United States Patent [19]

Strub

[11] **3,892,499**

[45] **July 1, 1975**

[54] **MULTISTAGE TURBOCOMPRESSOR HAVING AN INTERMEDIATE COOLER**

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[22] Filed: **July 12, 1973**

[21] Appl. No.: **378,428**

[30] **Foreign Application Priority Data**

July 13, 1972 Switzerland 10517/72

[52] **U.S. Cl.** **415/179;** 415/168; 417/372

[51] **Int. Cl.** **F01d 5/08**

[58] **Field of Search** 417/372; 415/179, 168

[56] **References Cited**

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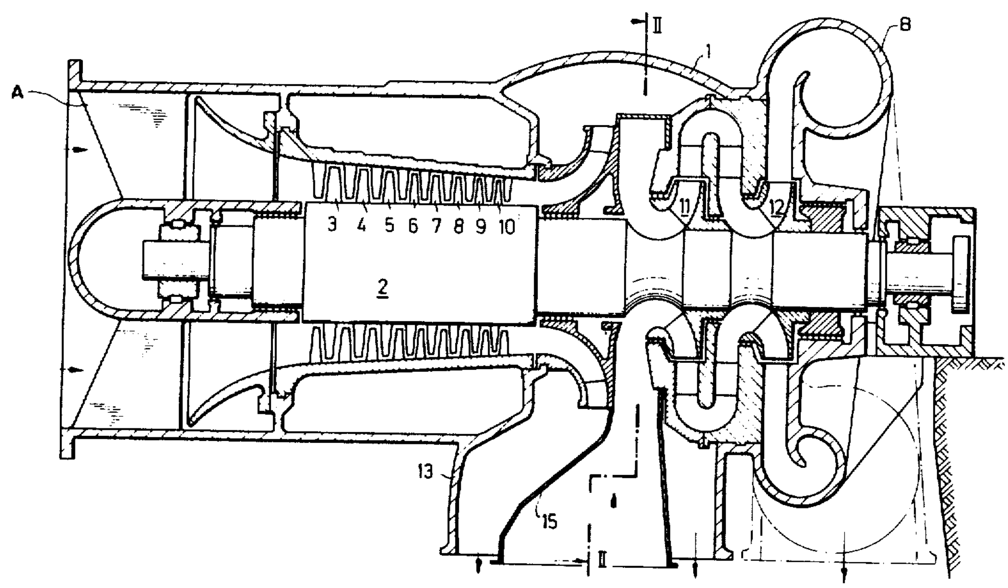
[57] **ABSTRACT**

The compressor housing is connected to the cooler by a casing duct to direct the intially compressed gas to the cooler while a central duct within the casing duct returns the cooled air to the housing and to the second compressor. The heated wall of the central duct serves to vaporize any droplets of fluid in the return gas flow which might otherwise damage the second compressor.

11 Claims, 4 Drawing Figures



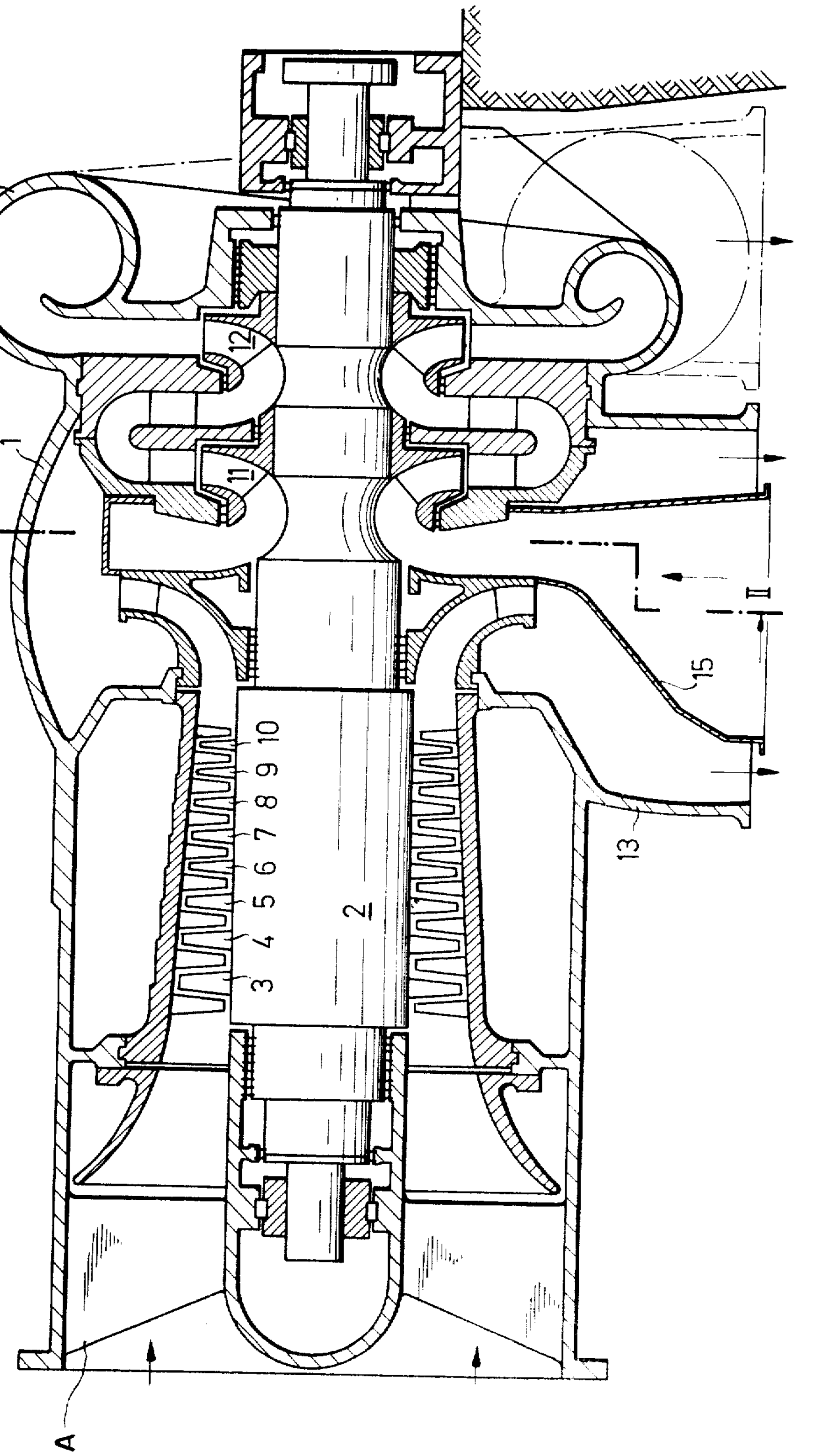
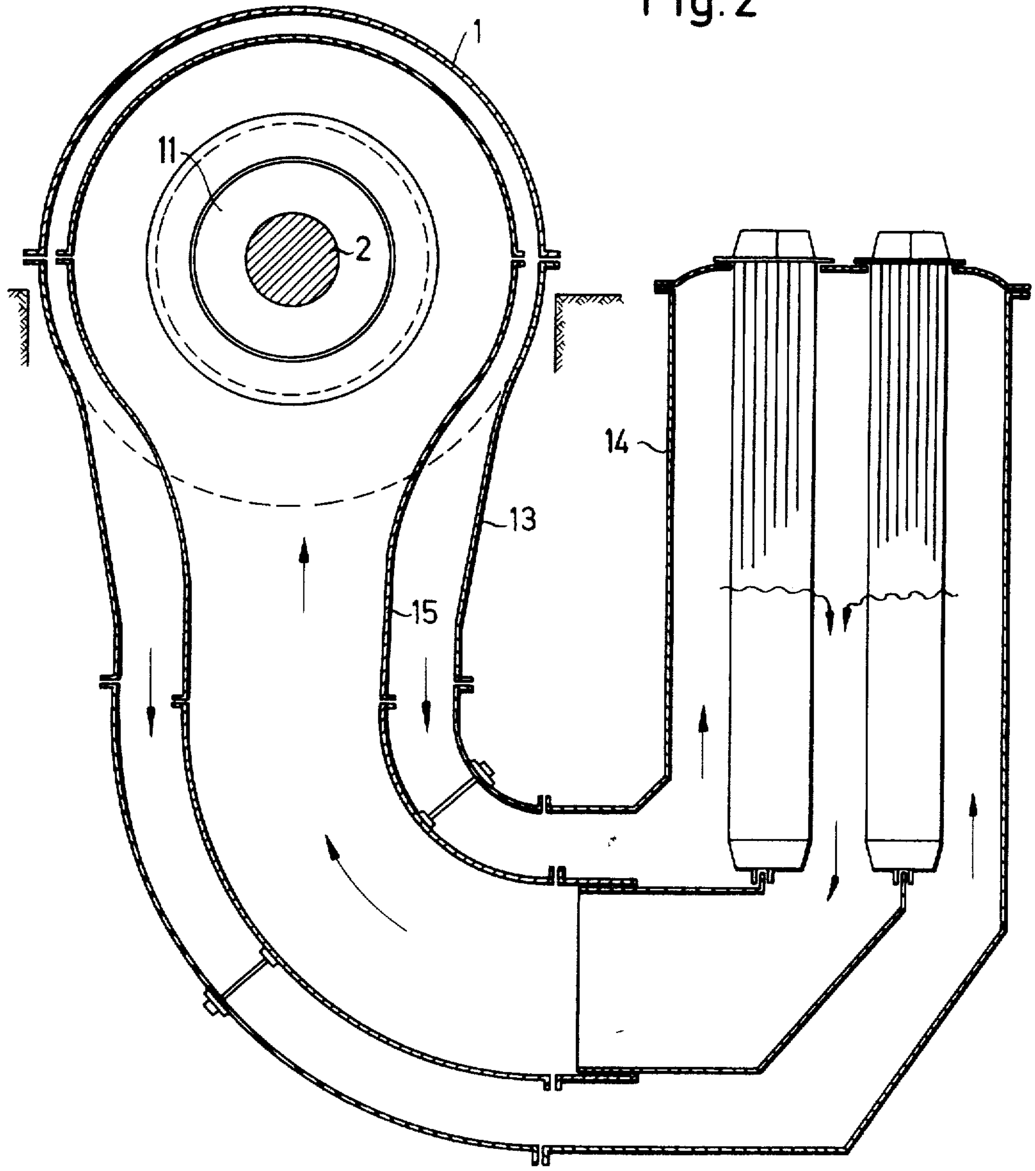


Fig.1

Fig. 2



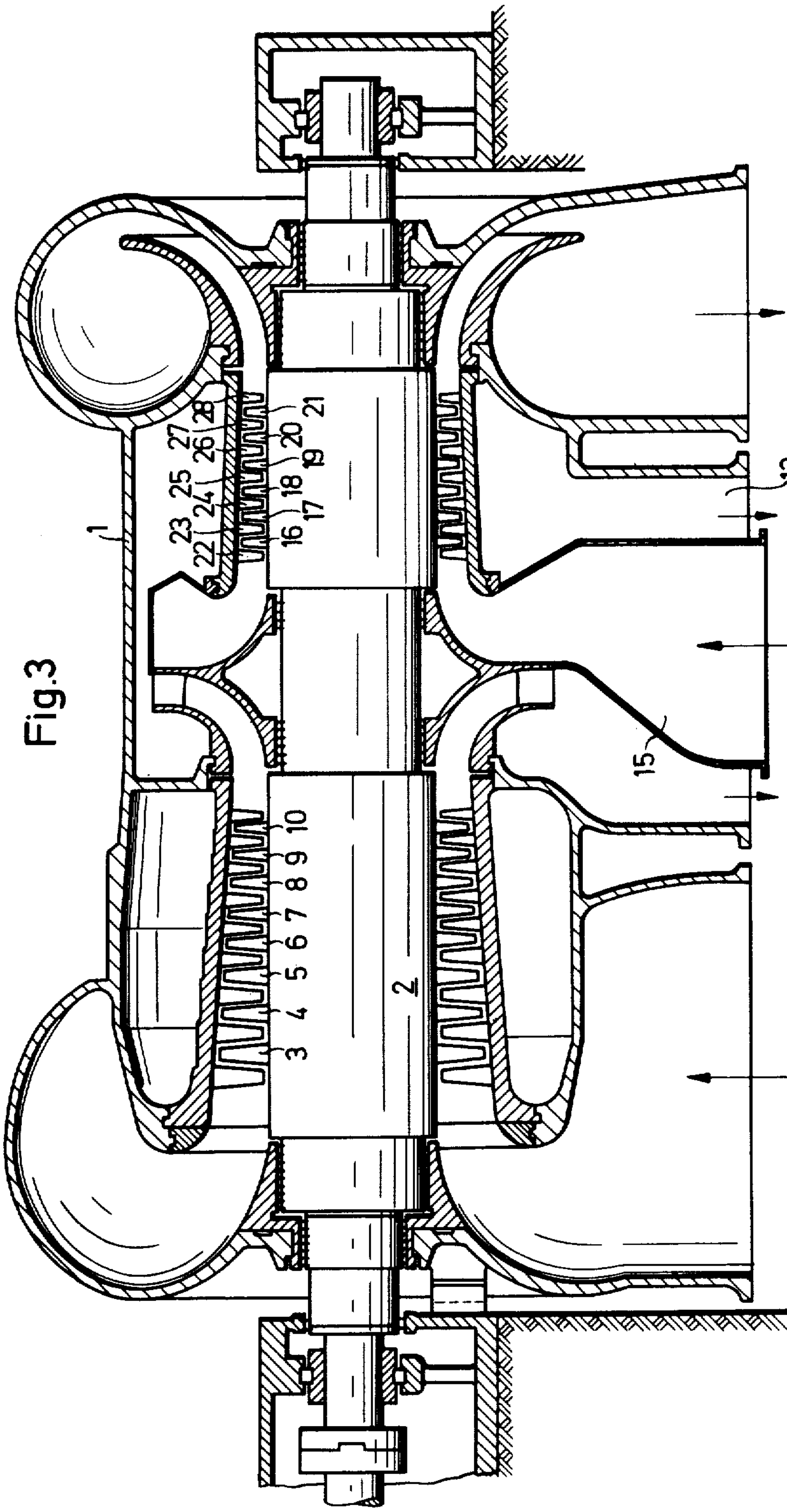


Fig.3

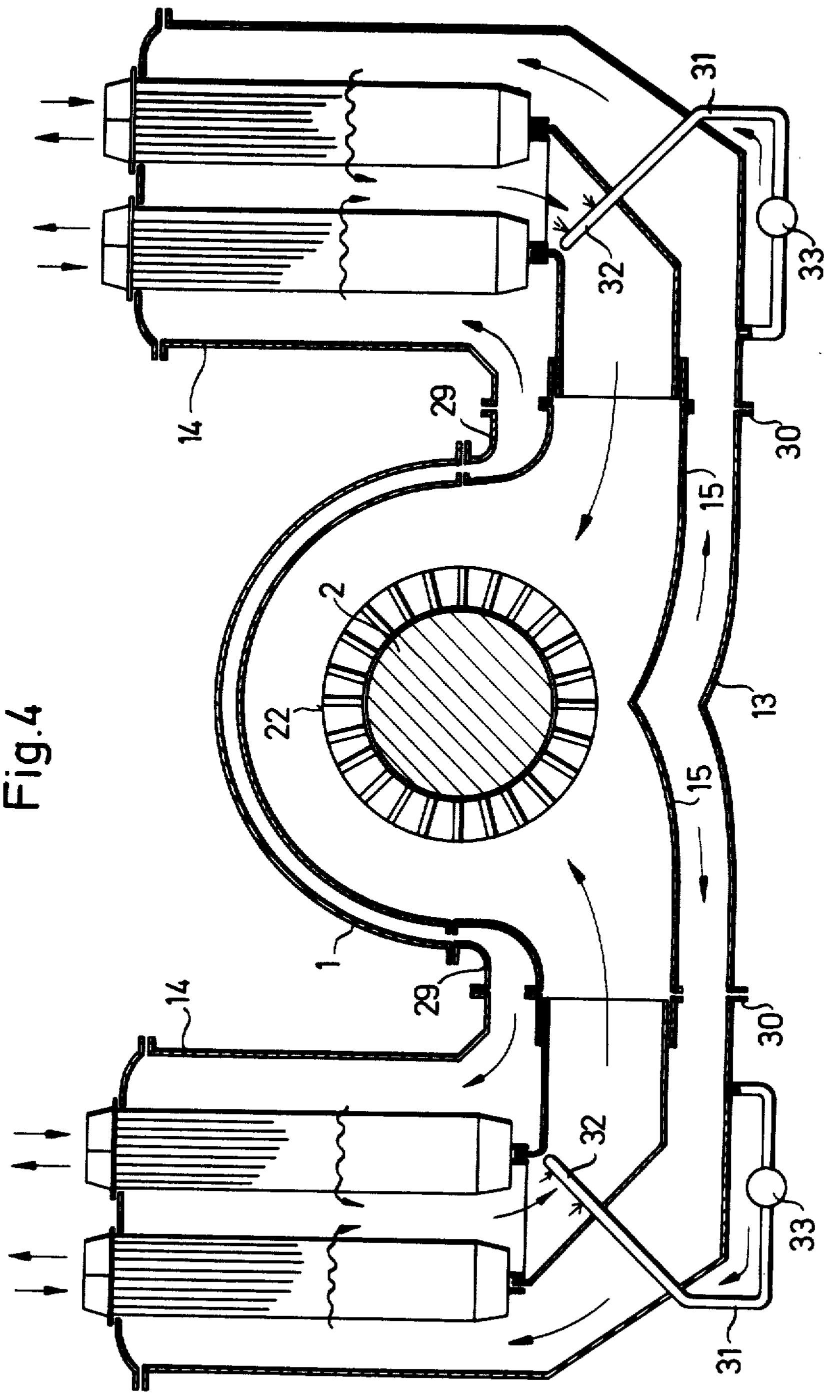


Fig.4

MULTISTAGE TURBOCOMPRESSOR HAVING AN INTERMEDIATE COOLER

This invention relates to a multistage turbocompressor having an intermediate cooler.

Heretofore, multistage turbocompressors have been known to use an intermediate cooler between various compressors in order to cool a gaseous working medium, e.g. steam, flowing between the compressors. However, a danger has existed that the gaseous working medium may cool to such an extent, either temporarily or for a relatively long time, as to allow the water vapor therein to begin to condense. Should this occur, the condensed water vapor would be delivered as water droplets to the blading channels of the turbocompressor and would cause damage through erosion and depositing of impurities contained in the gas flow. Axial blading is particularly endangered because higher speeds of the working medium to be compressed are generated relative to the blade surfaces driving the medium than is the case with the blading of a radial compressor.

Accordingly, it is an object of the invention to prevent the introduction of drops of condensate in a gaseous working medium into the blading of a compressor.

It is another object of the invention to provide a simple construction for removing drops of condensate from a flow of compressed gas leading to a turbocompressor from an intermediate cooler.

Briefly, the invention provides a multistage turbocompressor comprised of a compressor housing and an intermediate cooler outside the housing with a casing duct between the housing and cooler and a central duct enclosed within the casing duct and between the cooler and housing. The casing duct is connected to pass a flow of heated compressed gas from the housing, for example, from an initial compressor therein, to the cooler for cooling to suitable temperature for subsequent use. The central duct is connected to pass the flow of cooled compressed gas back to the housing, for example, to a second compressor. During passage through the casing duct, the heated gas heats the wall of the central duct. The resultant heat in the wall of the central duct then heats any condensate in the countercurrent flow of cooled gas within the central duct to vaporize the condensate. As a result, the return flow of gas becomes free of condensate.

Gas turbine equipment such as described in Swiss Pat. Nos. 214,837 and 221,377 have been known to use piping systems with a central duct disposed within a casing duct. However, these piping systems have been used to conduct a high-temperature gas through the central duct. In order to lower the temperature of a tube wall stressed by the pressure of the gas, a cooler gas has been conducted in the outer casing duct. In this way, it has been possible to obtain thermal relief of the wall loaded by the high internal pressure, avoiding strength problems and leak-proofing difficulties. In accordance with the invention, the hot gas is conducted in the outer casing duct and the cool gas in the central duct. Thus, the tube wall dividing the casing duct from the central duct can be maintained at a high-temperature by means of the flow of not-yet-cooled gas. As a result, the flow of cool gas laden with drops of condensate is surrounded on all sides by a high-temperature wall. Upon encountering this wall, because of the increase of surface area, the drops become vaporized before reaching the blading of the compressor.

The compressor may have an axial stage upstream of the exit point to the cooler of the medium being compressed, and may have a radial stage following the reentry of the cooler medium. The invention is of special importance for compressors with use axial stages following the re-entry of the cooled medium.

The function of the casing duct can be substantially facilitated by forming a bend in the casing duct as well as in the central duct since the drops of condensate will impact against the wall, and produce a greater surface area of contact. Thus revaporization can be accelerated.

The casing duct and central duct can advantageously be connected to the lower half of the housing where the housing is split in two halves. Also, it is possible to have two casing ducts disposed symmetrically of the perpendicular axial plane of the turborotor with each connected to the housing. Finally, a means may be disposed between the casing duct and the central duct to selectively introduce a variable amount of heated gas from the casing duct into the flow of cooled gas in the central duct in order to further promote the vaporization of the condensate drops.

These and other objects and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawing in which:

FIG. **1** illustrates an axial cross-sectional view of a turbocompressor according to the invention;

FIG. **2** illustrates a cross-sectional view taken on the plane II—II of FIG. **1.**

FIG. **3** illustrates an axial cross-sectional view of a further turbocompressor construction according to the invention made as a purely axial compressor; and

FIG. **4** illustrates a cross-sectional view through a compressor with separate intermediate coolers disposed at both sides according to the invention.

Referring to FIGS. **1** and **2**, an axial-radial turbocompressor includes in a housing **1** in which a rotor **2** is mounted and which has an inlet A for receiving air or a gas. The rotor **2** carries axial rotor rings **3** to **10** to compress air or a gas to a pressure at which the temperature rises to such an extent that intermediate cooling is necessary. The rotor **2** also carries radial stages **11** and **12** of a radial compressor to compress the gas further to a final pressure after cooling. The housing **1** also has an outlet B at the end of the radial compressor for the exhaust of the compressed gas.

In order to intermediately cool the gas, a casing duct **13** is connected to the housing **1** between the axial stages **3** to **10** and the radial stages **11, 12** (FIG. **1**) and extends to a cooler **14** (FIG. **2**) to conduct the flow of heated compressed gas to the cooler **14.** In addition, a central duct **15** is enclosed within the casing duct **13** and extends from the cooler **14** to the housing **1** to conduct the flow of cooled compressed gas back to the housing and to the radial stages **11, 12.** As shown, both ducts **13, 15** have a curved or bent position to deflect the respective flows of gas for purposes as described below.

Depending on the kind of gas to be compressed, the condition of the gas before reaching the compressor, and the condition desired at emergence from the compressor, the gas may be cooled in the intermediate cooler **14** to such an extent that the water contained in the gas before compression (or some other condensable inclusion) becomes condensed into drops. These drops are carried along by the gas flowing back into the compressor, and would, without an introduction of heat, only revaporize during the compression in the radial stage **11**, and deposit non-vaporized impurities on the blade surfaces. Non-vaporized residues might even arrive in stage **12.** As a result, and because of the high speeds at which the drops strike the rotor parts or other compressor parts, erosion and premature wear of these parts may occur.

By running the central duct **15** inside the casing duct **13**, the wall of the central duct **15** is supplied with heat from the gas heated through compression in stages **3** to **10** and flowing into the casing duct **13**. As a result, the drops of liquid carried along by the cooled gas receive so much heat that they revaporize and, as vapor, can no longer cause damage to the radial rotors **11** and **12.** The solid constituents are now dry, and are forced through the compressor without becoming deposited on the blades.

The vaporization of the drops of liquid in the central duct **15** can occur, in part, in the suspended state through the radiation of heat from the wall and also, in part, through contact with the duct wall. Because of the turbulence of the gas and the curved portions of the duct **15** some of the drops strike the heated duct wall and thereby become broken up. This gives the drops an enlarged surface area, thereby promoting more rapid vaporization. If there is a danger of a particularly great formation of liquid drops, then it is possible to install guide elements in the central duct to separate the drops out of the gas flow and conduct the drops against the wall. Such guide elements could also aid in the vaporization of the drops of condensate if heated to a sufficient temperature by radiation from the duct walls.

Referring to FIG. **3**, wherein like reference characters indicate like parts as above, an axial compressor having axial stages **16** to **21** follow the intermediate cooler (not shown). Axial stages are more endangered by drops in the gaseous working medium being compressed and by deposits than are radial stages, and in their flow, undergo greater deviations than radial compressors. Naturally, the most endangered parts are the blades of the introduction-stator **22** first reached by the intermediately cooled gas. These blades do not receive the flow of gas from the central duct **15** as uniformly as do the blades of the following rotors **16** to **21** and stators **23** to **28.**

Finally, referring to FIG. **4** wherein like reference characters indicate like parts as above, aa turbocompressor can be provided at each side of the housing **1** with an intermediate cooler **14.** The housing **1** is split into two halves, with the connection of each cooler **14** made in the lower housing half **29** by flanges **30.** This facilitates access to the rotor **2** for maintenance and overhauling work.

A means **31–33** is also provided between the casing duct **13** and the central duct **15** in order to selectively introduce a small variable amount of not-yet-cooled medium being compressed from the casing duct **13** into the central duct **15.** This means includes a pipe **31** connecting the casing duct **13** to the central duct **15**, a series of outlets **32** in the pipe **31** to introduce the heated gas into the central duct **15** and a valve **33** for controlling the amount of flow through the pipe **31.** This conducts so much heat to the cool gas in the central duct **15**, which still contains drops, that any drops not reaching the wall and not sufficiently heat-irradiated by the wall become vaporized. An undesirable reheating of the cooled gas is not to be expected because the brought-in heat is used chiefly to vaporize the drops.

I claim:

1. In a multistage turbocompressor having a compressor housing including an inlet and an outlet and an intermediate cooler outside said housing;

a casing duct connected between said housing and said cooler downstream of said inlet for passing a flow of heated compressed gas from said housing to said cooler for cooling therein, and

a central duct enclosed within said casing duct and connected between said cooler and said housing upstream of said outlet for passing the flow of cooled compressed gas from said cooler to said housing for passage out of said outlet.

2. In a multistage turbocompressor as set forth in claim **1**, said casing duct and said central duct each having a bend therein.

3. In a multistage turbocompressor as set forth in claim **1**, said housing being split in two halves in an axial plane and said ducts being connected to the lower half of said housing.

4. In a multistage turbocompressor as set forth in claim **3**, wherein two said casing ducts are connected to said lower housing half symmetrically of a vertical axial plane of said housing.

5. In a multistage turbocompressor as set forth in claim **1**, means connected between said casing duct and said central duct for selectively introducing a variable amount of heated gas from said casing duct into the flow of cooled gas in said central duct.

6. A multistage turbocompressor comprising a housing including an inlet and an outlet;

a first compressor in said housing downstream of said inlet for heating and compressing a flow of gas to a first pressure;

a second compressor in said housing downstream of said first compressor and upstream of said outlet for compressing the flow of gas to a higher pressure than said first pressure;

a cooler outside said housing for cooling the flow of heated gas;

a casing duct connected between said housing and said cooler for passing the flow of heated gas to said cooler from said first compressor; and

a central duct enclosed within said casing duct and connected between said cooler and said housing for passing the flow of cooled gas from said cooler to said second compressor.

7. A multistage turbocompressor as set forth in claim **6** wherein each duct has a bend therein for deflecting a respective flow of gas therein.

8. A multistage turbocompressor as set forth in claim **6** wherein said each compressor is an axial flow compressor.

9. A multistage turbocompressor as set forth in claim **6** wherein said first compressor is an axial flow compressor and said second compressor is a radial flow compressor.

10. A multistage turbocompressor as set forth in claim **6** further comprising a means connected between said casing duct and said central duct for selectively introducing a variable amount of heated gas from said casing duct into the flow of cooled gas in said central duct.

11. A multistage turbocompressor comprising

a compressor housing having an inlet and an outlet,

a first plurality of compressor stages in said housing adjacent and downstream of said inlet to receive and compress a flow of gas to a first pressure,

a cooler outside said housing for cooling the flow of compressed gas,

a casing duct connected between said housing and said cooler for passing the flow of compressed gas

to said cooler,

a central duct concentric to said casing duct and connected between said cooler and said housing for passing the flow of cooled gas from said cooler to said housing downstream of said compressor stages, and

a second plurality of compressor stages in said housing downstream of said first compressor stages and upstream of said outlet for compressing the flow of gas from said cooler and central duct.

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