

[54] **GAS TURBINE FOR SERIES OR PARALLEL OPERATION, SUBDIVIDED INTO AT LEAST TWO SECTIONS WITH PARALLEL AXES**[75] Inventors: **Werner Bruder, Neckarrems;**
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[52] U.S. Cl..... **60/39.15, 60/39.16, 60/39.17**[51] Int. Cl..... **F02c 1/06, F02c 7/02**[58] Field of Search..... **60/39.15, 39.16, 39.17,**
60/39.51 R, 39.51 H, 39.32; 417/405, 406,
407, 408, 122

[56]

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[57]

ABSTRACT

A gas turbine, particularly for vehicles, with a low-pressure compressor, a high-pressure compressor, a heat-exchanger, a combustion chamber, a compressor turbine, an output turbine with adjoining speed-reduction gear and with a shifting mechanism for series and parallel operation consisting preferably of shifting elements, in which the individual aggregates are subdivided into at least two sections with preferably parallelly disposed axes.

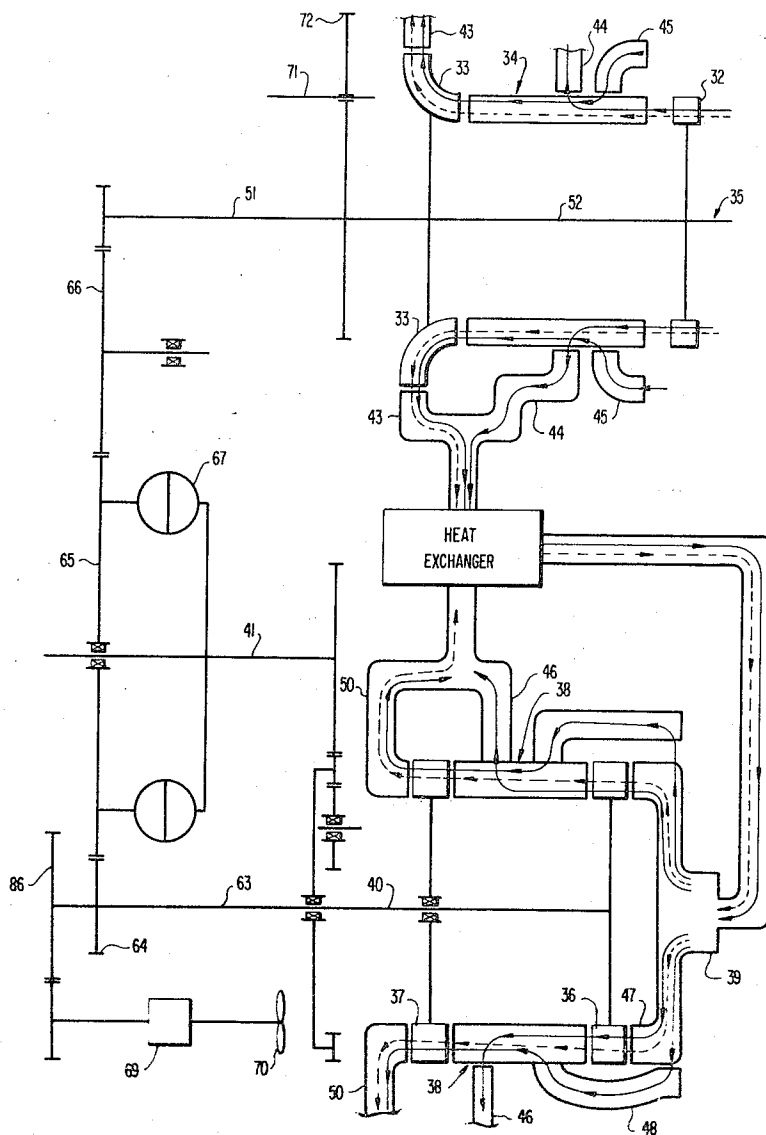
62 Claims, 8 Drawing Figures

FIG 1

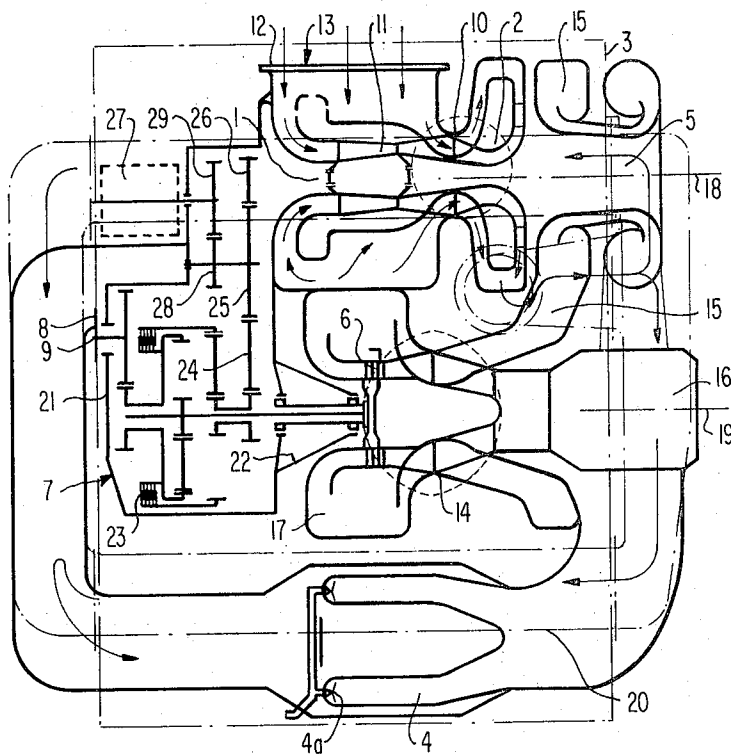
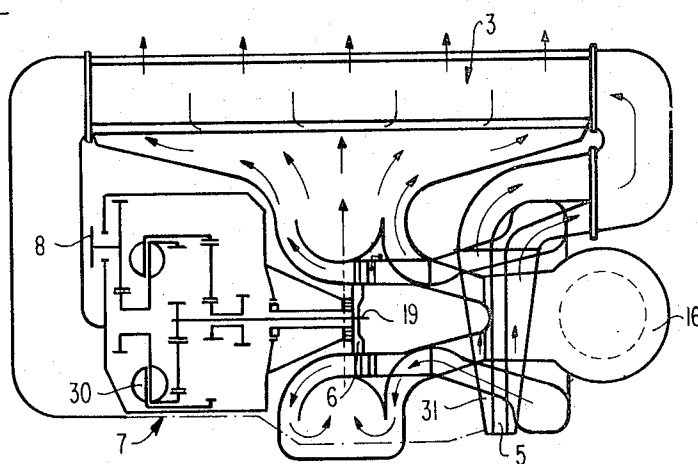


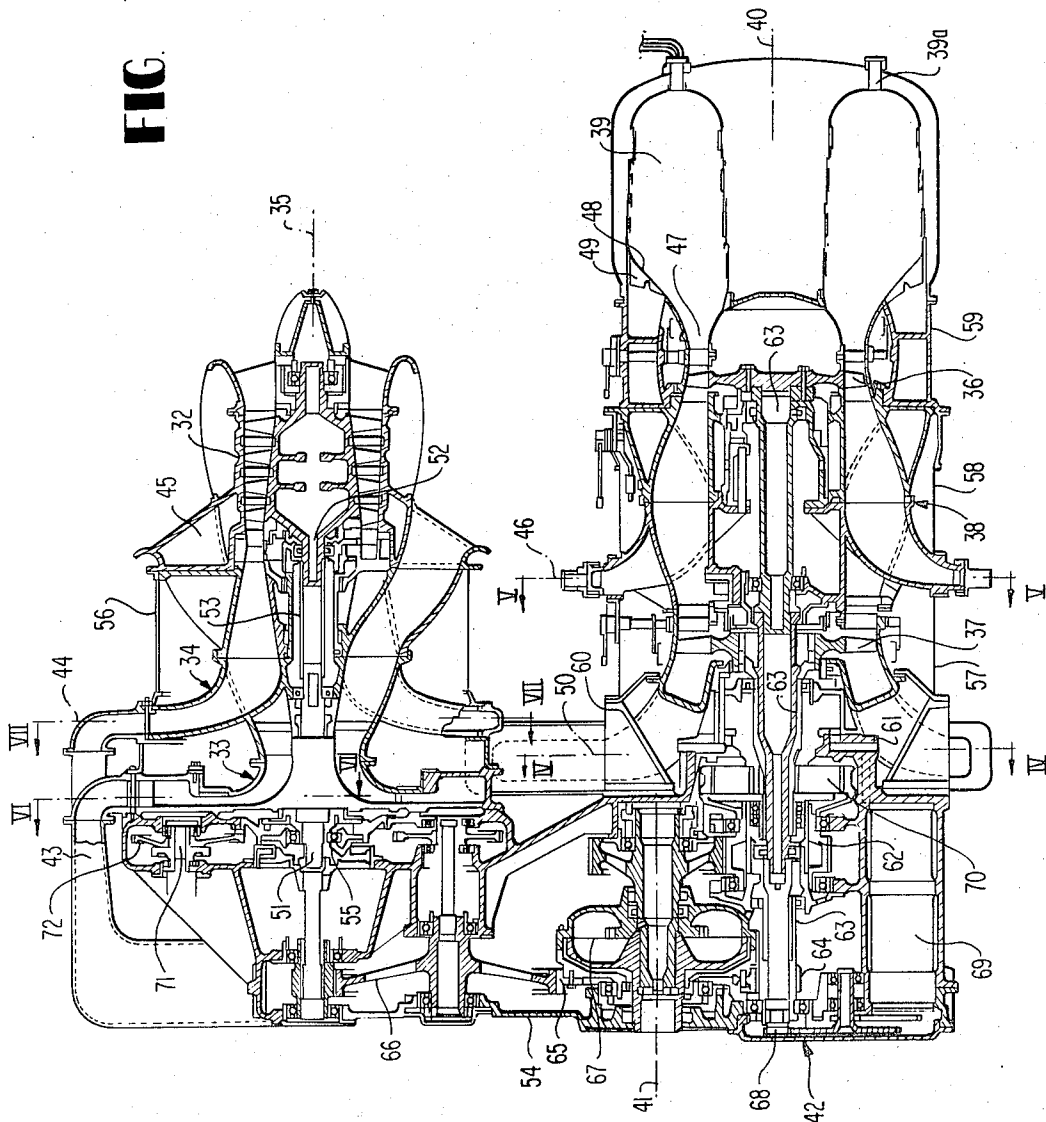
FIG 2



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FIG. 3



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FIG 3A

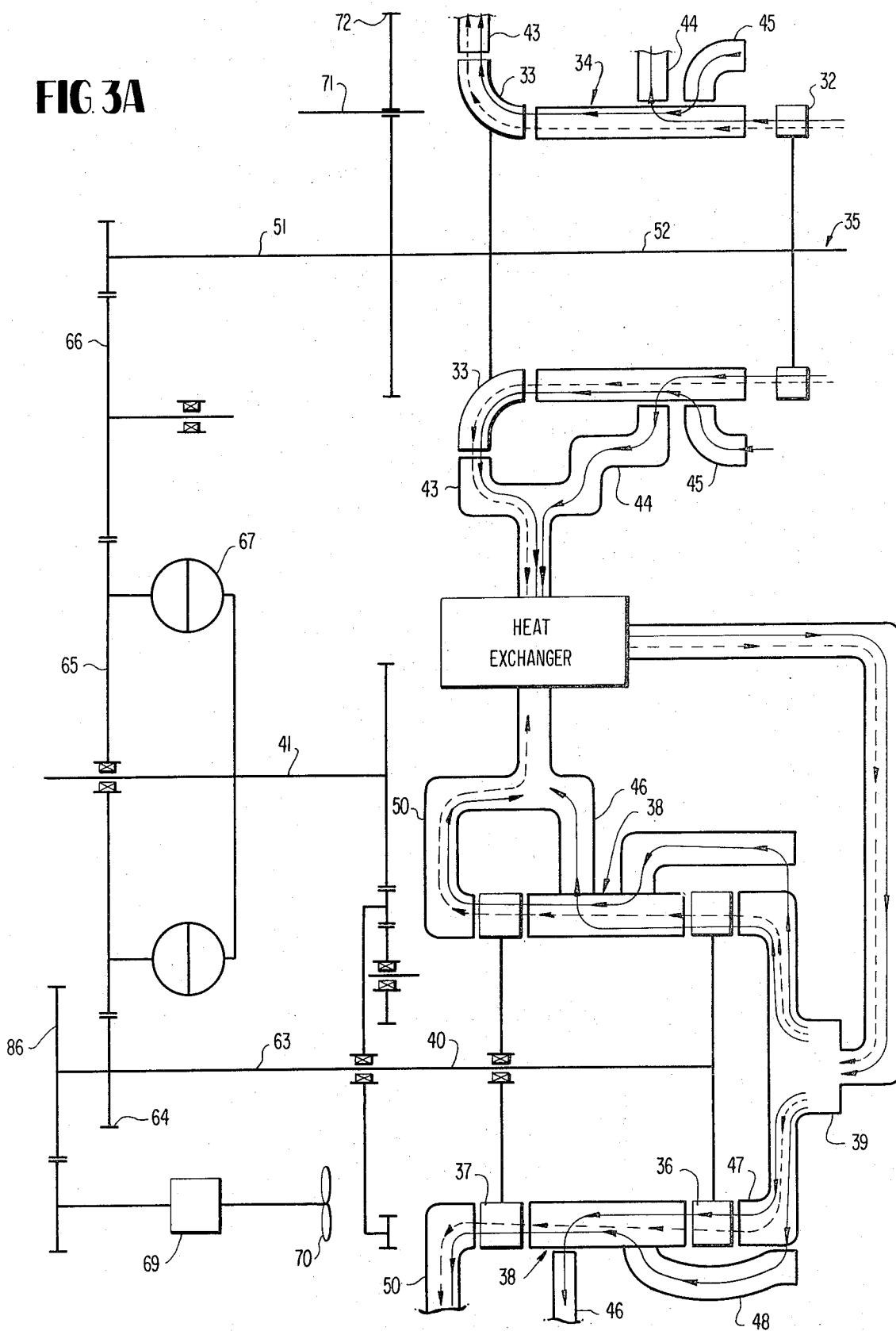


FIG. 7

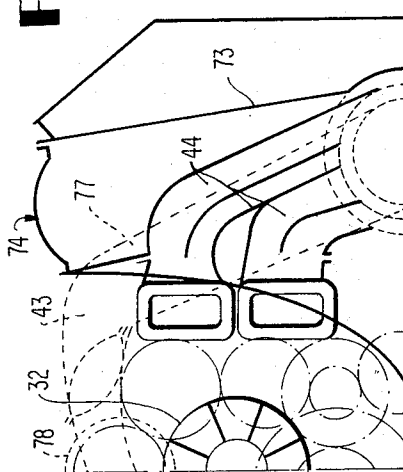


FIG. 6

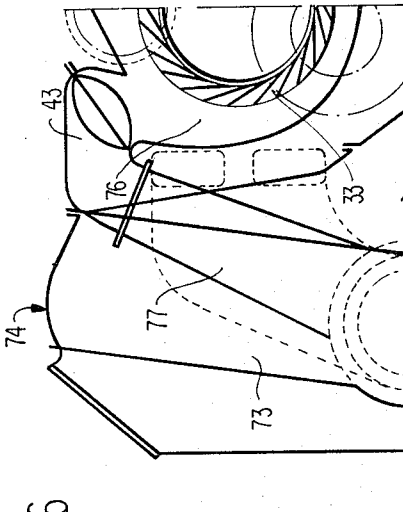


FIG. 5

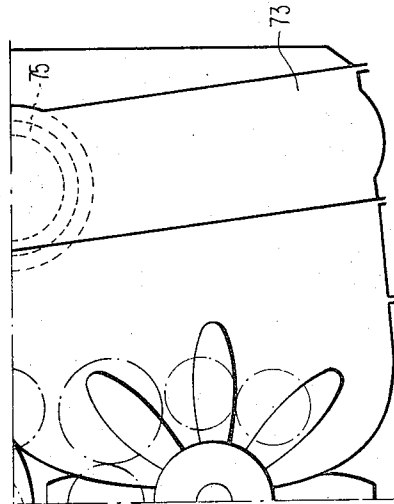
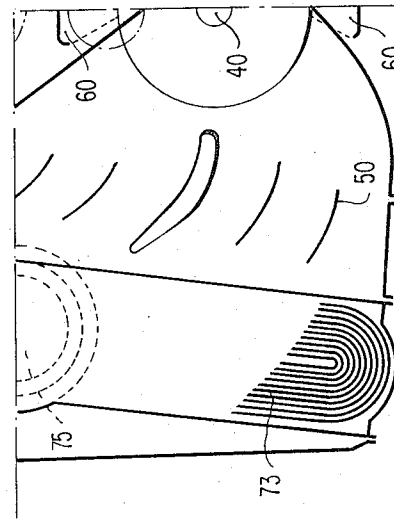


FIG. 4



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GAS TURBINE FOR SERIES OR PARALLEL OPERATION, SUBDIVIDED INTO AT LEAST TWO SECTIONS WITH PARALLEL AXES

The present invention relates to a gas turbine, especially for vehicles, with a low-pressure compressor, a high-pressure compressor, a heat-exchanger, a combustion chamber, a compressor turbine, an output or load turbine with adjoining speed-reduction gear and with a shifting installation for series and parallel operation, preferably consisting of shifting elements.

Gas turbines are known in the prior art whose rotating parts are all disposed on a common axis and which carry on the compressor inlet side, the inlet, the equipment section with starter, controller, fuel pump, oil pump, rotational speed indicator and limiting means, etc. as well as the gears necessary therefor. On the driven side, i.e., the turbine outlet or discharge, is arranged the speed reduction gear which, under certain circumstances, may include a fluid coupling or mechanical clutch in order to be able to utilize the compressor for engine braking of the vehicle. For that purpose, the energy absorbed by the compressor during the braking has to be transmitted through the interior of the output turbine. Additionally, a number of housings and the shifting elements for shifting from series to parallel operation, necessary for vehicle turbines to achieve a favorable fuel consumption in the partial load range, are to be arranged one behind the other in the axial direction of the installation, which, together with the gears and the equipments require a very large structural length of the overall turbine.

Constructive difficulties also result in that connection as regards the alignment of the shafts, the suspension, the arrangement of the channels or ducts, the seals and the bearing supports, etc. It is also costly to ensure the necessary oil supply for the forward and the rearward equipment and transmission parts.

The present invention is concerned with the task to avoid these disadvantages and to provide a gas turbine of the aforementioned type which, in addition to a very compact construction, also exhibits particularly favorable efficiencies in series and parallel operation.

The present invention essentially consists in that the individual aggregates or units are subdivided into at least two sections with axes disposed preferably parallelly adjacent one another. A very compact type of construction is made possible thereby, in which the aggregates and the apparatus can be combined favorably into structural units so that in addition to the favorable space utilization, the support and lubricating problems are considerably reduced. Additionally, favorable possibilities result for the air guidance. Therebeyond, the individual aggregates, for example, the compressor and the compressor turbine are no longer rigidly connected with each other as to the rotational speed thereof so that they can be designed optimally independently from one another. The overall efficiency can be increased thereby.

A favorable embodiment of the present invention is obtained if the gas generator consisting of the low-pressure compressor, the high-pressure compressor, and the compressor turbine inclusive its shifting element, is arranged on one axis and the output turbine with its associated shifting element is disposed on a second axis disposed adjacent thereto, whereas the combustion chamber is arranged on a third axis disposed

parallel and adjacent to the two first-mentioned axes. It is thereby particularly advantageous if a transmission housing for the speed-reduction gear and the drive of the auxiliary equipments is arranged only on one end face, whereby the gas generator and the output working turbine are flangedly connected to the transmission housing. Considerable structural simplification for the drive, the control and the monitoring result therefrom since only one common, overall transmission has to be provided now for all these function, in which the lubricating problems can be solved easily.

The axes may be arranged adjacent one another in a row or may be arranged offset to one another. In order to further enhance the compact construction, the heat-exchanger may be constructed as partially surrounding or enclosing the gas generator and the working turbine. It is possible by the construction according to the present invention of a gas turbine to arrange a second gas generator on a further axis. The output of the gas turbine can be doubled thereby. It is also possible without any difficulty to install into the transmission, an engageable means such as a friction disk clutch or fluid coupling connecting the gas generator with the output turbine, which is adapted to be engaged for engine braking. The advantage is achieved thereby that the energy absorbed during the braking does not have to be transmitted through the inside of the working or output turbine. The kinetic energy produced by the vehicle and to be dissipated, is transmitted to the compressor by way of the output shaft and the clutch or coupling. The supplied air flows through the combustion chamber cold and is conducted by way of adjusting guide blades both to the compressor turbine as also to the output turbine, however, with different angles of flow so that an additional braking effect is also achieved thereat.

In a further embodiment of the present invention in which the air conduction is still more favorable as regards the losses, the high pressure compressor and the compressor turbine may be arranged on one axis and the low-pressure compressor and the output turbine on a second axis. It is thereby appropriate if the associated turbo-elements are connected with each other, i.e., the low-pressure compressor is connected with the high-pressure compressor and the compressor turbine is connected with the output turbine by way of a shifting element each.

It is also appropriate to connect the turbo-elements of the gas generator with each other by way of gear wheels.

A particularly advantageous embodiment of the present invention is realized if the low-pressure compressor and the high-pressure compressor with the shifting element arranged therebetween is provided on one axis and the compressor turbine and the output turbine with the associated shifting element are combined on a second axis and if an overall gear or transmission is provided only on one side. In a particularly advantageous manner, the combustion chamber may thereby adjoin directly the outlet or discharge connection of the heat-exchanger and may be connected either directly or under interposition of a pipe line with the shifting element of the compressor turbine and of the output turbine. In this embodiment, it is particularly appropriate if an axial low pressure compressor and a radial high pressure compressor are provided.

It is also favorable if the combustion chamber includes a central main inlet leading to the compressor turbine and an auxiliary inlet concentrically surrounding the main inlet and leading to the shifting element provided with connecting pipe stubs and is adapted to be closed by the shifting element. The apertured sheet metal element acts as air guide means to the main inlet when the auxiliary inlet is closed by the shifting element.

This type of construction becomes constructively very favorable if the combustion chamber, the shifting element, the outlet channels or ducts of the compressor turbine and of the output turbine are secured at the transmission housing by way of concentric rings by means of preferably four arms. It is thereby appropriate if at least two arms or lugs are constructed for the absorption of lateral forces and torque. The housing of the working or output turbine can thereby laterally adjoin the heat-exchanger in an advantageous manner. It is structurally advantageous also if the output turbine is supported in a bracket of the transmission housing.

With this type of construction of the present invention, it is also appropriate and advantageous if the compressor and the shifting element are supported at and connected with the transmission housing by way of concentric rings.

It is particularly advantageous in connection with this embodiment of the present invention if the axes of the compressor turbine and of the compressor are connected with each other by way of a pair of gears supported on an intermediate shaft and disposed within the transmission. Since in this embodiment the rotational speeds of the compressor may differ from the rotational speeds of the compressor turbine, they can be designed and constructed independently of one another so that an optimum aero-thermodynamic construction and design of both units is possible. It is structurally advantageous if one-half of a fluid coupling arranged on the output shaft serves as a gear of the gear wheel pair, which fluid coupling half is provided with a toothed rim, whereas the other half is connected with the output shaft. On the one hand, a connection between the compressor turbine and the compressors is established thereby whereas, on the other, with a filled fluid coupling, the compressors are connected with the output shaft so that during the engine braking, energy can be absorbed by the compressors. The pairs of gear wheels are thereby so constructed that in the case of braking, i.e., with a filled fluid coupling and with maximum working turbine and compressor rotational speed (rated rotational speed), the coupling wheel or rotor on the compressor side rotates approximately 5-20 percent slower than the coupling wheel or rotor on the output turbine side so that the corresponding brake energy proportion can be transmitted in full to the compressor by the resulting slippage.

It is also structurally advantageous if the bearing support of the output turbine and the main shaft of the planetary gear serving as speed-reduction gear and adjoining the output turbine are constructed hollow, through which is extended the output shaft of the compressor turbine composed of several plug-type shafts.

According to a further feature of the present invention, the output pinion of the compressor turbine and/or the intermediate shafts of the gear wheel pair may carry one or several drive gears for the control apparatus

and/or auxiliary equipments. For example, the intermediate shaft disposed closest to the output shaft may carry a drive gear for a control apparatus, for example, a rotational speed indicator or limiter, necessary on the side of the output turbine. The intermediate shaft of the fluid coupling may carry a pump and valves for the filling and emptying of the fluid coupling. The output pinion of the compressor turbine may also carry a small gear wheel which drives by way of a countershaft, the oil pump and the oil centrifuge. The oil pump and the oil centrifuge are thereby located completely at the bottom in the oil pump sump and therefore operate completely satisfactorily in every inclined position of the vehicle. The intermediate shaft disposed in proximity to the compressor shaft may carry a drive gear for the starter and the control apparatus arranged on the compressor side. The drive of these equipments can take place by way of further intermediate gears.

In order to absorb the axial thrust of the high-pressure compressor, an equalization disk for the axial thrust may be arranged on the shaft of the high-pressure compressor projecting into the transmission. It is also advantageous if the shafts of the low-pressure compressor and of the high-pressure compressor are connected by way of a splined hollow shaft through which extends preferably a tie rod for the axial connection of the two shafts. The hollow shaft thereby connects the shafts in the direction of the torque whereas the tie rod establishes an axial connection so that also the axial thrust of the low-pressure compressor can be absorbed by the equalization disk arranged in the transmission.

Depending on the existing spatial conditions, the gas turbine may be arranged differently. The high pressure compressor may adjoin directly the transmission whereas the inlets for the high-pressure compressor and the low-pressure compressor may be arranged on the side opposite the transmission. However, if the suction intake is to take place at another location, then an intermediate shaft may be arranged between the transmission and the compressors, and the inlets for the compressors may be provided on the side facing the transmission.

Accordingly, it is an object of the present invention to provide a gas turbine, especially for vehicles, which avoids by simple means the aforementioned shortcomings and drawbacks encountered in the prior art.

Another object of the present invention resides in a gas turbine especially for vehicles, which is characterized by an extraordinarily compact construction of relatively short length and small space requirements.

A further object of the present invention resides in a compact gas turbine of the type described above which at least considerably reduces the problems concerning alignment of the shafts, suspension, arrangement of the ducts, seals, and bearing supports.

Still a further object of the present invention resides in a gas turbine for vehicles in which certain units can be combined into structural units in a very favorable manner as regards space utilization and bearing supports.

Still another object of the present invention resides in a gas turbine of the type described above in which individual units are no longer rigidly connected with each other and therefore can be designed for optimum efficiency at rated speeds and outputs.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein:

FIG. 1 is a schematic plan view of a gas turbine according to the present invention;

FIG. 2 is a schematic side elevational view of the gas turbine according to FIG. 1;

FIG. 3 is a schematic longitudinal cross-sectional view through a further embodiment of a gas turbine in accordance with the present invention;

FIG. 3A is a schematic flow diagram of the embodiment of FIG. 3;

FIG. 4 is a partial cross-sectional view, taken along line IV—IV of FIG. 3;

FIG. 5 is a partial cross-sectional view taken along line V—V of FIG. 3;

FIG. 6 is a cross-sectional view, taken along line VI—VI of FIG. 3; and

FIG. 7 is a cross-sectional view, taken along line VII—VII of FIG. 3.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIGS. 1 and 2, the gas turbine according to these figures essentially consists of a low-pressure compressor 1, of a high-pressure compressor 2, of a heat-exchanger 3 indicated in dash and dot lines only as to the contours thereof, of a combustion chamber 4, of a compressor turbine 5, and of an output turbine 6 which is adjoined by a reduction gear generally designated by reference numeral 7 which is constructed as planetary gear of any conventional construction and acts on an output shaft 9 provided with a coupling disk 8.

The gas turbine may be operated for use as a vehicle turbine either in series or in parallel operation. As a result thereof, the fuel consumption can be kept relatively small in the partial load and full load operation. For that purpose, a shifting element 10 is arranged between the low-pressure compressor 1 and the high-pressure compressor 2 which for the series operation assumes a position in which it connects the outlet 11 of the low-pressure compressor 1 with the inlet of the high-pressure compressor 2 so that air is drawn in only by the low-pressure compressor 1 at the inlet 13 provided with an air filter 12, which is then fed from the low-pressure compressor 1 to the high-pressure compressor 2. The compressed air is supplied from the compressors 1 and 2 to the heat-exchanger 3 of any conventional construction and indicated only in its outlines. The air is conducted from the heat-exchanger 3 to the combustion chamber 4 into which fuel is injected by means of the injection nozzles 4a and is combusted thus in the same. The hot gases are now supplied from the combustion chamber 4 to the compressor turbine 5, from which they are then conducted to the output turbine 6 in the series operation. A further shifting element 14 is connected in the input, i.e., up-stream of the output turbine 6, which connects the outlet 15 of the compressor turbine 5 with the inlet of the output turbine 6 for the series operation. The hot gases discharged from the output turbine 6 are conducted to the heat-exchanger 3.

For the parallel operation, the two shifting elements 10 and 14 are shifted. In that case, both compressors

1 and 2, i.e., both the low-pressure compressor 1 as also the high-pressure compressor 2 draw in the air directly from the outside. Both the axial low-pressure compressor 1 as also the radial high-pressure compressor 2 then act as low-pressure compressors. The shifting element 10 makes it possible that the air drawn in by the two compressors 1 and 2 is fed directly in that case by way of corresponding channels or ducts to the heat-exchanger 3, from which it reaches the combustion chamber 4. In the parallel operation, the hot gases are then fed both to the compressor turbine 5 as also to the output turbine 6. For that purpose, a branch line or duct 16 is provided in the line from the combustion chamber 4 to the compressor turbine 5 which is in communication with the shifting element 14 that is connected upstream of the output turbine 6. For the parallel operation, the shifting element 14 connects the branch 16 directly with the inlet of the output turbine 6 and the discharge 15 of the compressor turbine 5 directly with the discharge channel 17 leading to the heat-exchanger 3. Both the compressor turbine 5 as also the output turbine 6 then give off the hot gases flowing therethrough directly to the heat-exchanger 3. They both operate in that case as low-pressure turbines.

See commonly assigned application Ser. No. 149,699, filed June 3, 1971, for further information regarding shifting element structure that could also be utilized in conjunction with the present invention.

From the construction illustrated in FIG. 1 of a gas turbine, in which the gas generator consisting of a low-pressure compressor 1, of a shifting element 10, of a high-pressure compressor 2, and of a compressor turbine 5, is arranged on a first axis 18, the output turbine 6 is arranged on a second axis 19 and the combustion chamber 4 is arranged on the third axis 20, there results an extraordinarily compact construction, in which the bearing problems are far-reachingly avoided. By this subdivision of the gas turbine into different sections with several parallelly disposed axes 18, 19 and 20, in addition to the advantageous air guidance along extraordinarily short paths, the possibility is also created to arrange all drive and control means necessary for the other auxiliary equipments, in a common transmission housing 21 which is provided on one end face of the gas turbine. The transmission housing 21 is additionally provided with a bracket 22 in which the shaft of the output turbine 6 is supported.

In addition to the speed-reduction gear 7 constructed as planetary gear for the output shaft 9, all of the auxiliary drives are accommodated in the common transmission housing 21 arranged on one end face. A lamellae clutch 23 is provided in the planetary gear, by means of which the output shaft 9 is adapted to be connected by way of the planetary gear and gears 24, 25 and 26 arranged on intermediate shafts, with the shaft of the gas generator on the axis 18. This friction disk clutch 23 may be engaged when an engine braking is desired by means of the gas turbine, in which case energy has to be absorbed by the compressors 1 and 2. A starter 27 is illustrated as an example of an auxiliary aggregate, which is operatively connected by way of a pair of gears 28, 29 with the gears 24, 25 and 26 connecting the output turbine 6 and the gas generator.

FIG. 2 illustrates a similar embodiment of the transmission 7 in which, however, in lieu of a friction disk clutch 23, a hydraulic coupling 30 is provided. It can

be seen from the side view of FIG. 2 that the heat-exchanger 3 is arranged above the shafts with axes 18, 19 and 20 of the gas generator, of the work turbine 6 and of the combustion chamber 4 disposed in a common plane. The heat-exchanger 3 through which the air flows in the axial direction of the gas turbine, is traversed by the hot gases in the vertical direction which are supplied thereto either by way of the output turbine 6 or, by shifting the shifting element 14, also simultaneously directly from the compressor turbine 5. As can be seen from FIG. 1, a favorable temperature distribution and temperature equalization results within the area between the combustion chamber 4 and the compressor turbine 5 and/or the output turbine 6 due to the longer gas duct or channel. Additionally, a favorable flow toward and in the combustion chamber is realized. The construction according to the present invention also permits a greater freedom in the design of the turbine diffusor 31 (FIG. 2), especially of the compressor turbine, and therewith the realization of a better turbine efficiency. The exhaust gas shafts may be arranged exiting directly in the upward direction without encumbering the engine space. Since torque-transmitting nested shaft-connections are not required nor provided, also the difficulties as regards sealing, centering, lubrication and bearing support are eliminated. Depending on the installation connections, i.e., whether as ships' propulsion or as vehicle drive or as stationary drive, the axes 18, 19 and 20 of the turbo-units may be installed disposed one above the other or one adjacent the other, either in the vertical or horizontal direction. Additionally, the possibility advantageous in particular for stationary installations is available to connect two drive units of this type in series so that a compact structural unit of high power output results.

A further embodiment of a gas turbine in accordance with the present invention is illustrated in FIG. 3, in which the two compressors, i.e., the low-pressure compressor 32 and the high-pressure compressor generally designated by reference numeral 33, and the associated shifting element generally designated by reference numeral 34 are arranged on a first common axis 35, and the compressor turbine 36 and the output turbine 37 together with their shifting element generally designated by reference numeral 38 and the combustion chamber 39 are arranged on a second axis 40 disposed parallel to the first axis. In the illustrated embodiments, the two axes 35 and 40 are disposed one above the other. Also in this embodiment, a common transmission is provided on only one end face of the gas turbine, and more particularly on the side of the output axis 41, which accommodates both the speed-reduction gear generally designated by reference numeral 42 and constructed as planetary gear as also the drive for the auxiliary equipments.

FIG. 3A is a schematic diagram with reference numerals corresponding to FIG. 3 and showing the respective flow paths for series and parallel operation. The dashed line arrows show series operation flow and the solid line arrows show parallel operation flow.

The rotatable shifting element 34 is arranged between the axial low-pressure compressor 32 and the radial high-pressure compressor 33, which is provided with channels or ducts whereby the two compressors 32 and 33 are adapted to be selectively connected in series or in parallel by the rotation thereof. In the series position, the outlet of the low-pressure compressor 32

is connected by the shifting element 34 with the inlet of the high-pressure compressor 33. The drawn-in air which has been compressed by both compressors 32 and 33 is then supplied by way of a channel or duct 43 to the heat-exchanger (not shown). For the parallel operation, the shifting element 34, after its rotation, closes the inlet of the high-pressure compressor 33 with respect to the outlet out of the low-pressure compressor 32. The air compressed by the low-pressure compressor 32 is then fed by way of a separate line 44 to the heat-exchanger. Simultaneously therewith, the shifting element 34 connects by way of a further channel or duct 45 the inlet of the high-pressure compressor 32 with the atmospheric air so that in this case the high-pressure compressor 33 also operates as low-pressure compressor.

The shifting element generally designated by reference numeral 38 is arranged between the compressor turbine 36 and the output turbine 37, which is constructed in a similar manner. Also this shifting element 38 is rotatably arranged relative to the axis 40 of the compressor turbine 36 and of the output turbine 37 and is equipped with channels or ducts which either connect the outlet of the compressor turbine 36 with the inlet of the output turbine 37, or the outlet of the compressor turbine 36 with a discharge channel or duct 46 leading to the heat-exchanger and the inlet of the output turbine 37 directly with the combustion chamber 39. The combustion chamber 39 provided with injection nozzles 39a is provided for that purpose with a central main inlet 47 leading to the compressor turbine 36 and with an auxiliary inlet 48 arranged concentrically thereto. The auxiliary inlet 48 may consist of an apertured sheet metal plate or of a sheet metal plate provided with connecting stubs 49, which is constructed as guide plate or baffle to the main inlet 47 of the compressor turbine 36 when closed by the shifting element. During series operation, the gases heated by the combustion chamber 39 at first flow through the compressor turbine 36 operating as high-pressure turbine and thereafter through the output turbine 37 operating as low-pressure turbine, from which they are then conducted to the heat-exchanger. In the parallel operation, the heated gases flow from the combustion chamber 39 directly to the compressor turbine 36, from which they are conducted by way of a discharge channel or duct 46 to the heat-exchanger. Additionally, the gases from the combustion chamber 39 flow directly through the output turbine 37, from which they are also conducted to the heat-exchanger by way of a channel or duct 50.

The shafts 51 and 52 of the low-pressure compressor 32 and of the high-pressure compressor 34 are force-lockingly connected in the radial direction by a splined hollow shaft 53. In addition, a tie rod may be arranged within this hollow shaft 53 between the two shafts 51 and 52 which securely connects the two compressors 32 and 34 also in the axial direction. In that case, the equalization disk 55 for the axial thrust arranged outside of the transmission housing 54 on the axis 35 of the high-pressure compressor 33 may also absorb the axial thrust of the low-pressure compressor 32.

The low-pressure compressor 32 is secured at a ring 56 arranged concentrically to its axis, on the inside of which the shifting element 34 is arranged and the air shafts 44 and 45 are secured. This concentric ring 56 is secured at the transmission housing 54. The combus-

tion chamber 39, the compressor turbine 36, the shifting element 38 and the output turbine 37 are arranged and secured in a similar manner on the inside of rings 57, 58 and 59 concentric to the respective axes thereof, which are secured at the transmission housing 54 by way of arms or lugs 60. Preferably four arms 60 are provided, of which at least two are constructed triangularly shaped in order to be able to absorb also radial forces.

The output turbine 37 is supported in a bracket 61 of the transmission housing 54. Both the bearing support of the output turbine 37 as also of the parts 62 of the planetary gear serving as speed-reduction gear 42 adjoining the same are constructed hollow, through which is extended the shaft 63 of the compressor turbine 36 which consists of several shaft sections adapted to be plugged together. The shaft 63 of the compressor turbine 36 includes at its end disposed within the transmission 42 a toothed rim 64, by means of which it is connected under interposition of gear wheel pairs 65, 66 arranged on intermediate shafts with the shafts 51 and 52 of the compressors 33 and 32, respectively, so that it is able to drive the same. A gear 65 of this pair of gears 65, 66 is a component of one-half of a fluid coupling 67 which is arranged on the output shaft 41. For that purpose, a toothed rim 65 is threadably connected at this half of the fluid coupling 67. The fluid coupling, whose other half is securely connected with the output shaft 41 by means of a splined connection, is able, when it is filled, to connect the output shaft 41 with the compressor turbine 36 and the compressors 32 and 33. This possibility is provided for engine braking of the gas turbine, because the energy produced at the output shaft 41 can then be dissipated by the compressors 32 and 33. In order then to assure a sufficient energy transmission, the pair of gears 65, 66 is so dimensioned and designed that for the braking, i.e., with a filled fluid coupling 67 at maximum output turbine and compressor rotational speed (rated rotational speed), the coupling half on the compressor side rotates about 5-20 percent slower than the half on the side of the output turbine so that a sufficiently large slippage results. By the use of a pair of gears 65, 66 mounted on intermediate shafts for the connection of the compressor turbine and of the compressors, the rotational speeds can be chosen independently of one another. They may be identical or they may also be different. As a result thereof, an aero-thermodynamic optimum design of these two units is possible independently of one another.

The planet carrier of the speed-reduction gear is provided with a sleeve-like axial extension which serves as bearing support for a bearing of the output turbine 37 and for the plug-type shaft 63 of the compressor turbine 36.

In this embodiment, the intermediate shaft disposed in the transmission housing 54, the shaft 63 of the compressor turbine 36, the shafts 51 and 52 of the compressors 32 and 33 and further shafts for the drive of the necessary auxiliary equipments may be used. For example, one or several drive gears for the control apparatus such as rotational speed indicator and rotational speed limiter necessary for the output turbine may be arranged on the output shaft. The shaft with the axis 41, on which is mounted the fluid coupling 67, may carry a pump and valves for the filling and emptying of the fluid coupling. The output gear wheel 64 or pinion of

the shaft 63 of the compressor turbine 36 may include a small gear 68 which drives, by way of a counter shaft, an oil pump 69 and an oil centrifuge 70. An intermediate shaft 71 connected as counter shaft in parallel to the compressor shaft axis 35 may be provided with a drive gear 72 for the control apparatus and the starter arranged on the compressor side. The drive of these equipments may also take place by way of further intermediate gears.

Appropriately, the starter (not shown) is arranged above the compressor axis 35 whereby the air guide ducts or channels 43 and 44 from the compressors 32 and 33 to the heat-exchanger laterally surround the transmission 42 and the starter and reach the heat-exchanger pipes on the coupling side of the turbo motor. However, the starter may also be arranged laterally of the compressor axis 35 so that the air guide ducts 43 and 44 from the compressors 32 and 33 to the heat-exchanger may appropriately surround the transmission at the top or in any other suitable manner.

As can be seen from FIG. 3, the air for the compressors 32 and 33 is drawn-in on the side opposite the transmission 42. In case space condition so require, it is also possible, however, to provide the inlets within the area of the inner side of the transmission; however, a sufficiently long intermediate shaft has to be provided which bridges the free space between the compressor and the gear.

In the embodiment according to FIG. 3, the combustion chamber 39 is disposed directly between the heat-exchanger outlet connections (not shown) from which it receives the air and the connection to the compressor turbine 36 and to the shifting element 38 takes place directly. It is also possible to arrange the combustion chamber at a larger distance and to establish the connection to the compressor turbine 36 and to the shifting element 38 by way of a pipe line if this is desired for reasons of streamlining.

The fact that the construction of the gas turbine according to the present invention permits a very favorable, compact construction can be readily seen from FIGS. 4-7 which represent partial cross-sectional views through the gas turbine according to FIG. 3, however, combined into a unitary figure. FIG. 4 illustrates a cross-section through the exhaust gas channel or duct 50 of the output turbine 37, from which the hot gases are conducted to the laterally arranged heat-exchanger matrices 73. The heat exchanger 74 is arranged symmetrically to both sides of the gas turbine unit, whereby the matrices 73 extend vertically, whereas the supply pipes 75 extend horizontally. In FIG. 4, the arms 60 can be seen, by means of which the concentric rings 57, 58 and 59 (FIG. 3) which accommodate the exhaust gas lines 46 and 50, the compressor turbine 36, the shifting element 38 and the combustion chamber 39, are secured at the transmission housing 54.

FIG. 5 illustrates a cross-section through the exhaust gas channel or duct 46 of the compressor turbine 36 which also leads to the heat-exchanger generally designated by reference numeral 74.

FIG. 6 is a cross section through the radial high-pressure compressor 33. The spiral housing 76 of the compressor 33 can be recognized in this cross section, from which the lines 77 lead to the supply pipes 75 of the heat-exchanger 74 arranged on both sides of the gas turbine. Additionally, the starter 78 arranged above the compressor axis 35 is illustrated in dash lines.

FIG. 7 is a similar cross section through the air line leading from the low-pressure compressor 32. It can be seen from this figure that also these lines 44 lead to the supply pipe 75 of the heat-exchanger 74. Additionally, the gear wheels 64, 65, 66, 72, etc., and the gear pairs of the transmission 42 are partially indicated in the overall view represented in FIGS. 4-7 as well as the auxiliary aggregates and auxiliary installations driven thereby.

While we have shown and described several embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art, and we therefore do not wish to be limited to the details shown and described herein, but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

We claim:

1. A compact arrangement of rotatable-engine-units and transmission means for a gas turbine engine of the type having a plurality of operatively interconnected rotatable-engine-units and combustion chamber means operatively interconnected with said rotatable-engine units, said plurality of rotatable-engine-units including: low-pressure compressor means, high-pressure compressor means, compressor turbine means, and output turbine means; each of said rotatable-engine-units having a rotatable-engine-unit axis and means rotatable about said rotatable-engine-unit axis, said engine being divided into at least two sections with at least one of said rotatable-engine-units in each section, each section having a longitudinally extending section axis which coincides with the rotatable-engine-unit axes of the respective rotatable-engine-units in said section, said section axes being spaced from and parallel to one another, wherein transmission means are provided for operatively interconnecting the rotatable-engine-units in each section with the rotatable-engine-units in the other sections and for drivingly connecting said output turbine means to an outside load, wherein shifting means are provided for selectively shifting the gas flow through said rotatable-engine-units between series operation and parallel operation of said engine, wherein said low and high compressor means are interconnected with output flow from said low compressor means being supplied as input flow to said high compressor means during series operation, wherein the input flow to said high compressor means is separate from the output flow from said low compressor means during parallel operation, and wherein said shifting means includes a first shifting unit for controlling flow to said compressor turbine means and a second shifting unit for controlling flow to said output turbine means.

2. An arrangement according to claim 1, characterized in that the high-pressure compressor means directly adjoins the transmission means whereas inlets for the high-pressure compressor means and the low-pressure compressor means are arranged on the sides opposite the transmission means.

3. An arrangement according to claim 1, characterized in that an intermediate shaft is arranged between the transmission means and the compressor means and in that inlets for the compressor means are provided on the side facing the transmission means.

4. An arrangement according to claim 1, wherein said transmission means operatively engages said rotatable-engine-units only at said one transverse end face.

5. An arrangement according to claim 1, wherein gas generator means consisting of the low-pressure compressor means, the high-pressure compressor means, the compressor turbine means, and said first shifting unit are in a first of said sections; wherein the output turbine means together with said second shifting unit are in a second of said sections; and wherein the combustion chamber means is disposed in a third of said sections along the section axis of said third section.

6. An arrangement according to claim 5, wherein said transmission means includes a transmission housing, and wherein said gas generator means and said output turbine means are flangedly connected to said transmission housing.

7. An arrangement according to claim 6, characterized in that the heat-exchanger means partially encloses the gas generator means and the output turbine means.

8. An arrangement according to claim 7, characterized in that a second gas generator means is arranged in a further of said sections on a further axis.

9. An arrangement according to claim 7, characterized in that said transmission means includes an engageable means connecting the gas generator means with the output turbine means by way of a speed-reduction gear means of the means for connecting to an outside load, which engageable means is adapted to be engaged for engine braking.

10. An arrangement according to claim 9, characterized in that said engageable means is a friction clutch.

11. An arrangement according to claim 9, characterized in that said engageable means is a fluid coupling.

12. An arrangement according to claim 1, wherein the high-pressure compressor means and the compressor turbine means are in a first of said sections and wherein the low-pressure compressor means and the output turbine means are in a second of said sections.

13. An arrangement according to claim 12, wherein said transmission means includes gear means drivingly interconnecting said low-pressure compressor means, said high pressure compressor means, and said compressor turbine means to form a gas generator means of the engine.

14. An arrangement according to claim 1, in which the gas turbine engine drives the wheels of a motor vehicle.

15. An arrangement according to claim 4, wherein the high-pressure compressor means and the compressor turbine means are in a first of said sections and wherein the low-pressure compressor means and the output turbine means are in a second of said sections.

16. An arrangement according to claim 1, characterized in that the heat-exchanger means partially encloses a gas generator means formed by the low and high-pressure compressor means and the compressor turbine means, and the output turbine means.

17. An arrangement according to claim 16, characterized in that a second gas generator means is arranged on a further axis.

18. An arrangement according to claim 1, characterized in that said transmission means includes an engageable means connecting a gas generator means, formed by the low and high-pressure compressor means and the compressor turbine means, with the output turbine means by way of a speed-reduction gear means of the means for connecting to an outside load, which engageable means is adapted to be engaged for engine braking.

19. An arrangement according to claim 18, characterized in that said engageable means is a friction clutch.

20. An arrangement according to claim 18, characterized in that said engageable means is a fluid coupling.

21. An arrangement according to claim 1, wherein said transmission means is disposed at only one transverse end face of the sections of said engine, and wherein said transmission means operatively engages said rotatable-engine-units only at said one transverse end face.

22. An arrangement according to claim 1, wherein said low-pressure compressor means and said high-pressure compressor means are disposed in a first of said sections, wherein said output turbine means is disposed in a second of said sections, and wherein said shifting means includes a first movable shifting element surrounding the section axis of said first of said sections and a second movable shifting element surrounding the section axis of said second of said sections.

23. An arrangement according to claim 22, wherein each of said first and second shifting elements include movable fluid conducting portions.

24. An arrangement according to claim 22, wherein at least one of said first and second shifting elements is pivotably movable about the respective section axis surrounded thereby.

25. An arrangement according to claim 22, wherein each of said first and second shifting elements are pivotably movable about the respective section axis surrounded thereby.

26. An arrangement according to claim 1, wherein said low-pressure compressor means, said high pressure compressor means, and said first shifting unit are in a first of said sections; and wherein the compressor turbine means, the output turbine means and said second shifting unit are in a second of said sections.

27. An arrangement according to claim 26, wherein the combustion chamber means adjoins directly an outlet connection of the heat-exchanger means and is operatively connected with the first and second shifting units.

28. An arrangement according to claim 27, characterized in that the combustion chamber means is directly connected with said first and second shifting units.

29. An arrangement according to claim 27, characterized in that the combustion chamber means is connected with said first and second shifting units by pipe line means.

30. An arrangement according to claim 27, wherein said low-pressure compressor means is an axial compressor, and wherein said high-pressure compressor means is a radial compressor.

31. An arrangement according to claim 27, wherein the combustion chamber means is in said second section and includes a central main inlet means to the

compressor turbine means and an auxiliary inlet means surrounding the main inlet means concentrically to the second shifting unit, said auxiliary inlet means consisting of sheet metal plating and being adapted to be closed by said second shifting unit.

32. An arrangement according to claim 31, characterized in that said plating is apertured.

33. An arrangement according to claim 31, characterized in that said plating is provided with connecting stubs.

34. An arrangement according to claim 31, characterized in that the combustion chamber means, the second shifting unit, outlet channel means of the compressor turbine means, and outlet channel means of the output turbine means are secured at a transmission housing of said transmission means by way of concentric ring means.

35. An arrangement according to claim 34, characterized in that the combustion chamber means, the second shifting unit, the outlet channel means of the compressor turbine means, and the output turbine means are secured at the transmission housing by four arms.

36. An arrangement according to claim 34, characterized in that the output turbine means includes a turbine housing laterally adjoining the heat-exchanger means.

37. An arrangement according to claim 36, characterized in that the output turbine means is supported in a bracket means of the transmission housing.

38. An arrangement according to claim 37, characterized in that the high and low compressor means and the first shifting unit are supported in and connected with the transmission housing by way of concentric ring means.

39. An arrangement according to claim 38, characterized in that the compressor turbine means and the high and low compressor means include shafts which are operatively connected with each other by way of portions of said transmission means including a pair of gear means mounted on intermediate shafts and disposed in the speed-reduction gear means of the means for connecting to an outside load.

40. An arrangement according to claim 39, wherein said means for connecting to an outside load includes an output shaft, wherein one-half of a fluid coupling arranged on the output shaft serves as one gear means of the pair of gear means, which one-half is provided with a toothed rim, and wherein the other half of the fluid coupling is operatively connected with the output shaft.

41. An arrangement according to claim 40, further comprising bearing support means of the output turbine means and of a main shaft of the speed-reduction gear means which is constructed as planetary gear adjoining the output turbine means, wherein said bearing support means are constructed hollow for accommodating extension therethrough of a compressor turbine output shaft of the compressor turbine means.

42. An arrangement according to claim 41, characterized in that said compressor turbine output shaft is composed of several shaft sections connected with each other by plug-type connections.

43. An arrangement according to claim 41, characterized in that an output pinion of at least one of the two parts consisting of the compressor turbine means and of the intermediate shafts of the pair of gear means,

carries at least one additional drive gear means for control and auxiliary equipments.

44. An arrangement according to claim 43, characterized in that an equalization disk means for the axial thrust is arranged on a shaft of the high-pressure compressor means which extends into the speed-reduction gear means.

45. An arrangement according to claim 44, characterized in that shafts of the low-pressure compressor means and of the high-pressure compressor means are connected by a splined hollow shaft.

46. An arrangement according to claim 45, characterized by tie rod means extending through said splined hollow shaft for the axial connection of the two compressor shafts.

47. An arrangement according to claim 45, characterized in that the high-pressure compressor means directly adjoins the speed-reduction gear means whereas inlets for the high-pressure compressor means and the low-pressure compressor means are arranged on the sides opposite the speed-reduction gear means.

48. An arrangement according to claim 45, characterized in that an intermediate shaft is arranged between the speed-reduction gear means and the high and low compressor means and in that inlets for the high and low compressor means are provided on the side facing the speed-reduction gear means.

49. An arrangement according to claim 26, wherein the combustion chamber means is in said second section and includes a central main inlet means to the compressor turbine means and an auxiliary inlet means surrounding the main inlet means concentrically to the second shifting unit, said auxiliary inlet means consisting of sheet metal plating and being adapted to be closed by said second shifting unit.

50. An arrangement according to claim 26, characterized in that the combustion chamber means, the second shifting unit, outlet channel means of the compressor turbine means, and outlet channel means of the output turbine means are secured at a transmission housing of said transmission means by way of concentric ring means.

51. An arrangement according to claim 50, characterized in that the output turbine means includes a turbine housing laterally adjoining the heat-exchanger means.

52. An arrangement according to claim 26 characterized in that the output turbine means is supported in a bracket means of a transmission housing of said transmission means.

53. An arrangement according to claim 52, characterized in that the compressor means and the first shifting unit are supported in and connected with the transmission housing by way of concentric ring means.

54. An arrangement according to claim 26, characterized in that the compressor turbine means and the

high and low-compressor means include shafts which are operatively connected with each other by way of a pair of gear means mounted on intermediate shafts and disposed in speed-reduction gear means of the means for connecting to an outside load.

55. An arrangement according to claim 52, wherein said means for connecting to an outside load includes an output shaft, wherein one-half of a fluid coupling arranged on the output shaft serves as one gear means of the pair of gear means, which one-half is provided with a toothed rim, and wherein the other half of the fluid coupling is operatively connected with the output shaft.

56. An arrangement according to claim 26, further comprising bearing support means of the output turbine means and of a main shaft of the speed-reduction gear means which is constructed as planetary gear adjoining the output turbine means, wherein said bearing support means are constructed hollow for accommodating extension therethrough of a compressor turbine output shaft of the compressor turbine means.

57. An arrangement according to claim 56, characterized in that said compressor turbine output shaft is composed of several shaft sections connected with each other by plug-type connections.

58. An arrangement according to claim 56, characterized in that the compressor turbine means and the high and low compressor means include shafts which are operatively connected with each other by way of portions of said transmission means including a pair of gear means mounted on intermediate shafts and disposed in the speed-reduction gear means of the means for connecting to an outside load, and in that an output pinion of at least one of the two parts consisting of the compressor turbine means and of the intermediate shafts of the pair of gear means, carries at least one additional drive gear means for control and auxiliary equipments.

59. An arrangement according to claim 26, characterized in that an equalization disk means for axial thrust is arranged on a shaft of the high-pressure compressor means, which shaft extends into a speed-reduction gear means of said transmission means.

60. An arrangement according to claim 26, characterized in that shafts of the low-pressure compressor means and of the high-pressure compressor means are connected by a splined hollow shaft.

61. An arrangement according to claim 60, characterized by tie rod means extending through said hollow shaft for the axial connection of the two compressor shafts.

62. An arrangement according to claim 1, further comprising heat-exchanger means operatively interconnected with said combustion chamber means and said rotatable-engine-units.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,813,874 Dated June 4, 1974

Inventor(s) Werner Bruder, Hubert Grieb

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page as it reads now:

[73] Assignee: Motoren-Und Turbinen-Union
Munchen GmbH, Munchen,
Germany

[30] Foreign Application Priority Data

June 30, 1973 Germany 2027223

Title page as it should read:

[73] Assignee: Motoren-Und Turbinen-Union
Munchen GmbH, Munchen,
Germany

[30] Foreign Application Priority Data

June 3, 1970 Germany P 20 27 223.5

Signed and sealed this 17th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents