

Conversion valves of this type are known from U.S. Patent 2,725,221, French Patent 1,065,108 and British Patent 710,069. Such valves have bores for supplying water to be atomized within the valve space. Located on the downstream side of the valve seat is a throttle passage surrounded by an annular channel which is connected with a water supply line and communicates through the above-mentioned bores with a valve location between the valve seat and the throttle passage. In lieu of a multiplicity of bores, a suitable annular slot may serve for supplying the water to be atomized. The fact that the water passes into the internal valve space between valve seat and throttle passage renders such valves distinct from other known types of de-superheating valves. In contrast to conversion valves to which water is supplied in or behind the zone of maximum steam velocity, the injection of water ahead of the throttle zone, and hence ahead of the zone of greatest steam velocity, has the advantage that the pressure drop, which occurs between the initial pressure and the ultimate throttle pressure and which constitutes a power loss, is utilized to an appreciable extent for furnishing the power required for atomizing the water. As a result, a reduction of the water into extremely fine particles is secured regardless of variations in steam throughput quantity.

It is an object of our invention to make conversion valves of the above-mentioned type suitable for converting an additional supply of low-pressure steam to a higher pressure and, if desired, to also cool such additional steam supply, while simultaneously performing the above-mentioned functions of pressure-reducing and cooling hot steam of high pressure. Such a conversion of low-pressure steam to a higher pressure is desirable in numerous steam power plants where tapped or bleeder steam, available from turbines, possesses too low a pressure for a particular use intended.

According to the invention, the steam conversion valve serving for simultaneously reducing and cooling high-pressure steam as described above or in a similar manner, is designed as an ejector valve to whose ejector-nozzle portion the de-superheated high-pressure steam is supplied together with the additional supply of low-pressure steam.

According to another feature of our invention, the valve seat and valve cone of the conversion valve is given a nozzle-shaped design so that the throttle energy of the fresh steam to be reduced in pressure is utilized, on the one hand, for finely distributing at best possible efficacy the cooling water being supplied and, on the other hand, for increasing the pressure of the low-pressure steam with a satisfactory degree of efficiency.

The above-mentioned objects, advantages and features of our invention, said features being set forth with particularity in the claims annexed hereto, will be apparent from, and will be mentioned in, the following with reference to the embodiments of conversion valves according to the invention illustrated by way of example on the accompanying drawings in which:

FIG. 1 is a schematic circuit diagram of a steam power plant provided with a steam conversion ejector valve according to the invention.

FIG. 2 is a sectional view of a conversion valve.

FIGS. 3 and 4 are partial and sectional views of two other embodiments respectively of such a valve.

FIG. 5 is a sectional view of part of a fourth embodiment of the valve; and

FIG. 6 is a partly sectional top view of FIG. 5.

The circuit diagram shown in FIG. 1 relates to a plant in which a conversion valve is used in combination with steam supplied from uncontrolled tap lines of turbines, and serves for further elucidating the objectives of the present invention.

A boiler **1** with a superheater **2** furnishes fresh steam into a steam line **3** at about 40 atmospheres and a temperature of 470° C. In a counter-pressure turbine **4** the steam taken from line **3** is reduced to a pressure of approximately 5 atmospheres. The turbine is provided with two tap outlets **5** and **6** which supply steam to a consumer line **7** required to have a pressure of 12 atmospheres. The steam-consumer line **7** is normally supplied from several tap outlets, namely in the illustrated case from the two tap lines **5** and **6** connected with the turbine-drum and turbine-wheel space respectively.

When the turbine operates under high load, an output-pressure regulator **8** keeps a regulating valve **9** in the throttle position required for maintaining the pressure in the consumer line **7** at the desired datum value. When the turbine load drops and the steam supply from drum-tap line **6** no longer suffices for meeting the steam consumption in line **7**, the pressure regulator **8** switches over to a regulating valve **10** and closes the valve **9**. When the valve **10** is likewise regulated to fully open position and the turbine load decreases to a further extent, the valve device **11** is put into operation. This device is a steam-converting ejector operating under control by the regulator **8**. The steam conversion-ejector valve **11** now adds fresh steam from line **3** to line **7**. The flow energy of the fresh steam then converts a certain portion of the tap-line steam to the pressure of the consumer line **7** even if the tap-pressure should further decrease.

Further shown in FIG. 1 are the following conventional plant components. Denoted by *d* is a Venturi-nozzle and pressure measuring location. A steam quantity meter is denoted by *e*, a pressure and temperature measuring device in the drum-tap line by *f*, a fresh-steam pressure and temperature measuring device by *g*. Further provided are a pressure measuring device *h* for the consumer line, a temperature measuring device *i* for the consumer line, a temperature regulator *l* and a counter-pressure regulator *m*. Details of the ejector-type conversion valve **11** will be described presently with reference to the embodiments illustrated in FIGS. 2 to 6.

Referring to FIG. 2, the fresh steam (from line **12** in FIG. 1) is supplied to a first steam-inlet duct of the valve in the direction indicated by an arrow **50**. The steam entering under high pressure and at high temperature is reduced in a nozzle passage **21** when the disc and cone **20** of the valve are lifted to open position. The necessary quantity of cooling water is supplied through an annular slot **22** slightly ahead of the narrowest nozzle cross section. The cooling water passes in the direction of the arrow **23** through a water supply duct **24** into an annular channel **25** extending in the valve-seat structure around the throttle passage **21**, the channel **25** communicates with the valve space through the above-mentioned narrow slot at a location where the nozzle cross-section of passage **21** does not yet have its narrowest dimension.

The steam outlet duct of the valve is formed by a Venturi tube **26** which comprises a conical catch-nozzle portion tapering in the downstream direction and a pressure

increasing conical nozzle space widening in the downstream direction. The consumer steam passes out of the valve in the direction of the arrow **51** (to consumer line **7** in FIG. 1). The low-pressure steam to be converted to higher pressure passes into the second steam-inlet duct **54** of the valve in the direction of the arrow **27** (from line **5** and valve **10** in FIG. 1).

The Venturi tube **26** extends in coaxial relation to the pressure-reducing throttle passage **21** and has a Venturi inlet opening wider than the outlet opening of the throttle passage **21**. As a result, the second steam-inlet duct communicates with the Venturi tube **26** through the remaining annular gap and through an annular channel **52** which surrounds the passage-forming valve structure **53**. The low-pressure steam entering through the inlet duct **54** is supplied to the fresh steam leaving the throttle passage **21** at high speed. The low-pressure steam is then raised to the desired consumer pressure in the Venturi nozzle tube with a simultaneous reduction in flow energy of the fresh steam.

The Venturi tube **26** is preferably designed as a separate component which is joined with the housing of the valve by means of flanges **55** and **56**.

The known ejectors are generally operated with a constant fresh-steam quantity regulated by a throttle member ahead of the ejector. In a steam-converting ejector valve according to the invention, however, it is essential that, from the smallest steam quantity up to the applicable greatest quantity, an optimum degree of efficiency is always attained. Accordingly, the present invention, as described above, combines the valve-control of the fresh steam with the fresh-steam quantity regulation and with the cooling and pressure reduction of the fresh steam in the fresh-steam nozzle passage. With such a design, the full fresh-steam pressure always obtains ahead of the narrowest cross section of the nozzle passage. Consequently, the pressure drop in the nozzle passage and the conversion into flow energy remain constant even though the steam quantity may vary.

The embodiment illustrated in FIG. 3 constitutes an improvement over that described above with reference to FIG. 2, corresponding components of the valve device being denoted by the same reference characters in all of FIGS. 2 through 6.

When in the modified valve according to FIG. 3 the valve stem **28** is axially lifted, the sealing disc **29** is removed from the valve seat **30**. The high-pressure fresh steam can now pass from above beyond the slot **31** for the cooling water down to the narrowest location of the throttling nozzle passage **32**. On this steam path the cooling water is atomized to an optimum degree. The throttle cone **20**, extending coaxially with respect to valve stem **28** and valve disc **29** and tapering in the downstream direction within the widening inner surface **33** of the throttle passage, forms an annular reduction nozzle together with that passage. The regulation of the steam quantity is obtained by varying the narrowest throttle cross section at **32** in dependence upon the axial displacement of the valve stem **28**. The full fresh-steam pressure always obtains ahead of the narrowest throttle cross section. Consequently the pressure drop in the nozzle passage and the conversion into flow energy remain constant with variations in steam quantity.

The embodiment shown in FIG. 4 comprises a twin-nozzle assembly which secures a particularly favorable nozzle shape at small fresh-steam quantities. When the valve stem **28** is being displaced axially, the first effect is to open the narrowest cross section between the tapering valve cone **34** and the widening annular throttle space formed between the cone and a tubular member **61**. Member **61** is seated on stem **28** and axially displaceable relative thereto. After this narrowest cross section of the inner nozzle space is opened, an outer nozzle between the member **61** and the flaring bore of the nozzle structure **53** is opened. This takes place when the valve disc **36** abuts against a nut **37** in threaded engagement with the top of the displaceable member **61**. The cooling water supplied through the water inlet duct **24** and the annular channel **25** passes through a narrow slot into the space between nozzle structure **53** and member **61**. From channel **25** the water also passes through bores of member **61** into the space between member **61** and valve disc **36** at locations corresponding to those described above with reference to FIGS. 2 and 3. Consequently no essential change is involved in the embodiment of FIG. 4 relative to the cooling of the high-pressure steam.

In each of the above-described valves, the annular throttle nozzle varies its effective axial length in dependence upon the required lifting displacement of the valve stem. A condition less favorable from fluid-flow viewpoints, may occur if in a valve as shown in FIG. 2 the bottom edge of the valve cone **20** just lays open the narrowest cross section of the throttle passage **21**. However the valve can be modified to remain favorable also under conditions of the just-mentioned type, such a modification being exemplified by the embodiment illustrated in FIGS. 5 and 6.

The illustrated portion of this valve, otherwise corresponding to those described above, constitutes a double throttling nozzle of rectangular shape whose cross section is apparent from FIG. 6. In lieu of a rigid and fixed valve cone, as shown at **20** in FIG. 2, the valve of FIGS. 5 and 6 is provided with two nozzle limiting surface members **40** and **41** which are linked together at **40***a* and whose opposite edges are hinged to respective links **38** and **39** pivotally joined at **38***a* to the valve disc **29**. When the valve stem **28** is being lifted, the first effect, as in the valves described above, is to raise the valve disc **29** off the seat **30**. The links **38** and **39** then simultaneously act upon the respective surface members **40** and **41** to simultaneously turn them inwardly to the illustrated broken-line positions. With such a valve, the active nozzle length remain substantially the same over the entire steam throughput range, so that the nozzle has a favorable shape in fluid-flow respects for any steam quantity passing through.

It will be understood that for automatic control and regulating purposes as described above with reference to FIG. 1, the axial displacement of the valve stem **28** in the illustrated embodiments is preferably effected automatically under control by the pressure regulator **8** and under control by the temperature regulator **1** in accordance with the desired conditions of plant operation.

While, as described, an ejector-type conversion valve according to the invention is applicable for reducing and de-superheating high-pressure steam and simultaneously converting low-pressure steam to a desired higher pressure, it should be understood that ejector-type conversion valves according to the invention may also be employed in different ways. For example, the same valve may be used merely as a steam conversion valve. This is the case if no low-pressure steam to be converted to higher pressure is being supplied so that the only function desired of the valve is to reduce and cool fresh steam.

The novel steam ejector-type conversion valves may further be used to operate for pressure reduction purposes. With such an operation, too, no low-pressure steam to be converted to higher pressure is being supplied. The fresh-steam temperature in this case is so low as to require no cooling.

Further use of valves according to the invention is for the purpose of merely cooling the steam to be increased in pressure. The pressure of the steam supplied to the above-described second steam-inlet duct must be sufficiently high in this case to require no pressure increase by fresh steam. The cooling can be effected by passing the cooling water in the direction of the arrow **23** (FIG. 2) through the line **24** into the annular channel **25** so that the cooling water and the steam become mixed in the Venturi tube **26**. In each of these cases of modified use the one steam supply duct or the water supply duct not being used at a time may be closed.

It will be apparent to those skilled in the art, upon studying this disclosure, that ejector-type steam conversion valves according to our invention can be modified in various respects and hence may be given embodiments other than particularly illustrated and described herein, without departing from the esesntial features of the invention and within the scope of the claims annexed hereto.

We claim:

1. A steam conversion valve for pressure reduction and cooling of hot steam by throttling and water injection, comprising a valve housing provided with a first inlet duct for high-pressure hot steam from a fresh steam line, a second inlet duct for low-pressure steam withdrawn from a prime mover, and an outlet steam duct, nozzle means having a passage flaring outwardly in the direction of steam flow therethrough and positioned between said three ducts for passing hot steam from said first inlet duct to said outlet duct and for increasing the pressure of said withdrawn steam and passing the latter to said outlet duct, said outlet duct having a venturi tube coaxial with and communicating with said nozzle means, said second inlet duct having an annular channel surrounding said nozzle means and communicating with said venturi tube so that said nozzle means together with said annular channel and said venturi tube define jointly an ejector for driving steam through said outlet duct and for inducting said withdrawn steam in through said second inlet duct, whereby excess throttle energy inherent in the hot steam entering through said first inlet duct is utilized as a driving medium in the sense of a jet suction source for inducting said low-pressure steam through said second inlet duct and for increasing the pressure of the latter steam.

2. In a valve according to claim 1, said venturi tube having its end closest to said nozzle means of a diameter greater than said nozzle means to define an interspace therebetween, said annular channel communicating with said venturi tube through said interspace.

3. Steam conversion valve according to claim 1, further comprising means forming a water inlet within said nozzle means ahead of the narrowest cross section of said nozzle means in said flow direction.

4. Valve according to claim 3, said water inlet comprising an annular duct surrounding said outwardly flaring passage and communicating with the latter for evenly supplying cooling water to said passage.

5. A steam conversion valve according to claim 4, said nozzle means forming a valve seat and having a valve cone comprising a conical stem and a valve disc in coaxial relation to said nozzle passage and tapering toward the down-stream side whereby the active throttling flow cross section of said passage depends upon the distance said disc is moved off said seat.

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