To all whom it may concern:

Be it known that I, Benjamin Graemiger, a citizen of the Republic of Switzerland, residing at Zurich, Switzerland, have invented certain new and useful Improvements in Cooling Devices in Multistage Centrifugal Compressors; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use the same, reference being had to the accompanying drawings, and to letters or figures of reference marked thereon, which form a part of this specification.

This invention relates to a cooling device in multistage centrifugal compressors having cooling channels parallel to the axis of the compressor-shaft. The device according to this invention is so constructed, that channels of one pressure-stage come to lie coaxially to channels of a neighboring stage and pass through the partition walls of these pressure-stages. The cooling channels may be arranged in separately made pieces or bodies inserted into the lateral partition walls. In this case they may as well be cast into said walls. The cooling device may also comprise tubes parallel to the axis of the compressor and passing through the partition walls separating the single stages from one another. According to this invention two of these tubes must always be arranged coaxially, so that they act as a single continuous or through-going tube, or tubes passing through the partition walls may be inserted. The cooling channels connected in series may communicate at least at one end with water-chambers closed by means of covers, so that they are accessible upon the removal of the covers.

Several modes of carrying the invention into effect are shown by way of example in the accompanying drawings, in which:

Figure 1 is a part of a longitudinal section through an air-compressor having four stages, the cooling channels of this compressor being arranged in separately inserted bodies cast together with the side or partition wall of the stages.

Fig. 2 shows a part of a cross-section on the lines I, II, III and IV of Fig. 1 through this compressor, illustrating how the cooling channels are arranged in radial planes.

Figs. 3 and 4 are a front- and side-view respectively, of a separately made cooling body.

Fig. 3A shows a detail.

Figs. 5 to 7 are parts of longitudinal and cross-sections through a centrifugal air-compressor, in which the meridian-sections through the cooling channels are curved.

Figs. 8 to 11 show parts of centrifugal compressors, in which the cooling channels are formed by tubes.

In the embodiment of the invention shown in Fig. 1 four rotor wheels 2, 3, 4, 5 are fixed to the shaft 1. These wheels deliver the air sucked in through the branch 6 successively into the diffusers 7, 8, 9, 10 respectively. 11 denotes the delivery branch of the compressor. Let it be assumed, for instance, that the air delivered by wheel 2 into diffuser 7 has now to be re-cooled on its way to the next rotor wheel 3. To this end there are arranged, in a special annular space provided outside the diffuser-blades, channels 12, 13, 14, 15 parallel to the axis of shaft 1 and supplied with cooling water. These channels are provided in separately made bodies. Such bodies are shown by way of example in front- and side-view respectively, in Figs. 3 and 4. These bodies may be cast into the casing. The next pressure-stage is provided with channels 16, 17, 18, 19 arranged in a similar manner. Similar channels 20, 21, 22, 23 are also provided behind the rotor wheel 4. Moreover, similar channels 24, 25, 26, 27 are also provided in the suction-chamber and these channels communicate with the annular water-chamber 29. In order to avoid the provision of special water-chambers for the supply and exhaust of the cooling water in connection with each stage and to make all channels accessible from outside and render the cleaning of these channels also possible without disassembling the compressor, even during the running of the compressor, should necessity arise, the channels 24, 12, 16 and 20, as also channels 25, 13, 17 and 21, and so on, are arranged in a coaxial manner. The channels 20, 21, 22, 23 communicate with the water-chamber 30 provided on the right hand side. After the opening of the water-chambers 29 and 30 upon the removal of covers 31 and 32, the channels 24, 12, 16 and 20, the channels 25, 13, 17 and 21, and so
on, forming respectively a continuous or through-going channel, are accessible from outside and may be cleaned mechanically. Fig. 2 shows a part of a cross-section on the lines I to IV of Fig. 1 through the compressor. The channels 16, 17, 18, 19 are provided in a common, separately made body 33. As shown in Fig. 1, this body extends from the plane a—b at right angles to the axis of the shaft 1 to the plane c—d and has the cross-section shown in Fig. 2. Such a body has thus to be considered as a radially arranged cast wall having the thickness e, the height f (Fig. 2) and the length a—c (Fig. 1). It contains, for instance, the four channels 16, 17, 18, 19. In Fig. 2 are shown as further examples cooling bodies 23 and 25 in cross-section, the body 34 containing only two channels 36 and 37, and the body 35 only a flat channel 38. Instead of such an insertion-body extending in the axial direction only over one stage, as shown in Fig. 1, that is from the plane a—b to the plane c—d, it may, of course, also have the length of two or more pressure-stages; thus, for instance, it may extend from a—b to a—y.

The air leaving, for instance, the diffuser 8 (Fig. 1) is guided at first radially outward by the aid of a special annular wall 41, is turned around at \( \varphi \) and is then guided in a substantially radial direction inward toward the shaft, so that it comes within reach of the next rotor wheel 4. Along this path the air is forced to pass twice along the cooling bodies. According to Fig. 2 guide-blades 42—43 are inserted into the diffuser, said blades changing the nearly tangential direction of flow of the air leaving the rotor wheel 3 in a radial one. The cooling bodies 33 and 34 may act as a radial continuation of the diffuser-blades 42 and 43. The cooling action may be increased by inserting, for instance, a further cooling body 39 between the two bodies 33 and 34.

Further, an increased action may also be obtained by giving to the cooling channels a fish-bellied cross-section and by adjusting the outer surface of the bodies to this shape of channel. Fig. 3 shows three such shaped cooling bodies arranged side by side in cross-section. The air is forced to flow in a waving direction between and past these bodies.

In the embodiment of the invention shown in Figs. 5 to 7 the cooling device comprises cooling bodies, which have such a shape, that they effect the greater part of the diffusion and the deflection of the air after its outflow from the rotor wheel in the radial direction. Fig. 5 shows a part of a longitudinal section through a compressor provided with such cooling bodies; Figs. 6 and 7 are cross-sections along the lines V—VI and VII—VIII, respectively, of Fig. 5, while Fig. 5 is on its part a longitudinal section along lines IX—X—XI of Fig. 6. The air flowing out of the rotor wheel 51 passes, as shown in Fig. 6, into a space confined by the stationary blades 53, 54, the cooling bodies 55 and 56 forming the continuation of these blades. Between these two bodies 55 and 56 the cooling body 57 is arranged. With the aid of the radial annular wall 58 (Fig. 5), the air is at first guided outward, then it flows around the edge \( \epsilon \) and is carried toward the inlet of the next rotor wheel 52. Since the cooling bodies 55, 56, 57 have, as shown in Fig. 7, in the outer part of the returning chamber the same curvature as in the diffuser space (Fig. 6), guide-blades 59, 60 are provided in the inner part of the returning chamber and form a continuation of the cooling bodies 55, 56 thus imparting to the air toward the shaft a radial direction of flow.

Figs. 8 and 9 show a partial longitudinal and cross-section, respectively, through a compressor, in which the cooling channels are formed by through-going tubes 61, 62, 63, 64. These tubes are cast into the right 90 front-wall of the centrifugal compressor, that is into the wall 66, and they communicate on this side with an annular water-chamber 67, which is closed by means of a detachable cover 68. In order to facilitate the passing of the tube through the partition wall between two different pressure-stages, holes may be made in this wall, the internal diameter of which is greater than the outer diameter of the tubes. These holes must then be sealed in a special manner for the purpose of making them air-tight. Fig. 8 shows such a construction. The suction space 71 is divided from the first pressure-stage 72 by means of a specially inserted double wall 73 provided with holes for the passage of the tubes 61, 62, 63, 64, the inner diameter \( m \) of said holes being greater than the outer diameter \( n \) of the tubes. After the tubes have been mounted in the proper manner, the hollow space 74 of the inserted double wall 73 is filled out either with an easily fusible metal or cement or cotton or the like. It is evident, that instead of such a double wall a single one with inserted stuffing boxes may be used, as this is usually the case, for instance, in surface condensers.

Instead of using through-going tubes, as shown in Fig. 8, tubes which have only the length of a pressure-stage and which are cast into the side wall of the stages may also be used. Figs. 10 and 11 show a partial longitudinal and cross-section, respectively, of a compressor provided with such tubes.

The ends of the tubes 61, 62 and 63 (Fig. 125) arranged in series are slightly flanged and pointed, in order to facilitate their connection with the walls 66 and 67 forming a pressure-stage in the longitudinal direction upon the casting of said tubes into these
walls. As shown in Fig. 11, which is a cross-section on the line XV—XVI of Fig. 10, the tubes 82, 84 and 85 are staggered and they have an elongated cross-section. The longitudinal axis of this cross-section lies in radial direction.

In a cooling device constructed according to this invention it is possible to provide within a limited space a large and very effective cooling surface, which opposes a relatively small resistance to the air flowing past it. Such a device may be easily manufactured, is reliable in working and can be easily cleaned, even during the running of the compressor, should necessity arise. The possibility of any easy cleaning is of particular importance in those cases where only impure water is available for the cooling, as this is generally the case, for instance, in mines.

What I claim is:

1. In a multistage centrifugal compressor, a cooling device comprising a plurality of cooling channels arranged substantially parallel to the axis of the compressor and forming passages between their walls to direct the air, being compressed, in paths perpendicular to the axis of the compressor.

2. A multistage centrifugal compressor comprising a casing, a plurality of cooling bodies separate therefrom and having cooling channels arranged substantially parallel to the axis of the compressor.

3. A multistage centrifugal compressor comprising a casing, a plurality of cooling bodies separate therefrom and having cooling channels arranged substantially parallel to the axis of the compressor, the bodies of the channels forming radially arranged passages through which the air being compressed is passed.

4. A multistage centrifugal compressor comprising a casing, a plurality of cooling bodies separate from the casing and having cooling channels arranged parallel to the axis of the compressor, the sides of the bodies forming a plurality of radial air passages, and means to direct the air in opposite directions in substantially parallel paths perpendicular to the axis of the compressor.

5. In a multistage centrifugal compressor, a cooling device comprising separately made bodies having cooling channels substantially parallel to the axis of the compressor-shaft and mounted in the lateral partition walls of the pressure-stages, cooling channels of one pressure-stage being arranged coaxially to cooling channels of a neighboring stage, substantially as described.

6. In a multistage centrifugal compressor, a cooling device comprising separately made bodies having cooling channels substantially parallel to the axis of the compressor-shaft and cast into the lateral partition walls of the pressure-stages, cooling channels of one pressure-stage being arranged coaxially to cooling channels of a neighboring stage, substantially as described.

In testimony that I claim the foregoing as my invention, I have signed my name.

BENJAMIN GRAEMIGER.