J. F. METTEN.

SYSTEM OF STEAM DRIVING.

APPLICATION FILED AUG. 4, 1911.

1,047,908.

Patented Dec. 17, 1912.

3 SHEETS—SHEET 1.

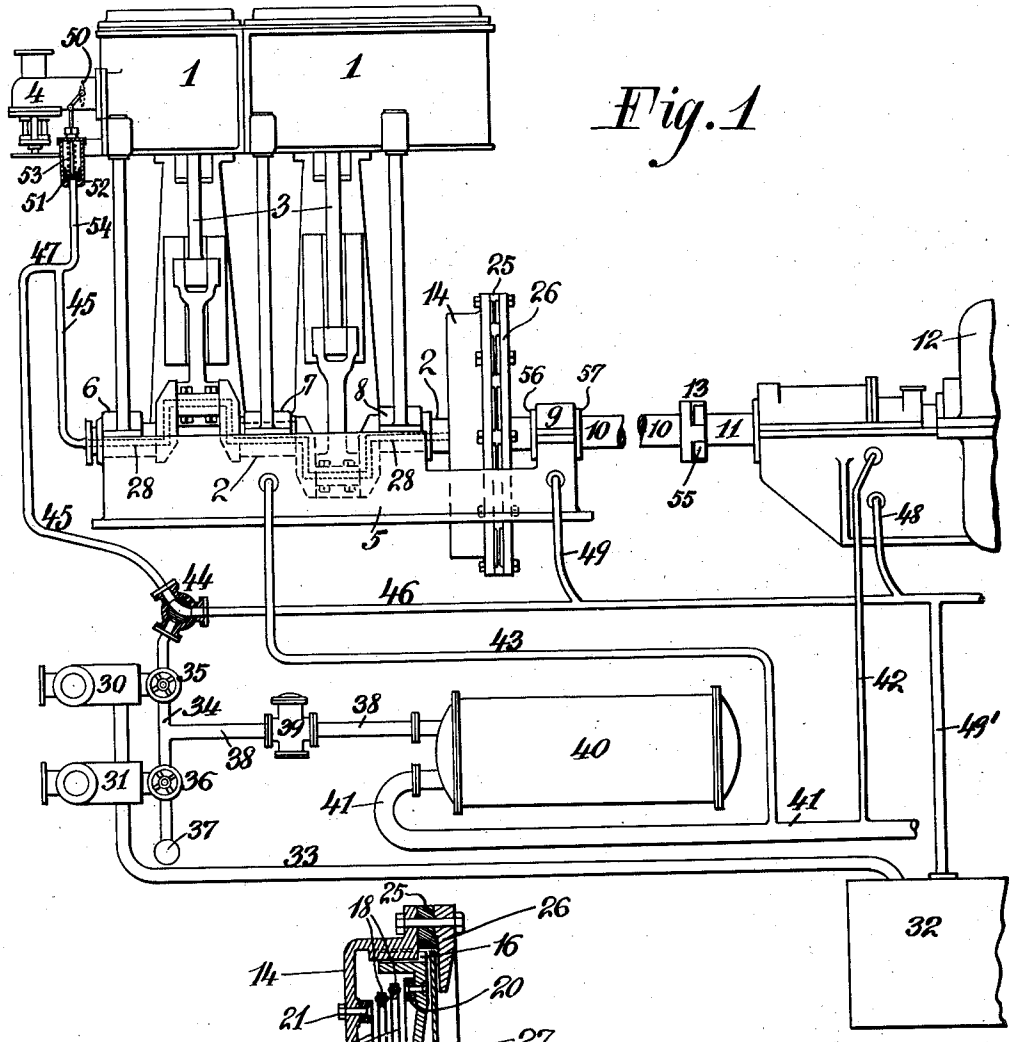

Fig. 1

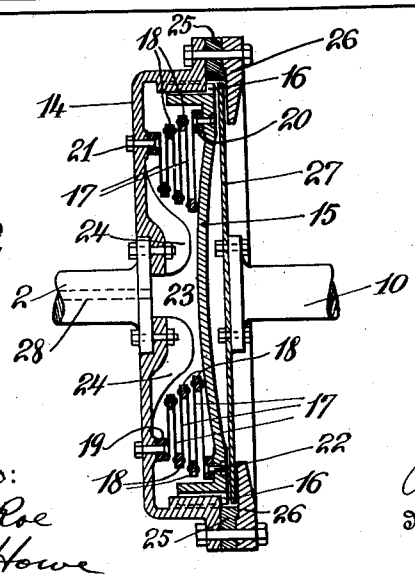

Fig. 2

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3 SHEETS—SHEET 2.

Fig. 3

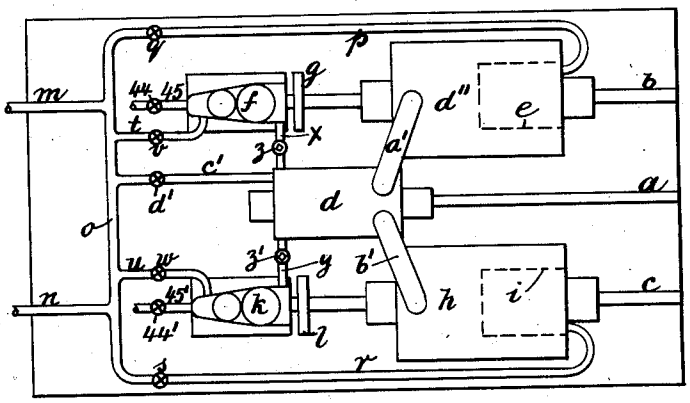


Fig. 4

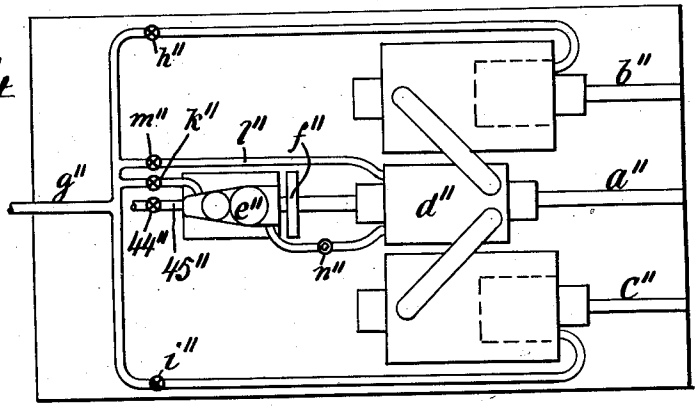
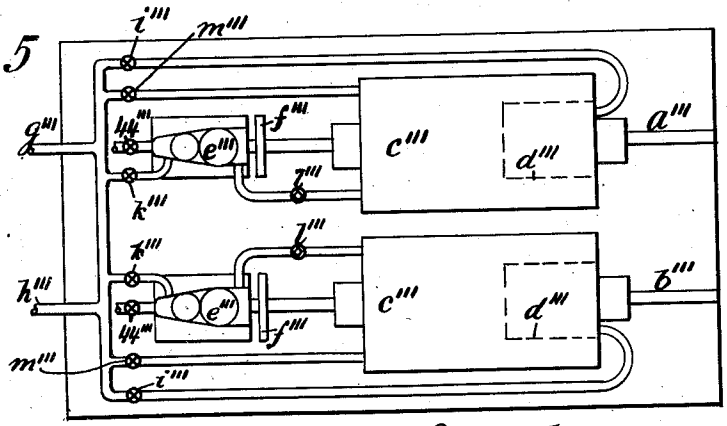


Fig. 5



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3 SHEETS—SHEET 3.

Fig. 9

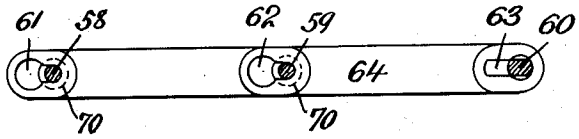
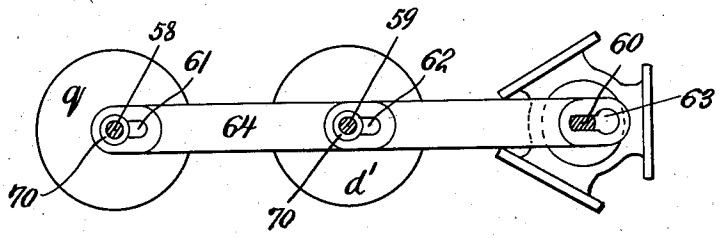


Fig. 7



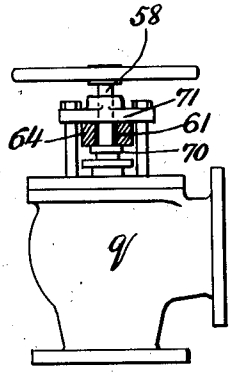


Fig. 8

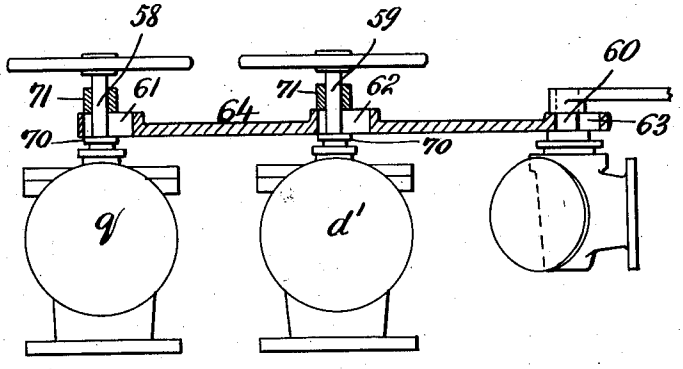


Fig. 6

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UNITED STATES PATENT OFFICE.

JOHN F. METTEN, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE WM. CRAMP & SONS SHIP & ENGINE BUILDING COMPANY, A CORPORATION OF PENNSYLVANIA.

SYSTEM OF STEAM-DRIVING.

1,047,908. Specification of Letters Patent. Patented Dec. 17, 1912.

Application filed August 4, 1911. Serial No. 642,301.

To all whom it may concern:

Be it known that I, JOHN F. METTEN, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Systems of Steam-Driving, of which the following is a full, clear, and exact specification.

This invention relates to the construction and arrangement of apparatus so as to efficiently drive shafts or other apparatus with varying speeds and powers and has special reference to steam driven apparatus. Although well adapted for use in the propulsion of ships, it may have other application.

In the propulsion of ships, steam turbines are well adapted for driving at the higher speeds and powers while reciprocating engines operate well at low speeds. It is therefore desirable in some cases to provide both steam turbines and reciprocating engines and to operate one of them or both together as the conditions of speed and power may require.

It is therefore an object of the invention to provide an improved arrangement and construction of apparatus whereby reciprocating engines and steam turbines may be connected in different relations to each other and to the load.

It is a further object of the invention to provide improved means for connecting and disconnecting power transmitting shafts.

It will be understood that the reciprocating engines and turbines referred to may be of any suitable type or construction. It is immaterial to this invention whether the turbines are of the reaction or impulse type, are single pressure stage or multipressure stage, have diverging or converging nozzles, or whether they are compounded or not, these types and features referred to being based upon the same principles, and the use of one or the other being a mere matter of selection or design according to the circumstances of operation to be met as is well known in the art.

Other and ancillary objects of the invention will appear hereinafter.

In the accompanying drawings which illustrate the invention Figure 1 is a side elevation of sufficient of a reciprocating engine and a steam turbine to illustrate a means for connecting and disconnecting the same, together with such means, the pressure connections for operating the clutch between the reciprocating engine and turbine being shown diagrammatically. Fig. 2 is an axial section through the clutch between the reciprocating engine and the steam turbine in Fig. 1. Fig. 3 is a diagram showing an arrangement of turbines and reciprocating engines especially adapted for driving ship propellers. Fig. 4 is a diagram showing a modified arrangement of turbines and a reciprocating engine adapted for ship propulsion. Fig. 5 is a diagram showing still another modification of the arrangement of turbines and reciprocating engine adapted to drive a ship. Fig. 6 is a side elevation of two steam valves and a cock for controlling the fluid pressure to the clutch provided with an interlocking bar for regulating the relative movements of the valves and cock. Fig. 7 is a top plan view of the apparatus of Fig. 6, the valve stems and cock spindle being shown in the section taken just above the locking bar, and the parts being shown in position to lock the cock spindle, but to leave the valve stem free to be operated. Fig. 8 is an end view of the apparatus shown in Fig. 6, viewed from the left hand end, the locking bar being shown in transverse section taken on a line through the axis of the valve. Fig. 9 is a top plan view of the locking bar, showing sections of the valve stems and cock spindle taken just above the locking bar, and the bar being in such a position with relation to the spindle and stems that the stems are locked against vertical movement while the cock spindle is free to be operated rotatively.

Referring to the drawings, and first to Figs. 1 and 2, a reciprocating engine having cylinders 1, crank shaft 2, and driving rods 3, is supplied with steam through a pipe 4, from a boiler or other suitable source. The engine is mounted upon a bed plate 5, which carries bearings 6, 7 and 8 for the crank shaft. The bed plate also supports a bearing 9, for a shaft-section 10. This shaft section is detachably secured to the engine crank shaft by a clutch at one end and at the other end is coupled with the shaft 11 of a steam turbine 12, by means of an articulated coupling 13.

The clutch for securing the engine crank shaft to the shaft-section comprises a shell or frame 14, which is bolted to a flange on

the end of the crank shaft. Within the frame 14 is fitted a head 15 which can slide axially in the frame but is secured against rotation with relation thereto by means of projections or keys 16, on the head which enter slots or key-ways in the frame. The head 15, is attached to the frame by means of a flexible diaphragm built up of thin annular plates 17, of spring metal spaced apart by rings 18, one being placed between each plate and the one adjacent to it and alternately at the inner and outer edges of the plates. The plates are riveted to each other through the rings so as to form fluid tight joints and the edges of the outside plates of the diaphragm are spaced from the head and frame respectively by rings 19 and 20, and are secured to the head and frame respectively so as to form fluid tight joints, by bolts or rivets 21 and 22, passing through the rings. There is thus formed a fluid tight chamber 23, within the diaphragm and between the frame 14, and the head 15. The diaphragm will permit the head to move axially but will act as a spring tending to move the head into a position where the plates of the diaphragm are parallel to each other. Extending from the frame 14, into the fluid chamber 23, are wings or blades 24, which operate to carry around with the frame, as it is rotated, any fluid which may be within the chamber. Bolted to the frame 14, and spaced therefrom, by a ring 25, is a gib-ring 26. For convenience in assembling, both the gib-ring 26, and the spacing-ring 25, may be made in halves or otherwise sectioned. Within the gib-ring is a disk 27, which is bolted to a flange on the shaft-section 10. If fluid under sufficient pressure fills the chamber 23, the head 15, will be forced against the disk 27 and the latter will be frictionally gripped between the head and the gib-ring and the shafts 2 and 10 will be connected together so that one can drive the other. If now the pressure in the chamber is reduced to a point at which the retractile force of the diaphragm preponderates, the head will be retracted and the disk 27 released. The clutch disk 27 is preferably thin enough so that it will flex into proper engagement with the head and gib-ring and also provided a flexible connection to compensate for any slight inaccuracy in the alinement of bearings.

The fluid for operating the clutch is supplied to the chamber 23 through a hole 28 extending through the crank shaft 2. This fluid may be supplied from any suitable source, but, in order that this source may be reliable the clutch is preferably operated by oil taken from the lubricating system of the apparatus, since this is always in operation. I have therefore shown the clutch as connected with such a source. Oil is supplied under pressure to the system by means of pumps 30 and 31, which, being in duplicate, one may be relied upon in case the other is out of order or both may be operated together. These pumps draw the oil from the tank 32 through the pipe 33 and they may be placed in communication with the pipe 34 or cut off therefrom by means of valves 35 and 36 respectively. Connected with the pipe 34 is an air vessel 37 for equalizing the pressure of the oil delivered from that pipe. From the pipe 34 another pipe 38 leads through a reducing valve 39 to an oil cooler 40. Pressure sufficient to operate the clutch is maintained in the pipe 34 and this being too high for use on the lubricating system, the reducing valve is provided. From the oil cooler a pipe 41 supplies oil to the different bearings to be lubricated by means of branch pipes as, for instance, the pipe 42 running to a turbine bearing and pipe 43 running to the reciprocating engine. From this latter pipe branches may be run to the various bearings of the engine in a well known manner. The pipe 34 connects, through a two-way cock 44, with the pipe 45 leading to the clutch, the pipe 45 being adapted to be connected by said cock either with the pipe 34 or the lubricating drain pipe 46. The pipe 45 is carried to a point 47 at a higher level than the clutch chamber 23 and is connected with the bore in the end of the engine crank shaft by means of a suitable swivel coupling which will permit rotation of the engine crank shaft. The carrying of the pipe 45 to a point higher than the clutch chamber produces the result that the oil will not drain out of the chamber, only such as is forced out by pressure leaving the clutch, and the clutch chamber will always remain full. This causes prompt action of the clutch when the pressure is turned on and also permits of an automatic operation, as will be hereinafter referred to. To the drain pipe 46 are connected branch pipes which extend to those points of the apparatus from which it is desired to drain the lubricant, thus the branch 48 drains the oil from a bearing of the turbine while a pipe 49 drains the oil from a receptacle in the bed plate of a reciprocating engine into which the various bearings of that engine discharge the oil. From the pipe 46 the oil is drained back through a pipe 49′ into the tank 32.

The flow of steam to the reciprocating engine is controlled by a butterfly valve 50, which is connected by a crank arm and piston rod with the piston 51 in the cylinder 52. Above the piston is a spring 53, tending to force the piston downwardly and close the valve 50 so as to shut off the steam. The pipe 54 opens into the cylinder 52 beneath the piston and serves to connect that cylinder with the pipe 45, which supplies

the oil under pressure to the clutch and through which the pressure in the clutch is released when the cock 44 is turned to connect with the drain pipe 46. It will now be apparent that when the pipe 45 is connected with the drain pipe 46 by turning the cock into the position as shown in Fig. 1, the pressure will be released and the piston 51 will move downwardly under the influence of the spring 53 and the valve 50 will close, shutting off the steam. Conversely, when pressure is applied to the clutch by turning the cock 44 so as to disconnect the pipe 45 from the drain pipe and connect it with the pressure pipe 34, pressure will be exerted upon the piston 51 which will move upwardly against the spring 53 and open the valve. It thus appears that steam can only be admitted to the engine when pressure is applied to the clutch to engage it and if the pressure is released or for any reason the pressure upon the clutch fails so that it becomes disengaged, the steam will automatically be cut off from the engine.

The articulated coupling 13 between the shaft section 10 and the shaft of the steam turbine 12 comprises, as shown, a flange upon each of the adjacent shaft ends, one of said flanges having projections 55 which extend into grooves in the other flange. This permits a certain amount of relative longitudinal movement of the shaft and allows for independent expansion of the turbine shaft.

Collars 56 and 57 fixed upon the clutch shaft 10 are one upon each side of the bearing 9 and serve to maintain the correct position of the clutch disk relative to the driving clutch member which is bolted direct to a flange on the end of the engine crank shaft.

With the cock 44 in the position as shown in Fig. 1, steam will be shut off from the reciprocating engine and the clutch parts will be in the positions as shown in Fig. 2. If now it be desired to start up the reciprocating engine and utilize its driving power, the cock 44 will be turned to connect the pressure pipe 34 with the chamber 23 of the clutch through the pipe 45 and the bore in the crank shaft of the engine which opens into the chamber 23. Pressure being thus applied to the head 15, this head will be moved toward the disk 27 and against the tension of the built up diaphragm. The disk 27 will thus be gripped between the head 15 and the gib ring 26. It will be observed by this arrangement that the friction available for driving the disk is double the thrust exerted on the head on account of the two surfaces of the disk being subjected to the load. The key and slot arrangement between the frame 14 and the head 15 serves to transmit the driving force from the frame to the head, thus relieving the diaphragm of any torsional load. It will be seen that under these conditions the engine crank shaft is securely clutched with the shaft section 10 and therethrough to the turbine shaft. If now, it should be desired to release the clutch to disconnect the engine, the cock 44 would be turned into the position as shown in Fig. 1 when the pipe 45 would be connected with the drain pipe 46 and the pressure in the clutch chamber 23 would be released. As the pressure is reduced below the tension exerted upon the head 15 by the built up diaphragm, that tension will draw the head away from the disk 27, thereby releasing it. At the same time the valve 50 closes and shuts off the supply of steam to the engine.

While automatic means connected with the valve 50 is provided for cutting off the steam whenever there is not sufficient pressure on the clutch to throw it into engagement, if it should happen because of derangement of the apparatus or some other reason that steam were applied to the reciprocating engine while it was unclutched, the engine, having no load, might attain a speed far beyond that allowable for it. The clutch acts, however, to automatically operate to clutch and connect the engine to the load (thereby preventing an excessive speed) in the following way: As hereinbefore referred to, the clutch is always maintained full of oil whether it is in engaged or disengaged position. Therefore, at any time when the engine crank shaft (with which revolves the oil chamber 23) exceeds a certain speed, the oil, which is rotated with the chamber by means of the wings 24, moves outwardly under centrifugal force thereby creating a pressure between the head 15 and the frame 14. This causes the head to move toward the gib ring 26 and the disk 27 is gripped, as before described, and the engine shaft is clutched to the load. When the engine is run at normal speed any pressure between the frame 14 and the head 15 due to the centrifugal action of the oil in the clutch is insufficient to overcome the retractile force of the built up diaphragm and the clutch remains disengaged unless it is connected with a source of fluid pressure, as, for instance, the pressure pipe 34.

The apparatus of Fig. 3, as before stated, is adapted for use in propelling ships, when the propellers would be mounted on the center shaft *a* and wing shafts *b* and *c*. Secured to the shaft *a* so as to drive the same, is a high pressure turbine *d*. Similarly secured to the shaft *b* is a forward turbine *d''*, adapted for ahead propulsion, and the astern turbine *e*, adapted for backward propulsion. These forward and astern turbines may be combined to form substantially a single structure as indicated in the drawing or they may be separate structures. A

reciprocating engine *f* of any suitable type or construction is adapted to be clutched to the turbine shaft and therethrough to the propeller shaft by a clutch *g*. This clutch may be of the construction, and the apparatus may be arranged and operated, as described in connection with Figs. 1 and 2. Also the shaft *c* is connected with forward and astern turbines *h* and *i* and a reciprocating engine *k* is provided which may be clutched to the turbine shaft by a clutch *l*, the construction and arrangement of the apparatus for shaft *c* being the same as that for shaft *b*. In both cases the arrangement shows the astern turbines are high pressure and the forward turbines are low pressure. The apparatus may be supplied with steam as follows: Steam is supplied from a boiler or other suitable source through pipes *m* and *n* to the pipe *o*. From pipe *o* a steam pipe *p* controlled by a valve *q* may supply high pressure steam to the astern turbine of wing shaft *b*. Similarly a pipe *r* controlled by a valve *s* may supply steam to the astern turbine of wing shaft *c*. Also steam pipes *t* and *u*, controlled by valves *v* and *w* serve to convey high pressure steam to the reciprocating engines *f* and *k* respectively. The engines *f* and *k* exhaust through the pipes *x* and *y* respectively into the high pressure turbine *d*, there being check valves *z* and *z'* in these pipes to prevent flow of the steam from the turbine into the reciprocating engines, but permitting flow in the reverse direction. The exhaust of the turbine *v* is supplied to the forward turbines on the wing shafts by means of pipes *a'* and *b'*. The fluid pressure for operating the clutches between the reciprocating engine and turbine for each wing shaft is indicated by the pipes 45, 45' controlled by the cocks 44, 44'. The manner of operation of these cocks and the manner of admission and release of pressure from the clutch has been described in connection with Figs. 1 and 2. High pressure steam from the boilers may be supplied to the turbine *d* by means of a pipe *c'* controlled by a valve *d'*. At low power the steam is admitted to the reciprocating engine through the pipes *t* and *u*, the valve *d'* being closed so as to shut off steam from passing therethrough to the turbine *d*. The exhaust steam from the reciprocating engine passes to the turbine *d* whence it is exhausted through the pipes *a'* and *b'* into the forward turbines upon the wing shafts *b* and *c*. During the operation just described the clutches between the turbines and reciprocating engines on the wing shafts are in engagement so that both turbines and reciprocating engines are connected in driving relation to the load. At full power the clutches between the turbines and reciprocating engines are released, thus disconnecting the reciprocating engines from the load. The valves *v* and *w* should be closed to shut off steam from the reciprocating engine, and the valve *d'* is opened to supply boiler steam directly to the turbine *v* whence the steam exhausts into the forward turbines on the wing shafts as before referred to. To move astern only the astern turbines on the wing shaft are employed, these turbines being supplied with boiler pressure steam by opening the valves *q* and *s*, these valves remaining closed during the operation of the apparatus for forward propulsion.

The two-way cock in the case of each wing shaft is interlocked with the valves controlling the admission of steam directly to the turbines either for ahead or astern so that pressure cannot be applied to the clutch so as to connect the reciprocating engines to the turbine shafts unless these valves are closed. An apparatus suitable for so interlocking the valves and cock is illustrated in Figs. 6, 7, 8 and 9. The valves and cock shown in these figures may be assumed to be the valves *q* and *d'* and the cock 44 of Fig. 3. It will be seen that the stems 58 and 59 of the valves and the spindle 60 of the cock pass through holes 61, 62 and 63 in a bar 64. It will be observed that the side of the cock spindle is flattened where it passes through the bar 64, and that each valve stem is provided with a collar 70 so located that the length of stem between the collar 70 and the valve yoke 71 when the valve is closed is slightly in excess of the thickness of bar 64. It will be further observed that each hole in the bar has an enlarged portion, which will permit the necessary partial turning of the cock spindle and also permit the collars on the valve stems to pass through when the valves are opened, also each hole has a narrow portion with parallel sides, within which the flat sides of the cock spindle will be prevented from turning, and in the case of the valves will prevent the collars passing upwardly through and consequently prevent the valves from being opened. If the bar is at the left as shown in Fig. 9 of the drawings the valves *q* and *d'* will be closed and the spindle of the cock can be turned to apply the clutch. When it has been so turned, however, it can not enter the narrow portion of the hole 63 so that the bar cannot be moved to the right and therefore the valves *q* and *d'* are locked closed. When however the cock is turned to release the clutch it may enter the narrow portion of the hole 63. The bar 64 may then be moved to the right when the collars of the valves may enter the enlarged portions of the holes 61 and 62. They may then be turned to open the valves *q* and *d'* and supply pressure to the ahead turbines.

Referring to Fig. 4, of the drawings, a modified arrangement of turbines and reciprocating engines is shown which is also

adapted for the propulsion of ships. In this arrangement low pressure forward turbines and high pressure reverse turbines are connected to the wing shafts b'' and c'' while to the center shaft a'' is secured a high pressure turbine d''. The arrangement thus far is the same as that of Fig. 3, but instead of having a reciprocating engine for each wing shaft there is one reciprocating engine e'' for the center shaft which is adapted to be connected and disconnected to and from the load by the clutch f'' of the same construction and operation as that of Figs. 1 and 2. Steam is brought from the boilers by a pipe g''. The admission of this steam to the astern turbines being controlled by valves h'' and i''. The admission of the steam to the reciprocating engine is controlled by a valve k'' and is adapted to exhaust into the turbine d'' which in turn exhausts into the forward turbines on the wing shafts in the same manner as described in connection with Fig. 3. The pressure pipe 45″ for the clutch is controlled by the cock 44″ as described in connection with Figs. 1 and 2. The high pressure steam from the boiler may be admitted to the turbine d'' through a pipe l'' controlled by a valve m''. The valve m'' may be interlocked with the cock 44″ in a manner similar to that described for interlocking the valves and cock of the apparatus of Fig. 3 so that the pressure cannot be applied to the clutch unless the throttle for the turbine d'' is closed. A check valve n'' permits the flow of the exhaust steam from the reciprocating engine to the turbine d'', but prevents a reverse flow.

To operate at low speed steam is admitted to the reciprocating engine whence it exhausts to the turbine d'' which in turn exhausts into the turbines on the wing shafts. At full speed steam is shut off from the reciprocating engine, and boiler steam is admitted direct to the turbine d'' which continues to exhaust through the turbines on the wing shafts. To drive the vessel astern the clutch remains disengaged and all the valves are closed except the valves h'' and i'' through which boiler steam is admitted to the astern turbines on the wing shafts.

In Fig. 5 is shown a modification in which a twin screw arrangement is employed. Upon each of the propeller shafts a''' and b''' is mounted a forward turbine and an astern turbine. There is also a reciprocating engine for each shaft. Taking the case of the shaft a''' it has a forward turbine c''' and an astern turbine d'''. Also a reciprocating engine e''' is adapted to be connected by a detachable clutch f''' of the construction and operation as shown in Figs. 1 and 2 and described in connection therewith. 44‴ represents the cock controlling this clutch. Steam is supplied from the boilers by pipes g''' and h'''. Steam is admitted to the astern turbine d''' through the valve i'''. Steam is admitted to the reciprocating engine through the valve k''' which exhausts into the forward turbine c''' through a check valve l''' which prevents the reverse flow of steam. The turbine c''' may also be supplied with boiler steam through the valve m'''. The apparatus for the shaft b''' is a duplicate of that just described for the shaft a'''. At low power the reciprocating engines will be clutched to the turbine shafts, the cocks controlling the clutches being in position to admit pressure to the clutches while the valves controlling the admission of steam to the reciprocating engines will be open. All of the other valves will be then closed. To operate at full power the valves controlling the admission of steam to the reciprocating engine will be closed, and the valves admitting boiler steam to the forward turbines will be open, the remaining valves being closed. Also the cocks controlling the clutches will be turned to release the pressure therefrom, thus disconnecting the reciprocating engines from the turbines. The turbines then operate alone under boiler steam to drive the shafts a''' and b''', the reciprocating engines being disconnected therefrom. With this arrangement also, interlocking means may be provided as described in connection with the apparatus for Fig. 3 so that, in the case of the equipment for each propeller shaft, pressure cannot be applied to the clutch except when the valves controlling the admission of steam to the ahead and astern turbines are closed.

While I have illustrated the invention in several of its best applications it will be understood that various changes and modifications may be made in the apparatus shown in the drawings without departing from the spirit of the invention. The invention is not therefore limited to the structures shown in the drawings.

What I claim is:

1. The combination with a reciprocating steam engine, of a steam turbine, and a clutch for connecting the shafts of said engine and turbine, said clutch being adapted to be automatically operated to connect said shafts in driving relation upon the occurrence of predetermined operating conditions.

2. The combination with a reciprocating steam engine of a steam turbine and a clutch for connecting the shafts of said engine and turbine, said clutch being adapted to be automatically operated to connect said shafts in driving relation upon the occurrence of predetermined operating conditions, and means for operating said clutch at will.

3. The combination with an elastic fluid turbine of an elastic fluid reciprocating engine, driving means for detachably connecting the shafts of said turbine and engine, and means interposed between said turbine

and engine for providing clearance for the expansion of the connected shafts.

4. The combination with an elastic fluid turbine, of an elastic fluid reciprocating engine, driving means for detachably connecting the shafts of said turbine and engine, and means interposed between the aforesaid means and said turbine for providing clearance for expansion of the turbine shaft.

5. The combination with an elastic fluid turbine of an elastic fluid reciprocating engine, a clutch having one member secured to the shaft of said engine, a shaft section to which the other member of said clutch is secured, and a coupling connecting said shaft section with the shaft of said turbine.

6. The combination with an elastic fluid turbine of an elastic fluid reciprocating engine, a clutch having one member secured to the shaft of said engine, a shaft section to which the other member of said clutch is secured, a coupling connecting said shaft section with the shaft of said turbine and means for arresting axial movement of said shaft section.

7. The combination with an elastic fluid turbine of an elastic fluid reciprocating engine, a clutch having one member secured to the shaft of said engine, a shaft section to which the other member of said clutch is secured, a coupling connecting said shaft section with the shaft of said turbine and a journal bearing in which said shaft section rotates.

8. The combination with an elastic fluid turbine adapted to drive a load, of an elastic fluid reciprocating engine, a lubricating oil system, a clutch adapted to connect said engine with said load, and means for operating said clutch with oil from said system.

9. The combination with an elastic fluid reciprocating engine, of an elastic fluid turbine adapted to drive a load, a fluid operated clutch adapted to connect said engine with said load and means for preventing the drainage of the fluid from said clutch when the clutch is in released position.

10. The combination with an elastic fluid turbine adapted to drive a load, of an elastic fluid reciprocating engine and a clutch adapted to be automatically operated to connect said engine with said load when the speed of said engine exceeds a predetermined limit.

11. The combination with an elastic fluid turbine adapted to drive a load, of an elastic fluid reciprocating engine, a fluid operated clutch adapted to connect said engine with said load, the centrifugal action of the fluid of said clutch operating to close said clutch to connect said engine to said load when the speed of said engine exceeds a predetermined limit.

12. The combination with an elastic fluid turbine adapted to drive a load, of an elastic fluid reciprocating engine, and a fluid operated clutch for connecting said engine with said load, the shaft of said reciprocating engine having an axially extending hole through which fluid is supplied to said clutch.

13. In a steam driving system, the combination with a steam turbine connected to drive a load, of a reciprocating steam engine, a clutch for detachably connecting said engine in driving relation to said load, and means operating automatically in accordance with the condition of said clutch to control the supply of steam to said engine.

14. In a steam driving system, the combination with a steam turbine connected to drive a load, of a reciprocating steam engine adapted to be connected to and disconnected from said load and means for automatically preventing the disconnection of said engine from resulting in a speed exceeding a certain limit.

15. In a steam driving system for ships, the combination with an "ahead" steam turbine, of a "reverse" steam turbine, each adapted to drive a load, a reciprocating steam engine adapted to drive ahead, means for detachably connecting said reciprocating engine with the load, valves for controlling the admission of high pressure steam to said turbines, means for controlling the operation of said connecting means and interlocking means preventing the admission of high pressure steam to said turbines when said connecting means is in connecting condition.

16. In a steam driving system, the combination with a steam turbine adapted to drive a load, of a reciprocating steam engine, means for detachably connecting said engine with said load, means for admitting high pressure steam to said engine, means for admitting high pressure steam to said turbine, and interlocking means for preventing the admission of high pressure steam to said turbine when said connecting means is in connecting condition.

17. In a steam driving system for ships, the combination with a "reverse" steam turbine of an "ahead" reciprocating engine, means for detachably connecting said engine with the load, means for controlling the admission of high pressure steam to said turbine and interlocking means for preventing the admission of high pressure steam to said turbine unless said detachable connecting means is in disconnected condition.

18. In a steam driving system for ships, the combination with a "reverse" steam turbine of an "ahead" reciprocating engine, means for detachably connecting said engine with the load, means for controlling the admission of steam to said turbine and interlocking means for preventing the admission of steam to said turbine unless said

detachable connecting means is in disconnected condition.

19. In a steam ship, the combination with propelling means, of a shaft therefor, an ahead steam turbine connected to said shaft, an astern steam turbine connected to said shaft, an ahead reciprocating steam engine, a detachable clutch for connecting said engine with said shaft, said clutch having its members held in driving relation by frictional engagement, fluid operating means for said clutch, means for supplying steam to said engine, means for exhausting the steam from said engine directly into the ahead turbine, said engine and turbine utilizing the entire expansion of the steam, means for supplying steam to the astern turbine and means for exhausting the steam from the astern turbine.

20. In a steam driving system, the combination with a steam turbine connected to drive a load, of a reciprocating steam engine, a fluid operated clutch for detachably connecting said engine in driving relation to said load, and means for automatically shutting off the supply of steam from said engine when the clutch operating fluid falls below a predetermined pressure.

In testimony whereof, I affix my signature, in presence of two witnesses.

JOHN F. METTEN.

Witnesses:
ISAAC ARROTT,
ROLAND L. HOWE.