No. 891,293. PATENTED JUN. 23. 1906.

R. SCHULZ.

COMPOUND STEAM TURBINE.

APPLICATION FILED MAR. 5, 1906.

2 SHEETS—SHEET 1.

Fig. 1.

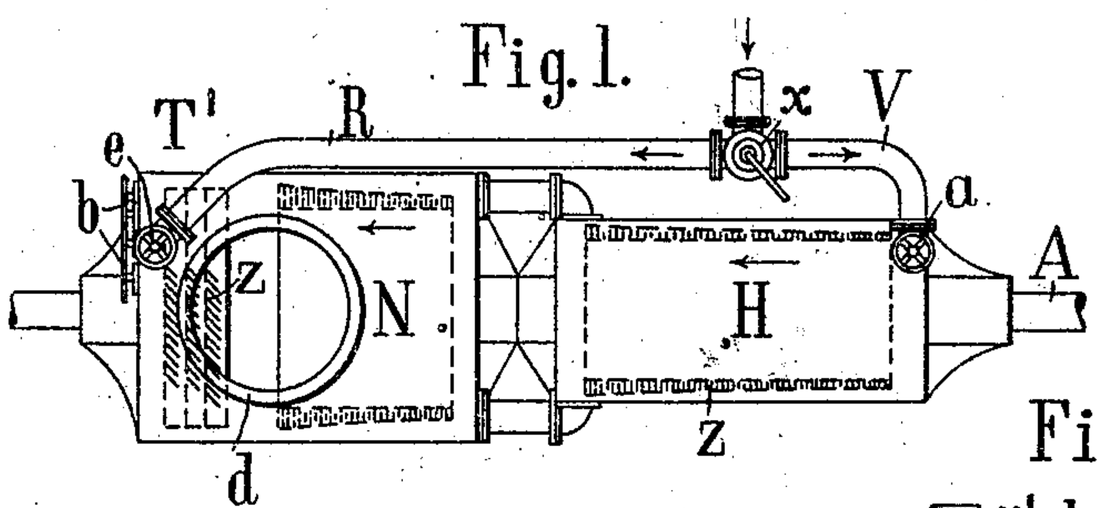


Fig. 2.

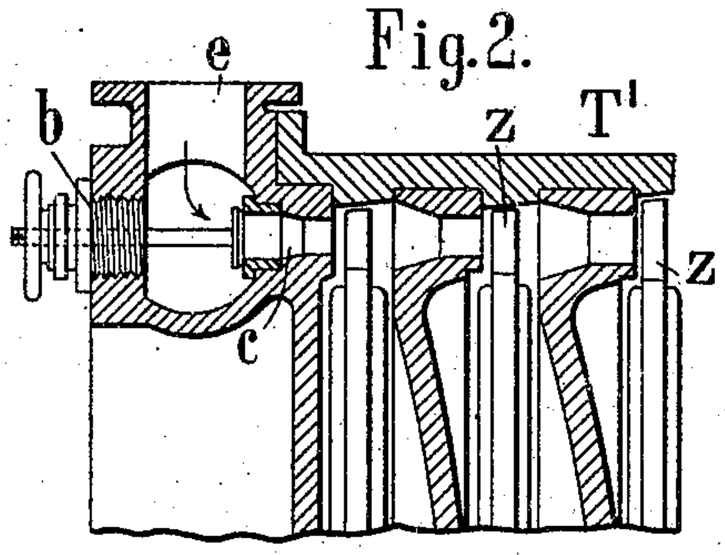


Fig. 3.

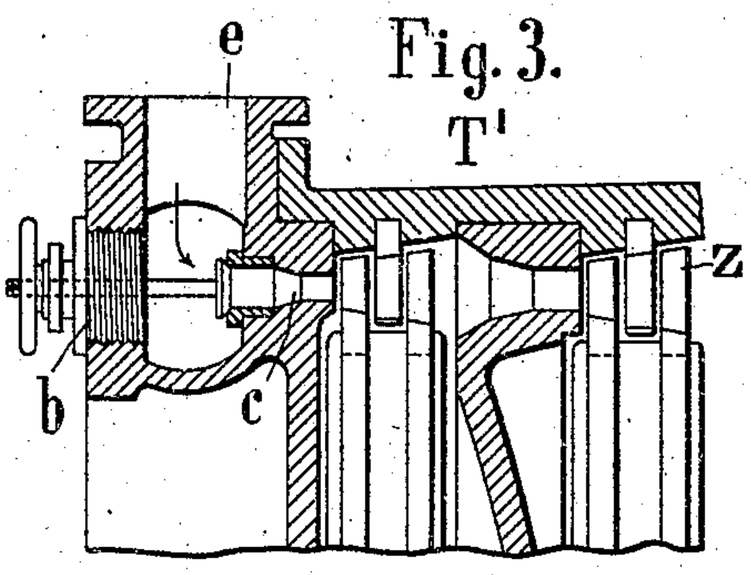


Fig. 4.

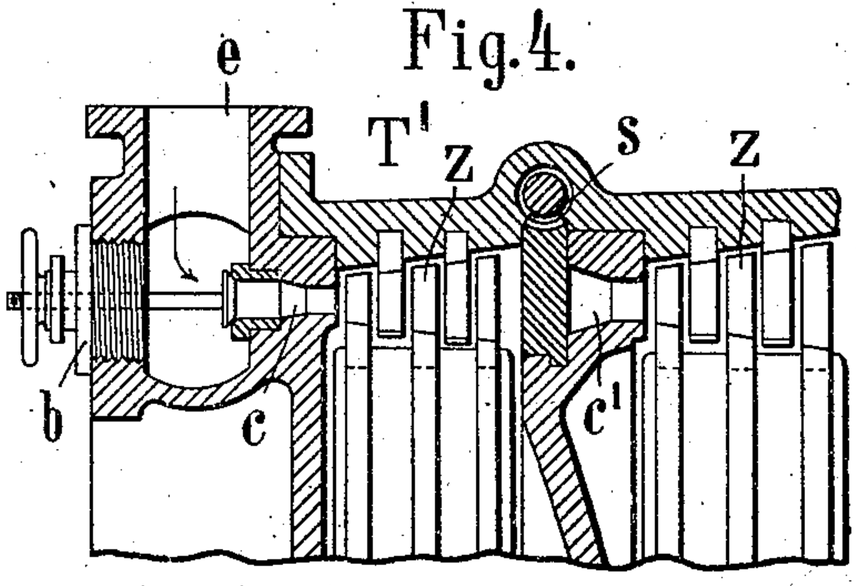


Fig. 9.

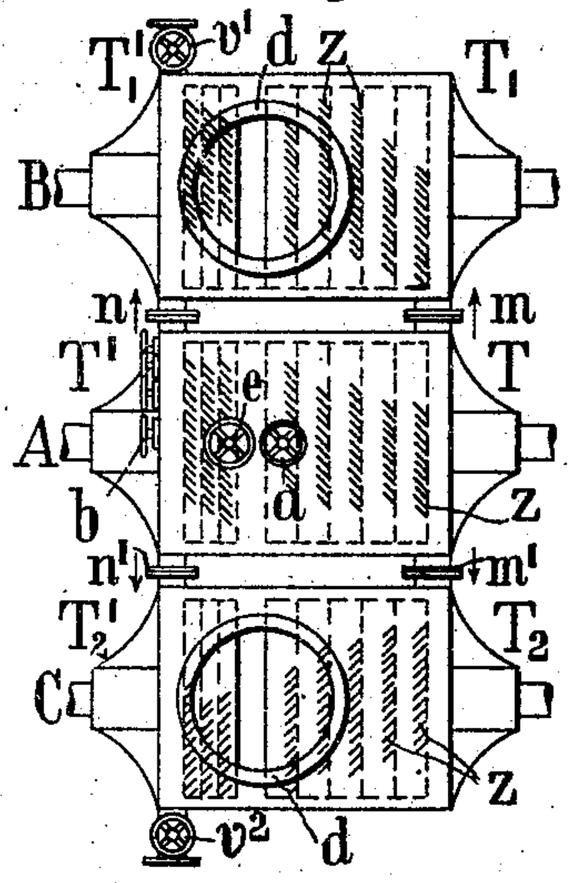
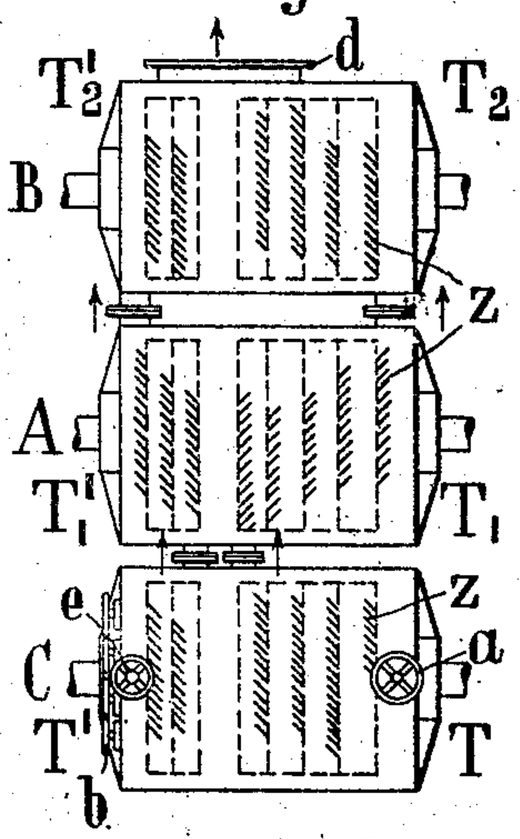


Fig. 10.



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2 SHEETS—SHEET 2.

Fig. 5.

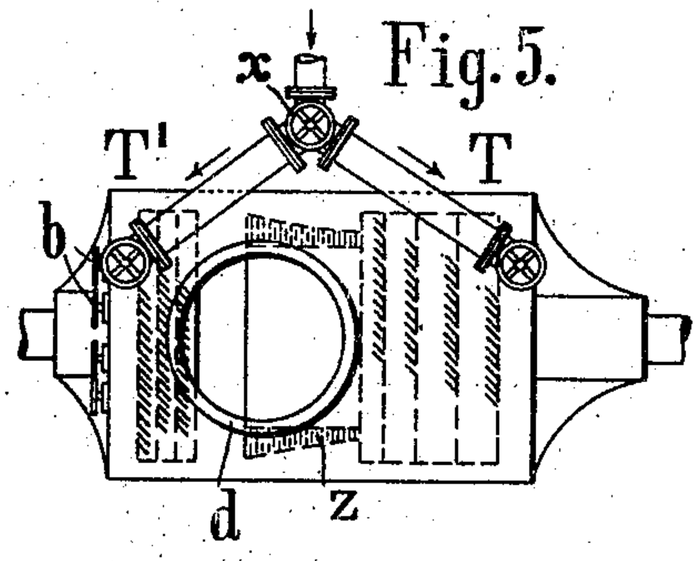


Fig. 6.

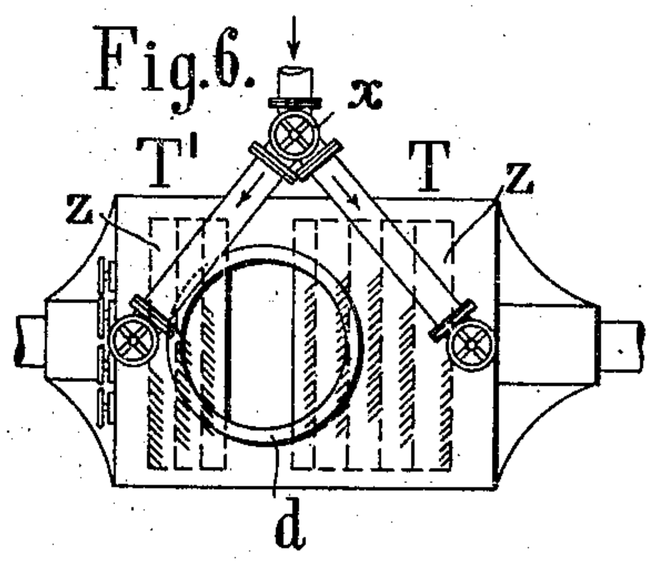


Fig. 7.

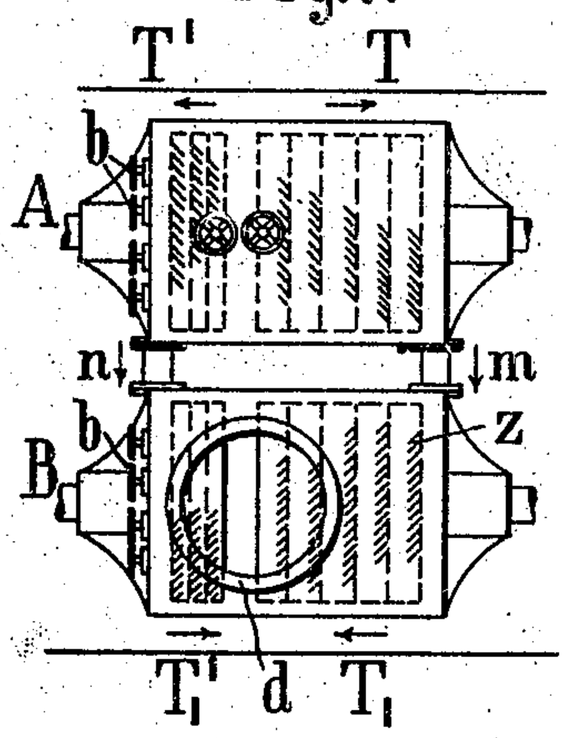


Fig. 8.

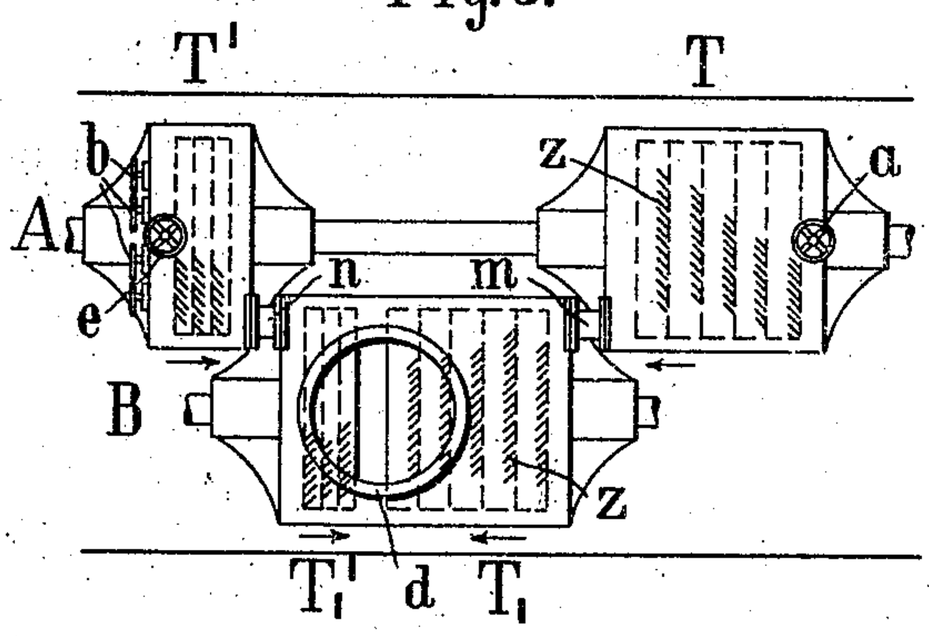
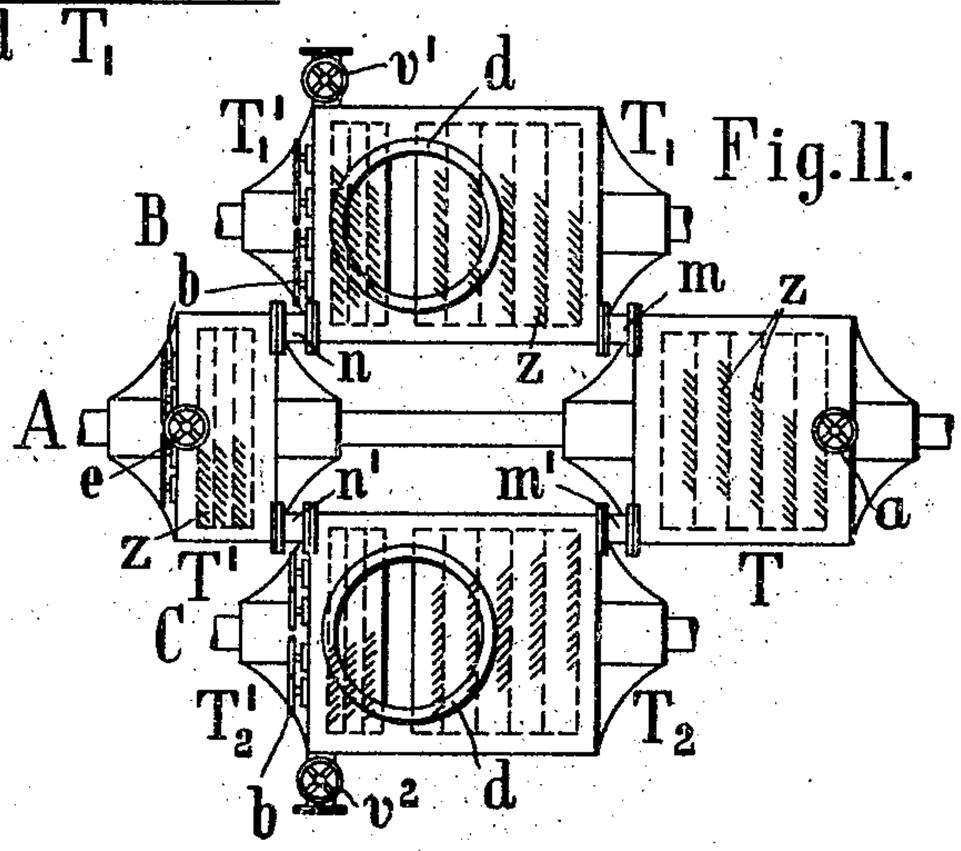


Fig. 11.



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UNITED STATES PATENT OFFICE.

RICHARD SCHULZ, OF BERLIN, GERMANY.

COMPOUND STEAM-TURBINE.

No. 891,293. Specification of Letters Patent. Patented June 23, 1908.

Application filed March 5, 1906. Serial No. 304,252.

To all whom it may concern:

Be it known that I, RICHARD SCHULZ, a subject of the German Emperor, residing in Berlin, Germany, have invented certain new and useful Improvements in Compound Steam-Turbines; 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 appertains 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 steam turbines, and more particularly to compound turbines provided with means to reverse the direction of rotation of the respective turbine shafts comprising impact reversing turbines with means to cut off the steam from any one of the steam supply nozzles in said impact turbines, together with their arrangement with the forward driving turbines, as will hereinafter more fully appear.

Referring to the drawings in which like parts are similarly designated—Figure 1 illustrates in plan an arrangement of turbines on a single shaft and a regulable reversing impact turbine, also on said shaft. Figs. 2, 3 and 4 are partial vertical sections through reversing turbines; Fig. 5 illustrates an arrangement, in plan, of a compound turbine comprising an impact and a reaction turbine with a regulable reversing turbine of the impact type on a single shaft. Fig. 6 is a plan of the direct and reversing turbine on a single shaft, both being impact turbines. Fig. 7 illustrates compound turbines arranged on a pair of shafts, each shaft provided with a regulable reversing turbine of the impact type. Fig. 8 is a view similar to Fig. 7, showing a closer arrangement of shafts but where the reversing turbine on one of the shafts is contained in a separate casing. Figs. 9, 10 and 11 show in plan the distribution of the turbines on three shafts, each shaft being provided with a reversing turbine.

It has been the practice to combine with the compound turbines for direct driving, one or a very few turbine blade crowns of the greatest possible diameter as reversing turbines on the same shaft in order to obtain the largest possible reverse drivage with the least possible steam consumption.

If, as heretofore, the steam be applied all around the reversing turbine wheel to give impact around the full circumference thereof, this steam will expand with great velocity and will pass through the reversing turbine at a great speed by reason of the small resistance offered thereto in consequence of the small number of turbine wheel blade crowns in its path across the wheel, so that steam pressure in the boiler rapidly sinks, on account of the great steam consumption, more steam being consumed than under normal forward driving. This is especially noticeable in slow reverse driving. If it now be desired, as is often the case in vessels, to suddenly change the direction of movement and drive forward again, the necessary boiler pressure will not be present, and it will require a considerable time with strong firing to produce normal conditions for direct driving. From these circumstances it is evident that turbine driven war vessels can be maneuvered with difficulty, in which the conditions are such that in both direct and reverse driving the boiler pressure must be maintained up to requirements.

In order to overcome the difficulties arising from reverse driving, and to satisfy the requirements of steam consumption, the present invention has for its object to construct the reversing turbine of the impact type, such as shown in Figs. 2, 3 and 4, preferably of a diameter as large as possible, and supply steam only to a portion of the circumference, or at symmetrical points around the circumference of the wheel and provide means for controlling the passage of steam to the nozzles, so that the steam consumption for reverse driving will be more nearly equal to that for direct driving, and the steam pressure for maneuvering at different speeds can be maintained the same for both forward and reverse driving, at the same time maintaining a more complete control of the turbines.

In the reversing turbines the steam is preferably expanded in stages, and substages when desired, in such a manner that the extent of circumference of the wheel acted on as well as the passage of the steam through the nozzles can be regulated, so that the steam may be used to the fullest extent in the reversing turbines, and when the reversing turbines are distributed on several shafts they are preferably compounded, as shown.

In the following description it is to be

understood that "impact type" includes such structures in which steam expands as in Figs. 2, 3 and 4, whether it be by stages, or by stages and sub-stages.

In all of the figures the blades of the turbine wheels are indicated by *z*, and it is to be understood that the proper direction and position is given to the blades on the turbine wheel, whether the turbine be for direct or reverse driving, to produce the desired direction of rotation.

In Fig. 1 the turbine for forward driving comprises a high-pressure turbine H and a low pressure turbine N connected in tandem and mounted on a single shaft, A. Steam is admitted by means of the three-way valve *x* through pipe V to the inlet chamber at *a* and expands through the reaction turbines at H and N to the exhaust pipe *d* connected to the condenser for direct or forward driving. Steam can also be admitted through the three-way valve *x* from which it enters at *e* to the inlet chamber of the reversing turbine T′ and exhausts through *d*, communication with pipe V being meanwhile cut off. The reversing turbine in this and the other figures may be of a structure shown in any of the Figs. 2, 3 or 4.

In Fig. 2 the reversing turbine T′ is of the impact type where the steam expands within the nozzles *c*, *c′*, *c²* &c. in stages acting upon a wheel having blades *z* at each stage, but the nozzles do not act on the entire circumference of the wheel, and means, such as valves *b* are provided to entirely cut off any one of the nozzles, so that there will be a lesser area of impact, that is a lesser amount of circumference of the wheel acted upon, at the same time these valves may partially cut off the steam. Any convenient form of valve may be used, and either a sliding or a flap valve be substituted for those shown.

In Fig. 3 the steam is expanded in stages in the nozzles *c* and *c′*, but also expands in sub-stages, there being two sets of blades on the wheel between the nozzles *c* and *c′* where the steam expands and acts partly by reaction while expanding on its way from the nozzle of one stage to that of another, so that in this case the turbine acts partly by impact and partly by reaction, valves *b* being used to close or partly close any of the nozzles *c*.

In Fig. 4 I have shown two sets of nozzles, and between them three sets of blades on the turbine wheel, the steam after leaving nozzle *c* acting as it passes from *c* to *c′* through three sub-stages, on the blades *z*. The nozzles *c* are controlled by independent valves *b* as in Figs. 2 and 3, but the nozzles *c′* are controlled by a ring valve *s*, being moved in front of the nozzles *c′* by means of a worm *s′*.

It will, of course, be understood that the number of stages of pressure as well as the sub-stages may be increased or diminished as the requirements of the particular turbine may demand, it being understood that in the reversing turbine the steam must not be supplied by nozzles around the whole periphery of the wheel, especially in the first stages of pressure, and it is evident that the turbines T and T′ instead of being contained in one common casing may each have its own casing.

In Fig. 5 I have shown the turbine T far direct driving as consisting in the first stages of pressure of an impact turbine 20 and in the last stage of expansion as a reaction turbine 21, and the reversing turbine T′ as an impact turbine, both of the turbines T and T′ having a common exhaust pipe *d* and mounted on a shaft common to both of them.

In Fig. 6, which is similar to Fig. 5, both of the turbines T and T′ mounted on shaft A are of the impact type, as indicated in Figs. 2, 3 and 4.

Figs. 7 and 8 show the turbines distributed upon two shafts. The high-pressure direct driving turbine T is on the shaft A, and the low pressure turbine T_1 on the shaft B, steam being admitted at *a*, passing through turbine T and connection *m* over to the low pressure turbine T_1 and exhausting through *d* to the condenser, not shown. The high pressure reversing turbine T′ on shaft A receives steam through *e* and discharges through *n* into the low pressure reversing turbine T'_1 on shaft B and exhausts through *d*.

Figs. 7 and 8 are similar, the only difference being that in Fig. 8 the direct turbine T and reversing turbine T′ are in separate casings to permit the shafts A and B to be mounted closer together, and in both of the figures both the high and the low pressure reversing turbines have nozzles controlled by the valves *b*. In Fig. 7 the steam passes through the direct driving turbines in opposite directions, while in Fig. 8 it passes through the two direct driving turbines in the same direction.

In the form shown in Fig. 9, where the turbines are arranged upon three shafts, the middle shaft A is driven by the high pressure turbines T and T′ for direct and reverse driving respectively, and on shafts B and C are the low pressure turbines T_1 and T_2 for direct driving and T'_1 and T'_2 for reverse driving. Boiler steam is supplied at *a* to turbine T, from which part of the steam passes through *m* and part through *m′* to turbines T_1 and T_2 exhausting at *d* and *d′*, thereby simultaneously driving all three shafts forward.

For reversing, the direction of rotation of the shafts, steam is admitted at *e*, passes through the turbine T′ and through *n* and *n′* into the reversing turbines T'_1 and T'_2 for shafts B and C respectively, and exhausting at *d* and *d′*. *v′* and *v²* are live steam inlets, whereby steam is admitted to turbines T'_1 and T'_2 to reverse the direction of either of the shafts B or C, while two adjacent shafts

are being driven forward, suitable valves being seated in the connection n, n', m and m' to cause the proper direction of the steam by opening and closing the proper valves. The one side shaft is then driven in a reverse direction independently of the other two, which may be driven forward.

The reversing turbine on the middle shaft A, or in lieu thereof, the two reversing turbines on the side shafts B and C may be omitted if desired, but the construction shown in Fig. 9 is preferable.

In Fig. 10 is shown an arrangement slightly different from that of Fig. 9, the high pressure turbine being on shaft C, steam being admitted at a passes through the three turbines T, T_1, T_2 in succession, and for the reversing turbines the steam is admitted at e and passes through turbines T^1, T^1_1 and T^1_2 in succession, d being the exhaust for all of the turbines.

For economizing space the turbines on the three shafts A, B, C, may be arranged as shown in Fig. 11, the direct and the reversing turbines T and T^1 being contained in separate casings, the operation of which turbines will be obvious from what has been said with respect to Fig. 8.

The arrangements shown in Figs. 6, 7 and 10 are especially advantageous for locomotives.

I claim—

1. The combination with a plurality of driving shafts, a turbine to drive each, one of the turbines exhausting into another; of a reversing turbine on each shaft, said reversing turbines compounded, and means to control the area of the turbine wheel to which steam is supplied.

2. The combination with a plurality of driving shafts, a turbine to drive each shaft, said turbines connected together in compound; of a reversing turbine of the impact type on each shaft, said reversing turbines connected together in compound, and means to control the nozzles supplying steam to the impact turbines, substantially as described.

3. The combination with three driving shafts, a turbine to drive each shaft forward, said turbines connected together in compound; of a reverwing turbine on each shaft of the impact type in which the steam is expanded in stages, and means to control the area of impact at each stage of expansion, substantially as and for the purposes set forth.

4. The combination with a plurality of shafts and turbines thereon to drive the same forward; of a reversing turbine on each shaft, said reversing turbines connected together in compound and having wheels supplied with steam partially around their circumference and the steam expanded in stages that are distributed on the several shafts, nozzles for each stage in which the energy of the steam is partially converted into velocity, and valves to control nozzles of the highest pressure stage of each turbine and valve to control nozzles of the subsequent stages of each turbine.

5. The combination with a plurality of shafts, and turbines thereon to drive the same forward; of a reversing turbine on each shaft, said reversing turbines having steam conduits connecting them together and having wheels supplied with steam partially around their circumference, the steam being expanded in stages that are distributed on the plurality of shafts, nozzles for each turbine in which the energy of the steam is partially converted into velocity, and valves independent of one another to control the nozzles of the highest pressure stage of each of the reversing turbines in any order.

In testimony that I claim the foregoing as my invention, I have signed my name in presence of two subscribing witnesses.

RICHARD SCHULZ.

Witnesses:

JOHANNES HEIN,

WOLDEMAR HAUPT.