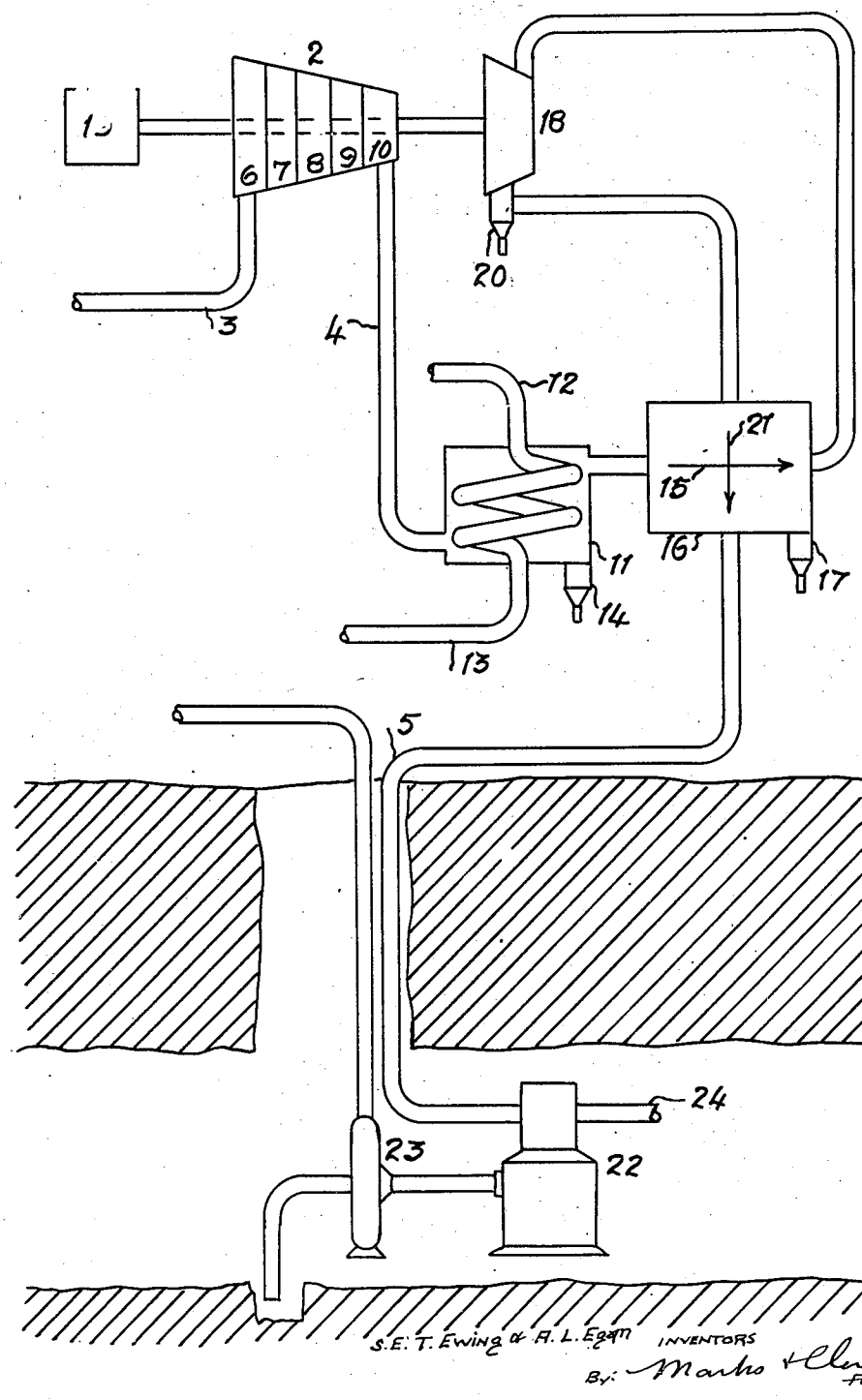
April 13, 1937. S. E. T. EWING ET AL 2,077,315

DE-VAPORIZING COMPRESSED AIR

Filed April 6, 1934. 3 Sheets-Sheet 1

Fig. 1



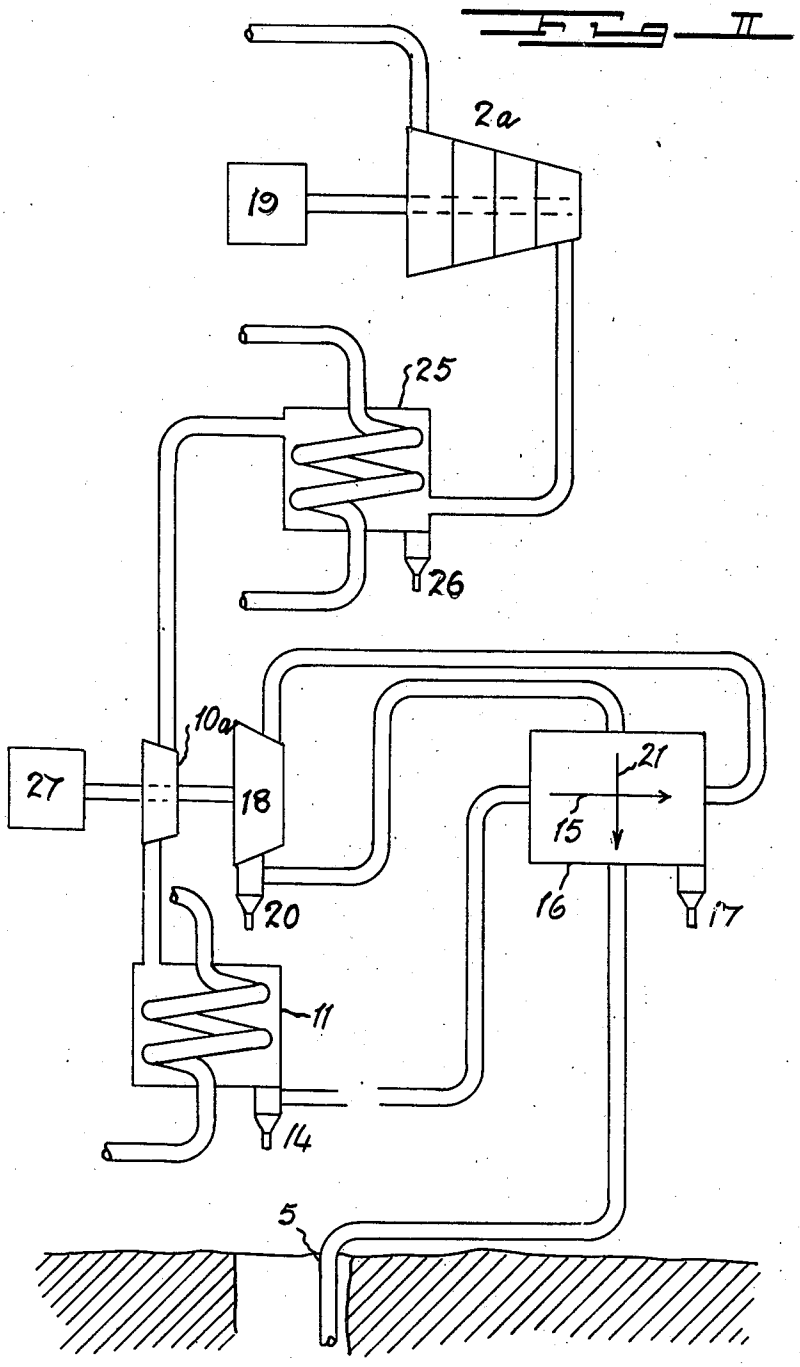
S. E. T. Ewing & A. L. Egan INVENTORS

By: Marks & Clerk Attys.

April 13, 1937. S. E. T. EWING ET AL 2,077,315

DE-VAPORIZING COMPRESSED AIR

Filed April 6, 1934 3 Sheets-Sheet 2



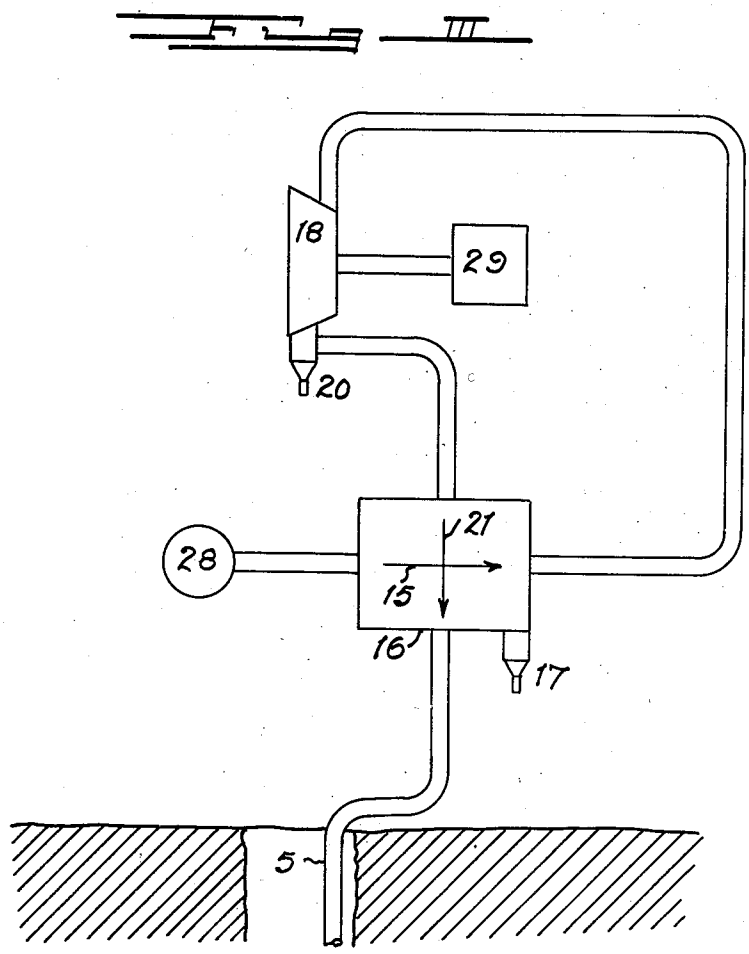
S. E. T. Ewing
A. L. Egan
INVENTORS

By: Marks & Clark
ATTYS.

April 13, 1937. S. E. T. EWING ET AL 2,077,315

DE-VAPORIZING COMPRESSED AIR

Filed April 6, 1934 3 Sheets-Sheet 3



S. E. T. Ewing
A. L. Egan INVENTORS

By: Marks & Clerk
Attys.

Patented Apr. 13, 1937

2,077,315

UNITED STATES PATENT OFFICE

2,077,315

DE-VAPORIZING COMPRESSED AIR

Sydney Edward Thacker Ewing and Arthur Lindsey Egan, Johannesburg, Union of South Africa

Application April 6, 1934, Serial No. 719,400
the Union of South Africa August 29, 1933

7 Claims. (Cl. 62—137)

The present invention relates to methods and apparatus for producing compressed air in a highly devaporized condition. One of the uses to which this product may be put is that of conditioning mine air by expanding the devaporized compressed air against a load so as to produce exhaust air which is both dry and cold and using such exhaust air to condition the mine air, as by mixing it with the latter.

For supplying to a mine de-humidified compressed air suitable for conditioning the mine air as described in the last paragraph, it has been proposed to devaporize the air at the pressure of its delivery to the mine and before such delivery.

According to the present invention, the air is first provided under the conditions

(a) That it is over-compressed; i. e. it is at a pressure substantially higher than its working pressure. By "working pressure" is meant the pressure at which it is required to be when devaporized and ready for its intended use; for instance the pressure at which it is to be delivered to a mine and to mine machinery.

(b) That its temperature is about the prevailing temperature.

(c) That it is dry in the sense that moisture which has condensed by reason of its compression and cooling to the prevailing temperature has been removed from it.

Such over-compressed air is cooled by heat exchange as explained hereafter and is then expanded, in a motor driving a load, down to its working pressure. Thereby it is substantially cooled; its over-compressed pressure and its heat-exchange cooling being preferably so arranged that its expansion down to its working pressure reduces it to the freezing temperature of water. The cooling by heat exchange and the further cooling in the expansion motor causes condensation of water vapour which was present in the over-compressed air; and when freezing temperature is attained as aforesaid practically the whole of the water vapour is condensed. The two condensates are removed from the air.

The cold and de-watered exhaust from the expansion motor at the working pressure is then passed through the heat exchange step mentioned above whereby it cools the over-compressed air passing to the motor and is itself brought nearer to the prevailing temperature. The product thus consists of air at working pressure, highly devaporized, and ready for its intended use.

The heat exchange between the over-compressed air going to the motor and the compressed air exhausted from the motor is an important feature of the invention from the economic aspect since it reduces the temperature range through which the air must pass in the expansion motor in order to attain the final temperature corresponding to the desired degree of devaporization. Correspondingly with the temperature range, the necessary pressure range is reduced; and, as the final pressure is determined by the working pressure at which the air is to be delivered, the net result is to minimize the degree of over-compression to which the air must initially be brought. The degree of over-compression is also dependent upon the adiabatic efficiency of the expansion motor.

A further feature of the invention which is economically important is that the work derived from the expansion motor is applied to assist the compression of the air.

The invention is illustrated in the accompanying drawings in which:

Figure I is a diagrammatic representation of apparatus for conditioning mine air.

Figure II is a similar representation of surface plant including a pre-existing compressor.

Figure III shows a surface plant suitable for the case where compressed air is available from a public supply at a pressure above the mine working pressure.

Referring to Figure I, 2 indicates a compressor which takes in atmospheric air at 3 and delivers it at 4 at a pressure higher than that at which the air is required to be delivered to the mine compressed air system 5. Said compressor 2 would usually compress in stages indicated by 6, 7, 8, 9, 10. It may also cool the air between some stages, but in any event the delivered compressed air is cooled at 11 by natural means available for bringing it to about the prevailing temperature. As shown it is cooled by water taken in at 12 and delivered at 13 to say a cooling pond. The condensate is removed at 14.

The cooled compressed air is passed, as indicated by arrow 15, through a heat exchanger 16 where it is further cooled. Moisture precipitated by such cooling is removed at 17. The cooled and de-watered air is supplied to the expansion motor 18. Said motor is shown as driving the compressor 2 and thereby assisting the main compressor motor 19. In said expansion motor 18 the air is expanded to its working pressure, that is the pressure at which it is to be delivered to the mine system 5.

In expanding in the motor 18, the air falls to a low temperature. Preferably it is brought to

the freezing temperature of water. Its vapour content is thereby precipitated as water or ice, and is removed at 20. The cold dewatered exhaust air is led, as indicated by the arrow 21, through the heat interchanger 16 where it cools the over-compressed air passing at 15 to said motor 18.

From the heat interchanger, the air, now at working pressure and highly devaporized is conducted to the mine compressed air system 5. It is worked in expansion motors for various purposes as described in the specification of our application No. 683,528; for instance in the expansion motor 22 which drives the pump 23. When exhausted from said motor 22 it is discharged into the mine atmosphere at 24 or otherwise employed to condition the mine atmosphere.

Figure II shows a surface arrangement suitable for the case where there exists a compressor 2a adapted to produce compressed air at the working pressure. It is desirable in this case to provide the water cooler 25 for cooling the air delivered by the compressor 2a; said cooler 25 having means 26 for removing water condensed by the cooling. Additional plant required includes the compressor 10a which is driven by the expansion motor 18 and a make-up motor 27; together with the cooler 11 and the heat exchanger 16 as in the last example. The air from the compressor 2a is thus cooled at 25, dewatered at 26, over-compressed at 10a, again cooled at 11, dewatered at 14, further cooled at 15, re-expanded at 18 and dewatered at 20 with heat interchange at 16 between the air going to and air coming from the expansion motor 20, and dewatering at 17.

Figure III illustrates the case where air at a higher pressure than the working pressure and at about the prevailing temperature, is delivered from a public supply at 28.

Such air is passed through the heat exchanger 16, dewatered at 17, and then conducted to the expansion motor 18. The latter drives any appropriate load indicated by 29. The exhaust from the expansion motor 18 is de-watered at 20, passed through the heat exchanger 16 and thence conveyed to the mine system 5.

We claim:

1. The process of conditioning mine air by providing, at the surface of the mine, air which is compressed to a higher pressure than the working pressure at which it is to be used in said mine, said air being at the prevailing temperature and containing no water other than water vapour, cooling such air by heat exchange with the air exhausting from an expansion motor, further cooling it by expanding it against a load in said expansion motor down to its working pressure, causing the cold exhaust compressed air from said expansion motor to cool the over-compressed air incoming thereto, then working said air expansively in the second expansion motor driving a load and causing it thereafter to cool the mine atmosphere.

2. The process of conditioning mine air by compressing air at the surface of the mine to a pressure substantially above its working pressure in said mine, cooling it by a naturally occurring cooling medium such as air or water to about the prevailing temperature, removing from it moisture condensed from such compression and cooling, cooling it by heat exchange with the air exhausting from an expansion motor, further cooling it by expanding it against a load in said expansion motor down to its working pressure, causing the cold exhaust compressed air from said expansion motor to cool the over-compressed air incoming to said expansion motor, thereafter working said air expansively in a second expansion motor driving a load and then causing it to cool the mine atmosphere.

3. The process which consists in providing air at about the prevailing temperature and containing no water other than water vapour and at a pressure substantially above a predetermined working pressure so that when it has been cooled, expanded and warmed as hereafter specified, it will attain said working pressure and be at about the prevailing temperature, cooling such air by heat exchange with the air exhausting from an expansion motor, removing resulting condensate, further cooling it by expanding it in said expansion motor and against a load until it reaches said predetermined pressure, removing resulting condensate, then causing the cold compressed air exhausted from said motor to cool the over-compressed air which is entering said motor, and thereby warm itself to about the prevailing temperature, so providing a supply of compressed air which, by reason of its being at the working pressure and about the prevailing temperature, is available as a source of power and is highly devaporized.

4. The process which consists in compressing air to a pressure substantially above a predetermined working pressure so that when it has been cooled, expanded and warmed as hereafter specified it will attain said working pressure and be about the prevailing temperature, cooling the whole of the so compressed air by a cooling medium to about the prevailing temperature, removing resulting condensate, cooling it by heat exchange with the air exhausting from an expansion motor, removing resulting condensate, further cooling it by expanding it in said expansion motor and against a load until it reaches said predetermined pressure, removing resultant condensate, then causing the cold compressed air exhausted from said motor to cool the over-compressed air which is entering said motor, and thereby warm itself to about the prevailing temterature, so providing a supply of compressed air which, by reason of its being at the working pressure and about the prevailing temperature, is available as a source of power and is highly devaporized.

5. The process which consists in providing air at about the prevailing temperature and containing no water other than water vapour and at a pressure substantially above a predetermined working pressure so that when it has been cooled, expanded and warmed as hereafter specified, it will attain said working pressure and be at about the prevailing temperature, cooling such air by heat exchange with the air exhausting from an expansion motor, removing resulting condensate, further cooling it by expanding it in said expansion motor and against a load until it reaches said predetermined pressure, and is at a temperature not higher than the freezing temperature of water, removing resulting condensate, then causing the cold compressed air exhausted from said motor to cool the over-compressed air which is entering said motor, and thereby warm itself to about the prevailing temperature, so providing a supply of compressed air which, by reason of its being at the working pressure and about the prevailing temperature, is avail-

able as a source of power and is highly devaporized.

6. The process which consists in compressing air to a pressure substantially above a predetermined working pressure so that when it has been cooled, expanded and warmed as hereafter specified it will attain said working pressure and be at about the prevailing temperature, cooling the whole of the so compressed air by a cooling medium to about the prevailing temperature, removing resulting condensate, cooling it by heat exchange with the air exhausting from an expansion motor, removing resulting condensate, further cooling it by expanding it in said expansion motor and against a load until it reaches said predetermined pressure, removing resultant condensate, causing the energy given out by said expansion motor to assist in compressing the air as aforesaid to the pressure substantially above its working pressure, then causing the cold compressed air exhausted from said motor to cool the over-compressed air which is entering said motor, and thereby warm itself to about the prevailing temperature, so providing a supply of compressed aid which, by reason of its being at the working pressure and about the prevailing temperature, is available as a source of power and is highly devaporized.

7. Apparatus for producing highly devaporized air having a substantial energy content due to its pressure, comprising a source of relatively highly compressed air, a heat interchanger having means for conducting the original compressed air through it so that said air is cooled, means for removing condensate from said air, an expansion motor arranged to receive the relatively highly compressed air and having such a ratio of expansion as to exhaust it at a pressure substantially above atmospheric pressure and at a temperature of substantially the freezing point of water, a load for the expansion motor, means for removing condensate from the motor exhaust air, and means to conduct the devaporized exhaust air through the heat intercharger, the heat inter-changer providing such rate of heat exchange that said exhaust air is warmed by the original compressed air to about the prevailing temperature.

SYDNEY EDWARD THACKER EWING.
ARTHUR LINDSEY EGAN.