H. A. CHUSE.

STEAM ENGINE.

APPLICATION FILED AUG. 14, 1916.

1,293,713.

Patented Feb. 11, 1919.

3 SHEETS—SHEET 1.

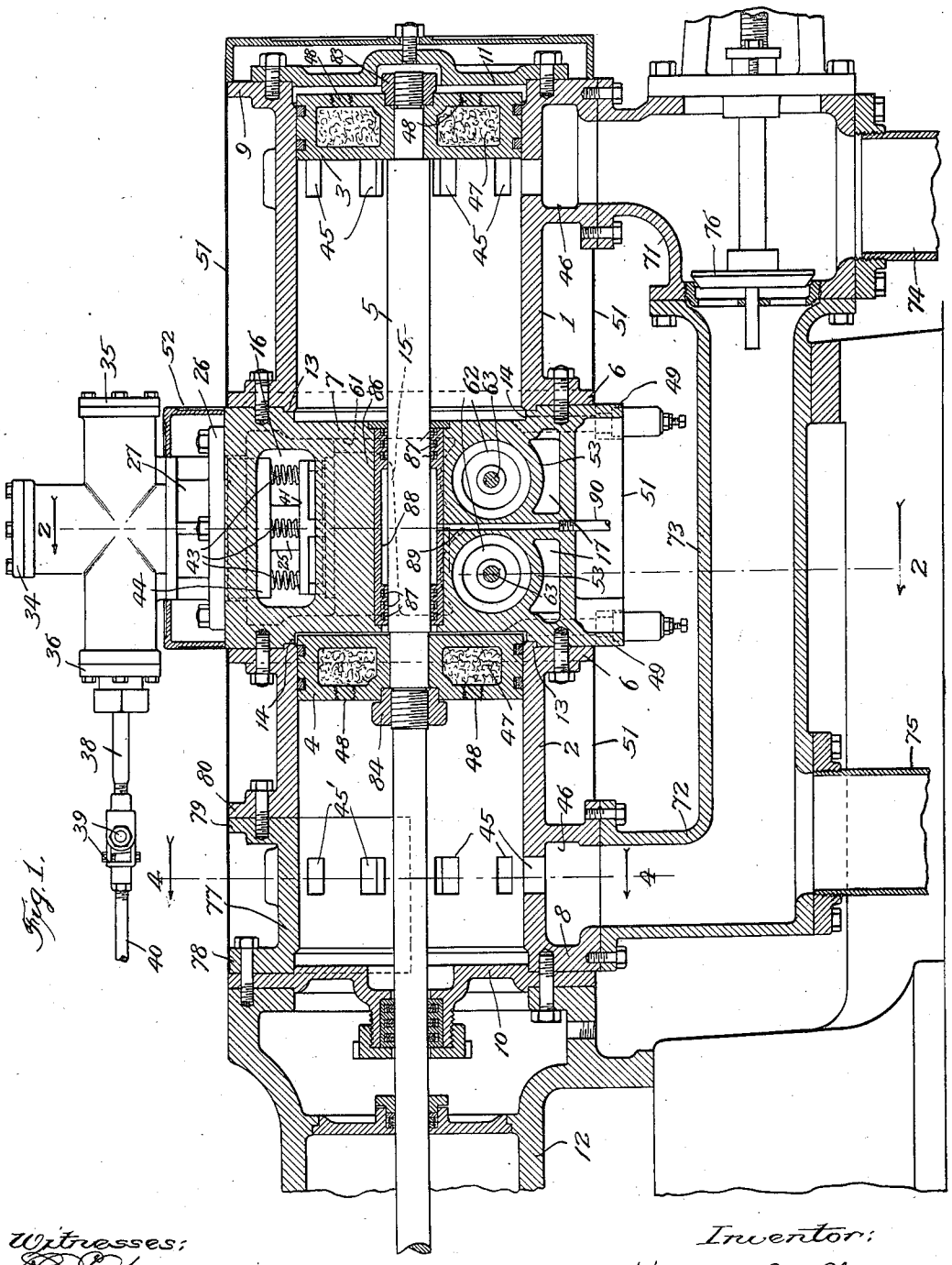


Fig. 1.

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3 SHEETS—SHEET 2.

Fig. 5.

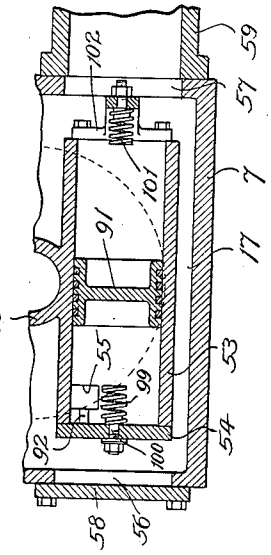


Fig. 6.

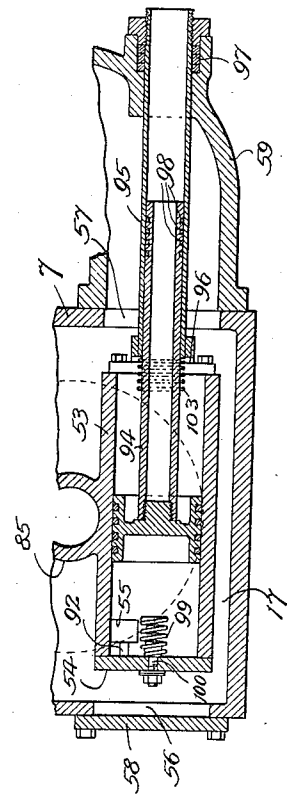
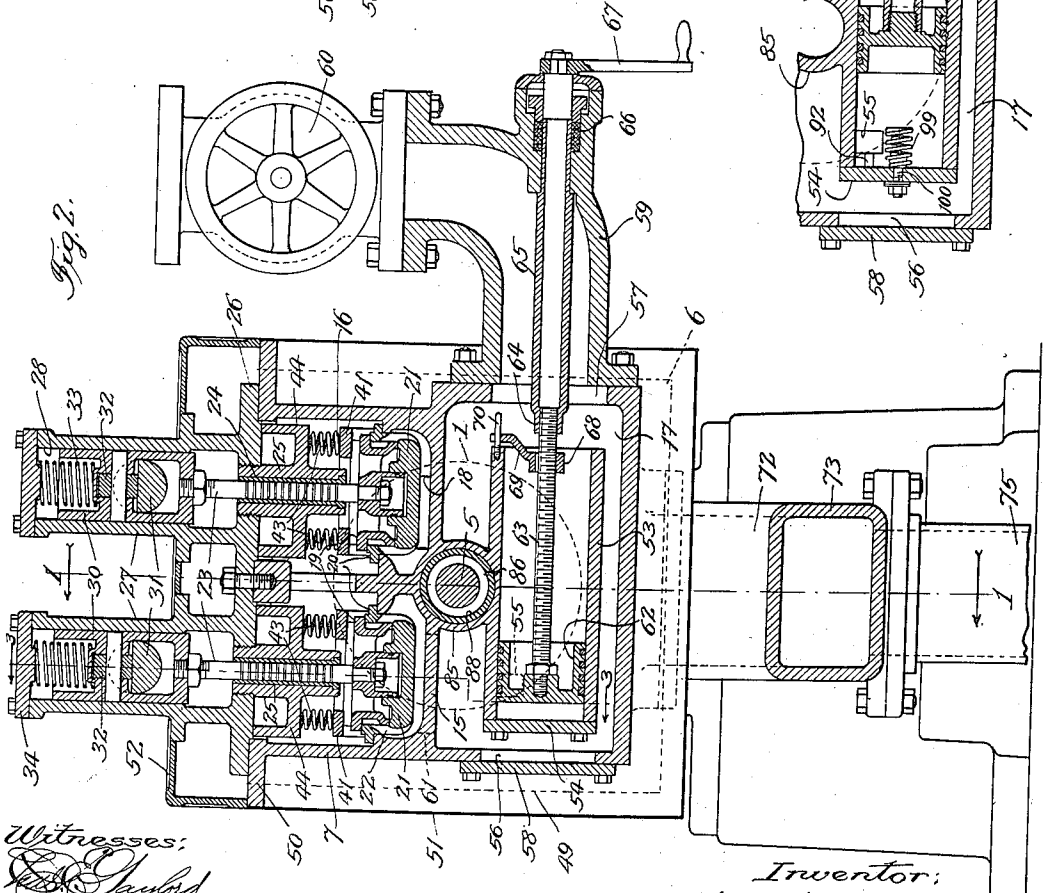


Fig. 2.



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3 SHEETS—SHEET 3.

Fig. 4.

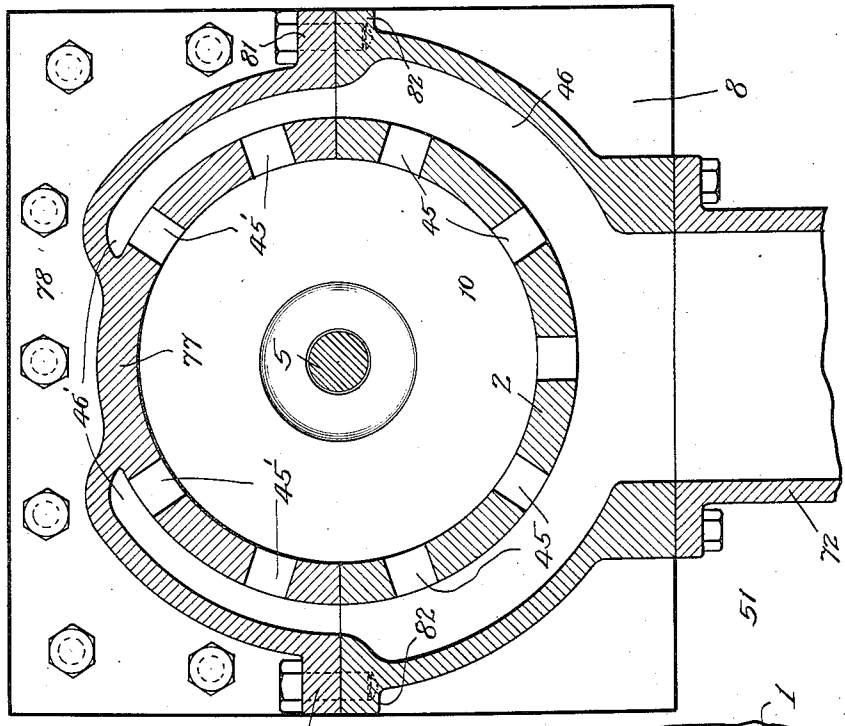
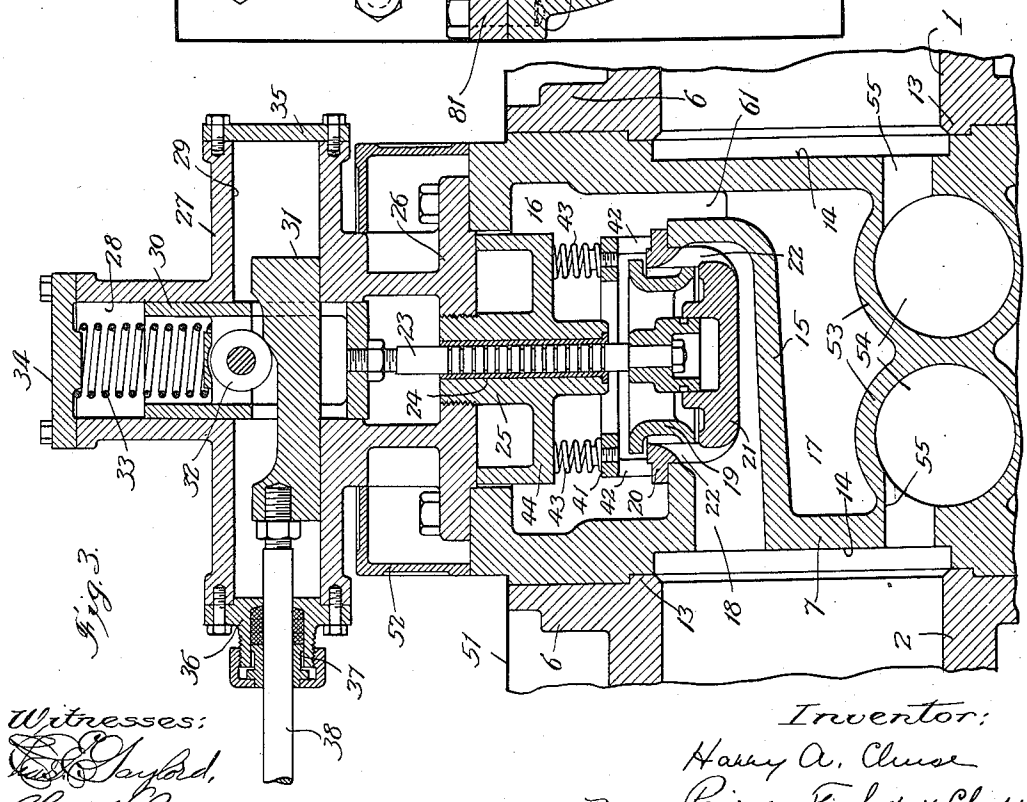


Fig. 3.



Witnesses:

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UNITED STATES PATENT OFFICE.

HARRY A. CHUSE, OF MATTOON, ILLINOIS, ASSIGNOR TO CHUSE ENGINE & MFG. COMPANY, OF MATTOON, ILLINOIS, A CORPORATION.

STEAM-ENGINE.

1,293,713. Specification of Letters Patent. Patented Feb. 11, 1919.

Application filed August 14, 1916. Serial No. 114,726.

To all whom it may concern:

Be it known that I, HARRY A. CHUSE, a citizen of the United States, and a resident of Mattoon, county of Coles, and State of Illinois, have invented certain new and useful Improvements in Steam-Engines, of which the following is a specification.

This invention relates to a so-called "uniflow" or terminal exhaust steam engine in which the inlet and exhaust ports are spaced apart as far as possible longitudinally of the engine cylinder. In this type of engine, the relatively cool expanded steam does not pass back over the walls of the cylinder adjacent the inlet ports and hence does not, as in the ordinary type, tend to chill the cylinder walls adjacent the inlet ports. In this way, loss of heat and condensation of the ingoing steam is avoided. In the common type of uniflow engine, however, the steam is admitted at the ends and exhausted at the center of the cylinder and there is necessarily a loss of heat by radiation from the cylinder ends or from the steam jackets therefor. Heretofore, attempts have been made to overcome this objection by providing two cylinders in tandem with exhaust ports at their outer ends and steam inlet and admission ports at their inner adjacent ends. But in such constructions the steam chest or chests and valve mechanism has been arranged upon the side of the cylinder and are so exposed to loss of heat by radiation. Furthermore, in addition to the main terminal exhaust ports which are over-run by the piston at the end of its working stroke, it is common to employ auxiliary exhaust ports and passages at or adjacent the inlet ends of the cylinder or cylinders and because of the cooling effect at the inlet ends of the cylinder, such auxiliary exhaust ports necessarily occasion some loss of efficiency. Instead of employing auxiliary exhaust ports, it has also been proposed to use clearance chambers which can be open to the clearance spaces of the cylinder when the engine is running non-condensing or shut off therefrom when the engine exhausts into a vacuum, but there is a loss of heat from such clearance chambers unless effectively protected against radiation.

The present invention seeks to overcome the above noted difficulties and provide an improved uniflow engine in which the steam exhaust ports and passages for the outgoing steam are entirely separated from the admission passages and ports for the ingoing steam and in which the inlet ends of the cylinders, the inlet passages and ports and admission valves, are effectively protected against radiation and thus maintained at a uniform high degree of temperature. A further object of the invention is to provide an adjustable clearance space for regulating the compression of the cylinder in accordance with different back pressure conditions under which the engine is operated and to effectively prevent loss of heat by radiation from such clearance space. The invention also seeks to provide an improved uniflow engine comprising two single acting cylinders arranged in tandem with a hollow steam chest having opposite end walls forming the inner ends of the cylinders and provided with inlet ports communicating therewith, together with inlet valve mechanism arranged in said steam chest between said end walls, so that the steam chest forms a steam jacket for the inlet ends of the cylinders and is itself, together with the inlet valves and ports, effectively protected against radiation and maintained at a uniformly high temperature by the ingoing steam.

With these and other objects in view, as will presently appear, the invention consists in the features of improvement hereinafter set forth, illustrated in the preferred form in the accompanying drawings and more particularly pointed out in the appended claims.

In the drawings—

Figure 1 is a longitudinal section of the improved engine taken on line 1—1 of Fig. 2. Fig. 2 is a cross section on the line 2—2 of Fig. 1. Fig. 3 is an enlarged partial longitudinal section on the line 3—3 of Fig. 2. Fig. 4 is an enlarged cross section on the line 4—4 of Fig. 1. Figs. 5 and 6 are detail cross sections illustrating modifications of the means for controlling the compression in accordance with the different conditions under which the engine is operated.

The improved engine comprises two single acting cylinders 1 and 2 arranged in tandem and having pistons 3 and 4 mounted upon a common piston rod 5. The adjacent ends of the cylinders 1 and 2 are provided with

annular, radially projecting flanges 6 which are bolted to the opposite end faces of a hollow casting or steam chest 7, which is located between the cylinders and forms the cylinder ends or heads. The opposite outer ends of the cylinders are provided with flanges 8 and 9 to which the heads 10 and 11 are bolted. Flange 8 and head 10 of the inner cylinder 2 are also securely bolted to the end of the engine frame 12. The flanges 6 at the inner adjacent ends of the cylinders abut against and are bolted to the vertical end faces of the steam chest 7 and the cylinders are provided with annular ribs 13 which project slightly beyond the flanges 6 and fit within annular recesses formed in the end faces of the steam chest. The abutting parts of the cylinders and the intermediate steam chest are, of course, machined to form tight joints. It should also be noted that counter-bored portions 14 at the inner ends of the cylinder spaces are formed in the steam chest and not in the cylinder, thereby reducing the clearance and the length of the inlet ports in the steam chest. The steam chest is divided by a horizontal partition 15 into an upper valve chamber 16 and a lower steam jacketing space 17. This partition is provided with two ports or passages 18 which extend through the body of the partition and which lead from the upper valve chamber 16 and open respectively through the opposite end walls of the hollow steam chest into the inner adjacent ends of the cylinders. These ports are preferably controlled by a pair of puppet or lift valves 19 which, in the preferred construction shown, are of the double seated type. Each valve seat comprises an upper annular part 20 and a lower circular part 21 connected together by vertically disposed spider arms 22. These valve seats fit within openings formed in the upper face of the partition 15 and communicating with the ports or passages 18. Each valve is fixed to the lower end of a stem 23 that extends through a stuffing box 24 carried by a valve stem guide 25. The latter is secured at its upper end to a cap plate 26 which extends over and is bolted to the upper end of the steam chest 7.

The hollow intake steam chest having the inlet valve chamber 16 and the steam jacket and space 17 therein forms, in effect, a steam jacket for the inlet ends of the cylinders and is so located that it is effectively protected against radiation to the atmosphere or to the exhaust. The inlet ends of the cylinders, the steam chest and the inlet valves and ports are thus effectively protected against radiation and are maintained at a uniformly high temperature by the ingoing steam.

The inlet puppet valves may be operated in any suitable manner. In the construction shown, hollow heads 27 are cast integral with the cap plate 26, each head having vertical and horizontal chambers 28 and 29 for respectively receiving and guiding a guide member 30 fixed to the upper end of the valve stem and an operating cam 31. The guide member 30 is provided with a roller 32 which is engaged by the cam 31 and a spring 33 interposed between the guide member and a cap plate 34 on the upper end of the head 27 holds the roller in engagement with the cam and tends to close the valve. The horizontal chamber of each head is closed at one end by a cap plate 35 and at its opposite end by a plate 36 having a stuffing box 37 and through which extends a rod 38. The rod 38 is connected to and operates the cam 31 and its opposite outer end is pivotally connected by a coupling 39 to an eccentric rod 40.

In the construction shown, the seat of each puppet valve is yieldingly held in place by a stool comprising an upper annular portion 41 and depending legs 42 that engage the upper annular part 20 of the valve seat. Springs 43 interposed between the stool and a flange 44 on the guide 25 hold the stool and valve seat in position under all normal conditions. But if, for any reason there is an excessive amount of compression in the cylinder, the valve seat will yield or lift against the pressure of the springs 43 and thus relieve excessive pressure in the engine cylinder on the return stroke of the piston.

This improved arrangement of the steam chest, valve chamber and inlet valves between the inlet ends of a pair of single acting, uni-flow cylinders arranged in tandem greatly reduces the condensation of the incoming steam and materially increases the efficiency of the engine. Each cylinder is provided at its outer end and at a point as far removed as possible from its inlet end with an annular series of exhaust ports 45 which communicate with exhaust passages 46. It should be noted that the exhaust ports and passages are separated as far as possible from the inlet ports and passages and that condensation of the incoming steam is therefore avoided. As a further aid in preventing the condensation of the incoming steam, by the transmission of heat through the piston walls, each of the pistons 3 and 4 is hollow and the chambers or spaces therein are compactly filled with insulating material 47. The openings in the piston walls through which the insulating material is inserted are tightly closed by plugs 48 so that no water of condensation can accumulate in the hollow pistons.

In the improved construction having the hollow steam chest arranged between and forming the inlet ends of the cylinders, these parts and the inlet ports and valves which are arranged within the steam chest and en-

tirely surrounded by the live steam therein, are not in any way exposed to the cooling effect of the exhaust steam and are effectively protected against external radiation. Furthermore, as noted, the hollow steam chest is not in contact with the walls of the cylinders except at the joints between the same and is not exposed to the cooling effect of the walls of the cylinders which gradually decrease in temperature from their inner admission ends to their outer exhaust ends in correspondence with the expansion of the steam. For these reasons there is little or no loss of heat by external radiation or internal condensation.

The flanges 8 and 9 at the outer ends of the cylinders and the flanges 6 at the inner ends thereof, in the construction shown, are rectangular in outline and the sides and lower portion of the steam chest are provided with corresponding rectangular flanges 49, the upper side portions of the steam chest having horizontally projecting flanges 50. These flanges support sheet metal casings 51 which form jacketing spaces about the cylinders and about the sides and lower portion of the steam chest. The upper end of the steam chest is also provided with a jacketing casing 52 that surrounds the lower portions of the heads 27.

Sufficient steam passes out through the exhaust ports 45 to prevent excessive compression in the cylinders when the engine is running condensing with a good vacuum, but additional means must be provided for preventing excessive compression in the engine cylinders when the engine is running under varying conditions or non-condensing. Usually, supplemental exhaust ports are provided for this purpose at or adjacent the intake ports, but since the flow of steam through such supplemental exhaust ports tends to cool the walls of the cylinder at the intake end thereof, adjustable clearance spaces or compression chambers are provided instead in the present construction. To eliminate radiating surfaces and effectively steam jacket such clearance chambers, they are arranged entirely within the steam jacketing space 17 in the lower portion of the steam chest 7 and comprise two cylindrical chambers 53 cast integral with the opposite vertical side walls of the steam chest and arranged between the partition 15 and the lower wall thereof (see Figs. 2 and 3). The outer ends of the clearance chambers or cylinders 53 open into the steam space 17, but their inner ends are closed by cap plates 54 and communicate through ports 55 (see Fig. 3) with the respective cylinders. The outer walls of the steam jacketing space 17 of the steam chest opposite the ends of the cylindrical chambers 53 are provided with openings 56 and 57. The opening 56 is closed by a cap plate 58 and affords means whereby access may be had to the clearance chambers. The opening 57 forms a steam intake and is connected by an elbow 59 to a throttle valve 60. The incoming steam thus passes entirely around and into the outer ends of the clearance or compression chambers 53 located in the steam jacketing space 17 and from the latter the steam passes through two ports or passages 61 into the valve chamber 16. Fig. 3 shows in detail the inlet passages and valves for the inner cylinder 2. For the outer cylinder 1 they are the same, except that the passages 18 and 61 are reversed. Thus, the partition 15 has passages 61 located at diagonally opposite corners thereof and the live steam passing into the intake 57 circulates through all portions of the steam chest which forms the intake ends of the cylinders and effects a maximum amount of heating thereof. Furthermore, the live steam as noted, passes entirely around and into the outer ends of the clearance chambers, around the inlet valves and seats and over the supper and lower faces of the partition 15 through which the admission ports 18 extend so that these parts are effectively protected against the loss of heat by radiation or condensation.

To regulate the clearance in the cylinders to suit different conditions, each cylindrical clearance space is provided with an adjustable piston 62. Each piston is provided with a threaded rod 63 that engages the inner threaded end 64 of a sleeve 65. The outer end of the sleeve is journaled in and extends through a stuffing box 66 on the steam intake elbow 59, the extreme outer end of the sleeve being closed and provided with a crank handle 67. The piston 62 and the screw-threaded piston rod 63 are held against rotation by a collar 68 thereon which is not threaded, but is keyed to the rod, as shown, so that the rod is free to move longitudinally through the collar. The collar has an arm 69 the upper end of which engages a horizontal pin 70 on the end of the cylinder 53 to thereby hold the collar and rod against rotation. The sleeve 65 having the nut 64 at its inner end is held against longitudinal movement, so that by rotating these parts by means of the handle 67, the piston 62 and piston rod 65, which are held against rotation as described, they can be moved longitudinally to adjust the amount of clearance space between the piston and the inner closed end of the clearance chamber. At the inner end of its movement, the piston closes the corresponding port 55 and reduces the clearance space in the cylinder to a minimum amount. By the construction described, the clearance in the two cylinders can be adjusted to suit different conditions. That is to say, the piston can be moved to the outer end of the clearance chamber

to provide a maximum amount of clearance so that the engine will operate properly when running non-condensing. When the engine is running condensing with a good vacuum the piston is adjusted to the inner end of its movement to reduce the clearance space of the cylinder to a minimum amount. At intermediate positions of the piston in the clearance chamber, a proper amount of clearance is provided in starting the engine or when the latter is running condensing under a partial vacuum. It should also be noted that the clearance in the two cylinders can be independently adjusted if desired. As already noted, the clearance chambers are effectively insulated and steam jacketed and have no external radiating surface, so that there is no loss of economy due to the use of such clearance chambers.

As shown in Fig. 1, the exhaust passages 46 at the opposite outer ends of the cylinders communicate, respectively, one with a valve casing 71 and the other with the upturned end or elbow 72 of a by-pass pipe 73. The opposite end of the pipe 73 communicates with the valve casing 71. Separate exhaust pipes 74 and 75 communicate respectively with the valve casing 71 and with the opposite end of the pipe 73. A valve 76 in the casing 71 is arranged to open and close the by-pass pipe 73 and thus establish or cut off communication between the two exhaust pipes 74 and 75. By closing the by-pass valve 76, the exhaust from the two cylinders can be passed through the separate exhaust pipes 74 and 75 and, by connecting one of the pipes to a condenser, one of the cylinders can be operated condensing and the other non-condensing. Such an arrangement is permitted because the clearance spaces of the two cylinders can be independently adjusted by means of the separate pistons 62. By opening the by-pass valve 76 and shutting off the flow through either of the pipes 74 or 75, the exhaust from both cylinders can be passed to the other pipes so that both cylinders can be operated either condensing or non-condensing. Thus, if the engine is employed in a combined heating and lighting plant, it can be operated non-condensing during the cold winter months and all of the exhaust steam passed to the heating system. In the hot summer months, for economy's sake, both cylinders can be operated condensing and during the remainder of the year, one of the cylinders can be operated condensing and the other non-condensing, so that part of the steam can be diverted to the heating system. The arrangement is thus very economical and flexible, being readily adjusted to suit different conditions.

Where engine cylinders are arranged in tandem, difficulty is often encountered in effecting access to the piston and surface of the inner cylinder next to the engine frame. In the present construction, the inner cylinder 2 is provided at its exhaust end with a removable semi-circular section 77. As shown, this section is provided with vertical flanges 78 and 79 which are bolted respectively to the head 10 and to a flange 80 formed upon the main body of the engine cylinder. The removable section is also provided with horizontal flanges 81 bolted to corresponding horizontal flanges 82 on the main body of the engine cylinder. This removable section contains certain of the exhaust ports 45′ and is provided with exhaust passages 46′ which communicate with the main exhaust passage 46. As shown, the portion of the piston rod 5 largest in diameter extends between the two pistons 3 and 4 which are mounted on slightly reduced portions thereof and clamped in place by nuts 83 and 84. The portion of the piston rod extending from the nut 84 through the head 10 and the engine frame 12 is still further reduced so that by removing the outer cylinder head 11 and loosening the nut 84, the piston 3 and piston rod can be readily removed. Then, by removing the cylinder section 77, the piston 4 can be lifted from the cylinder 2. In this way, access is had to the surfaces of the cylinders and pistons for repairs or the like. It should be noted that the removable section 77 is located at the exhaust end of the cylinder 2, where it and the joints at its edges are subjected to but slight pressure.

The steam chest is provided at its center with a portion 85 which is bored out to receive a stuffing box 86 through which the piston rod 5 extends. This stuffing box is provided at its opposite ends with suitable means for holding packing rings 87 in place. Between its ends the stuffing box is provided with an open space 88 which communicates with a passage 89 and a pipe 90, the latter being open to the atmosphere. By this construction, any leaking of the packing around the piston rod is readily detected.

If desired, the cylindrical clearance chambers 53 may be provided with pistons which will automatically adjust the clearance space in accordance with different conditions. As shown in Fig. 5, the clearance chamber 53 is provided with a freely movable piston 91 and the wall of the cylinder is provided with a groove 92 which extends from the port 55 to the inner end of the cylinder. The piston 91 is thus exposed on one side to the pressure within the cylinder and on the opposite side to the intake pressure.

When the engine is running condensing with a good vacuum, the intake pressure will hold the piston 91 at the extreme inner end of the cylinder 53 and thus maintain the clearance space at a minimum. When the engine is running non-condensing or with a

poor vacuum, the compression at the end of the return stroke of the piston would tend to exceed the intake pressure and thus shift the piston 91 away from its inner end to such an extent that the compression in the cylinder will equal or balance the intake pressure. By this arrangement, the compression could not exceed the intake pressure and the piston 91 will be automatically adjusted to suit different conditions of back pressure or vacuum. Usually, it is desirable to prevent the compression from exceeding 80 per cent. of the intake pressure. For this purpose, as shown in Fig. 6, the automatically adjusting piston 93 is provided on the side exposed to the intake pressure with an enlarged hollow piston rod 94. The latter extends through a sleeve 95 which is fixed at its inner end to a bracket or spider 96 on the outer end of the cylinder and the outer end of such sleeve extends through a stuffing box 97 on the intake elbow 59. To prevent leaking between the sleeve and hollow piston rod 94, the latter is provided at its outer end with packing rings 98. The piston 93, like the piston 91 shown in Fig. 5, will automatically adjust itself to vary the clearance space in accordance with different conditions, but in the form shown in Fig. 6, because of the reduced piston area exposed to the intake pressure, the compression can not exceed about 80 per cent. of the intake pressure. When the engine is running non-condensing or under a reduced vacuum, the pistons 91 and 93 will shift back and forth at each revolution and a certain amount of work would be lost during the return stroke of the engine piston but this will be restored on the forward stroke. To prevent the knocking of the pistons 91 and 93, bumper springs are provided at the opposite ends of the cylindrical clearance chamber. As shown, the plate 54 in each instance is provided with a buffer spring 99 mounted upon a bolt 100. The opposite end of the cylinder shown in Fig. 5 is provided with a bumper spring 101 mounted on a bracket 102 that is fixed to the adjacent end of the cylinder. The bumper 103 at the outer end of the cylinder shown in Fig. 6 encircles the hollow piston rod 94 and abuts against or is secured to the bracket 96.

It is obvious that numerous changes may be made in the details set forth without departure from the essentials of the invention as defined in the claims.

I claim as my invention:—

1. A steam engine comprising two single-acting cylinders arranged in tandem and having exhaust ports at their outer ends, separate exhaust chambers in contact with the outer ends only of said cylinders, a hollow intake steam chest arranged between said cylinders and having opposite end walls forming the adjacent cylinder heads, said steam chest having an intake opening and admission ports leading into said cylinders, and valve mechanism disposed in said steam chest for controlling the flow of steam to said cylinders, whereby the inner cylinder heads, the intake steam chest and valve mechanism therein are protected against radiation to the atmosphere and to the exhaust.

2. A steam engine comprising two single-acting cylinders arranged in tandem and having exhaust ports at their outer ends, separate exhaust chambers in contact with the outer ends only of said cylinders, a pair of connected pistons in said cylinders controlling said exhaust ports, a hollow intake steam chest arranged between said cylinders and having opposite end walls forming the adjacent cylinder heads, said steam chest having an intake opening and admission ports leading into said cylinders, two valves for respectively controlling the admission of steam through said ports into said cylinders, said valves being arranged within said steam chest, whereby said steam chest, said inner cylinder heads, said valves and admission ports are protected against radiation to the atmosphere and to the exhaust, and means for operating said valves.

3. A steam engine comprising two single acting cylinders in tandem having exhaust ports at their outer ends, a hollow intake steam chest arranged between said cylinders and having opposite end walls forming the adjacent cylinder ends, said steam chest having an intake opening and admission ports opening into said cylinders, a pair of puppet valves arranged side-by-side within said steam chest for controlling the admission of steam to said cylinders, and means for actuating said valves.

4. A steam engine comprising two terminal exhaust cylinders in tandem, a hollow intake steam chest interposed between and bolted to said cylinders and having opposite end walls forming the inner cylinder heads, the latter and said steam chest having radial joint faces substantially in line with the inner ends of said cylinder and being out of contact except at said joint faces, said steam chest having admission ports communicating with said cylinders and inlet valve mechanism for controlling said ports arranged within said steam chest.

5. A steam engine comprising two terminal exhaust cylinders in tandem, a hollow intake steam chest interposed between said cylinders and forming the adjacent cylinder ends, said intake steam chest being provided with a partition wall dividing the same into a live steam jacketing space and a valve chamber, said partition wall having admission ports leading from said valve chamber to said cylinders, and valve mechanism in said valve chamber controlling said ports.

6. A steam engine comprising two termi-

nal exhaust cylinders in tandem, an intake steam chest interposed between said cylinders and forming the adjacent cylinder ends, said steam chest being provided with a partition wall dividing the same into a steam jacketing space and a valve chamber, said partition having admission ports therein communicating with said valve chamber and said cylinders, a pair of puppet valves arranged in said valve chamber for controlling said ports, and seats for said valves carried by said partition.

7. A steam engine comprising two single acting, terminal exhaust cylinders in tandem, a hollow, intake steam chest interposed between said cylinders and having opposite end walls forming the cylinder ends, said chest having an intake opening and having admission ports opening into said cylinders through the opposite end walls of said steam chest, and a pair of valves arranged side-by-side in said steam chest between said end walls and respectively controlling the flow of steam through said admission ports.

8. A steam engine comprising two single acting, terminal exhaust cylinders in tandem, an intake steam chest interposed between said cylinders, said chest having opposite end walls forming the adjacent cylinder ends and a transverse partition dividing the chest into a steam jacketing space and a communicating valve chamber, said partition having admission ports opening into said cylinders through the opposite end walls of said steam chest, and a pair of puppet valves arranged side-by-side in said valve chamber for controlling said admission ports.

9. A steam engine comprising two single acting, terminal exhaust cylinders in tandem, an intake steam chest interposed between said cylinders, said chest having opposite end walls forming the inner ends of the cylinders and a transverse partition dividing said steam chest into an upper valve chamber and a lower steam jacketing space, and said chest having a steam intake opening into said jacketing space, said partition having openings therein connecting said jacketing space and said valve chamber and said partition having admission ports connecting said valve chamber and said cylinders, and valve mechanism in said valve chamber for controlling said admission ports.

10. A steam engine comprising two terminal exhaust cylinders in tandem, a hollow intake steam chest interposed between said cylinders and having opposite end walls forming the adjacent cylinder ends, said cylinder having radially extending flanges abutting against and bolted to the opposite end walls of said steam chest and the end faces of said steam chest being counter-bored or recessed opposite said cylinders, said steam chest having admission ports opening through the counter-bored portions of said opposite end walls into the ends of said cylinders, and valve mechanism controlling said ports.

11. A terminal exhaust steam engine comprising a cylinder having an exhaust port and an inlet port at one end, a piston in said cylinder arranged to overrun and open said exhaust port at the end of its working stroke, a hollow intake steam chest forming a steam jacket for the inlet end of said cylinder, a valve in said steam chest controlling said inlet port, a chamber arranged within said steam chest and having a clearance space therein communicating solely with the inlet end of said cylinder, the walls of said chamber being spaced from the walls of said steam chest to permit the incoming steam to practically surround said clearance space, and a piston in said chamber for adjusting said clearance space.

12. A steam engine comprising two single acting, terminal exhaust cylinders in tandem, a hollow, intake steam chest interposed between said cylinders and having an intake opening and admission ports leading to said cylinders, and two clearance chambers arranged within said steam chest and communicating respectively with said cylinders, the walls of said clearance chambers being spaced from the walls of said steam chest to permit the incoming steam to practically surround said clearance chambers.

13. A steam engine comprising two single-acting terminal exhaust cylinders arranged in tandem and having inlet ports at their inner adjacent ends and exhaust ports at their outer ends and a steam jacketing space between their inner adjacent ends, two cylindrical clearance chambers arranged in said steam jacketing space at right angles to the axis of said cylinders and communicating respectively with the inner ends thereof, and pistons in said chambers for adjusting the clearance spaces therein.

14. A steam engine comprising two single-acting terminal exhaust cylinders arranged in tandem and having inlet ports at their inner adjacent ends and exhaust ports at their outer ends and a steam jacketing space between their inner adjacent ends, two cylindrical clearance chambers arranged in said steam jacketing space at right angles to the axis of said cylinders and communicating respectively with the inner ends thereof, pistons in said clearance chambers and manually operable means for independently adjusting said pistons.

15. A steam engine comprising two single acting, terminal exhaust cylinders in tandem, a steam intake chest interposed between said cylinders and having opposite end walls forming the cylinder ends, said chest being divided into a steam jacketing space and a communicating valve chamber, inlet

valve mechanism in said valve chamber, and clearance chambers arranged within said steam jacketing space and communicating respectively with said cylinders.

16. A steam engine comprising two single-acting cylinders arranged in tandem and having exhaust ports at their outer ends and inlet ports at their inner adjacent ends, and separate exhaust passages communicating with said exhaust ports, connected pistons in said cylinders controlling said exhaust ports, two clearance chambers communicating respectively with the inner, inlet ends of said cylinders, and means for independently varying the clearance spaces in said chambers, whereby said cylinders may be operated under different back-pressure conditions.

17. A steam engine comprising two single acting cylinders in tandem having separate exhaust outlets at their outer ends and inlet ports at their inner adjacent ends, two clearance chambers communicating respectively with the inner, inlet ends of said cylinders, means for independently varying the clearance spaces in said chambers, a by-pass between said exhaust outlets, and a valve in said by-pass.

18. A terminal exhaust engine comprising two single acting cylinders arranged in tandem and having inlet ports at their inner adjacent ends and exhaust ports at their outer ends, separate exhaust chambers in contact with the outer ends only of said cylinders, a hollow intake steam chest interposed between and forming a steam jacket for the inner inlet ends of said cylinders, valve mechanism in said steam chest controlling said inlet ports, and connected insulated pistons in said cylinders controlling said exhaust ports, whereby the inner inlet ends of said cylinders, said intake steam chest and said valve mechanism are protected against radiation to the atmosphere and to the exhaust.

19. A uniflow steam engine comprising a cylinder, a hollow steam chest having an end wall forming one of the heads of said cylinder, said steam chest having a transverse partition extending across said end wall and dividing said steam chest into communicating valve and steam jacketing chambers, said steam jacketing chamber having an intake and said partition being exposed on opposite sides to the incoming steam in said chambers and having an admission port extending therethrough from said valve chamber and opening through the end wall of said steam chest into said cylinder, a valve in said valve chamber for controlling said port and mechanism for operating said valve.

20. A uniflow steam engine comprising a cylinder, a hollow steam chest having an end wall forming one of the heads of said cylinder, said steam chest having the heads and a partition extending across said end wall and dividing said steam chest into communicating valve and steam jacketing chambers, said steam jacketing chamber having an intake and said partition being exposed on opposite sides to the incoming steam in said chambers and having an admission port extending therethrough from said valve chamber and opening through the end wall of said steam chest into said cylinder, a valve in said valve chamber for controlling said port, a clearance chamber arranged in said seam jacketing chamber and having its walls spaced from said partition and means for controlling said clearance chamber.

21. A uniflow steam engine comprising a horizontal cylinder having an exhaust port, a piston in said cylinder arranged to overrun and open said exhaust port at the end of its working stroke, a hollow steam chest having a vertical end wall forming the end of said cylinder, said steam chest having a horizontal partition therein dividing the same into an upper valve chamber and a lower steam jacketing chamber, said steam jacketing chamber having an intake and communicating with said valve chamber and said horizontal partition being exposed on its opposite sides to the incoming steam in said chambers and having an admission port extending therethrough from said valve chamber and opening through the end wall of said steam chest into said cylinder, and a puppet lift valve in said valve chamber controlling said port.

22. A steam engine comprising two single acting cylinders in tandem having separate exhaust outlets at their outer ends, connected pistons in said cylinder controlling said exhaust outlets, a hollow steam chest interposed between said cylinders and having opposite end walls forming the adjacent cylinder ends, said steam chest having a transverse partition dividing the same into valve and steam jacketing chambers, said steam jacketing chamber having an intake and communicating with said valve chamber, said partition having admission ports extending therethrough from said valve chamber and opening through the opposite end walls of said steam chest into said cylinders and valve mechanism in said valve chamber between the end walls of said steam chest for controlling said ports.

23. A steam engine comprising two single acting cylinders in tandem having separate exhaust outlets at their outer ends, connected pistons in said cylinder controlling said exhaust outlets, a hollow steam chest interposed between said cylinders and having opposite end walls forming the adjacent cylinder ends, said steam chest having a transverse partition dividing the same into valve and steam jacketing chambers, said steam jacketing chamber having an intake and communicating with said valve chamber,

said partition having admission ports extending therethrough from said valve chamber and opening through the opposite end walls of said steam chest into said cylinders, two puppet valves arranged in said valve chamber between the end walls of said steam chest for controlling said ports, said valves being arranged side by side in a direction transverse to the axis of said cylinders and mechanism for operating said valve.

24. A steam engine comprising two single acting cylinders in tandem having separate exhaust outlets at their outer ends, connected pistons in said cylinder controlling said exhaust outlets, a hollow steam chest interposed between said cylinders and having opposite end walls forming the adjacent cylinder ends, said steam chest having a transverse partition dividing the same into valve and steam jacketing chambers, said steam jacketing chamber having an intake and communicating with said valve chamber, said partition having admission ports extending therethrough from said valve chamber and opening through the opposite end walls of said steam chest into said cylinders, separate valves in said valve chamber between the end walls of said steam chest for controlling said ports, separate clearance chambers arranged in said steam jacketing chamber below and out of contact with said partition and communicating respectively with the inner ends of said cylinders, and means for controlling said clearance chambers.

25. A steam engine comprising two, horizontal, single acting cylinders in tandem and having exhaust ports at their outer ends, connected pistons in said cylinders controlling said exhaust ports, a hollow, intake valve chest having opposite vertical end walls forming adjacent cylinder ends, said steam chest having a horizontal transverse partition between said end walls dividing the same into an upper valve chamber and a lower steam jacketing chamber, said steam jacketing chamber having an intake and communicating with said valve chamber, said partition having admission ports extending therethrough from said valve chamber and opening through the opposite end walls of said steam chest into said cylinders, a pair of puppet lift valves arranged in said valve chamber between the end walls of said steam chest for controlling said ports, said valves being arranged side by side in a direction transverse to the axis of said cylinders and means for operating said valves.

26. A steam engine comprising a cylinder having an exhaust port, a piston in said cylinder arranged to over-run and open said port at the end of its working stroke, an intake steam chest having a valve controlled admission port opening into said cylinder, a clearance chamber having a cylindrical bore communicating at one end with the inlet end of said cylinder and at its opposite end with said steam chest and an adjustable piston in said chamber for adjusting the clearance space therein.

27. A steam engine comprising a cylinder having an exhaust outlet, a piston in said cylinder arranged to over-run and open said exhaust outlet at the end of its working stroke, a steam chest forming the end of said cylinder, admission valve mechanism controlling the flow of steam from said chest to said cylinder, a cylindrical clearance chamber arranged within said chest and communicating at one end with said cylinder and at the opposite end with said steam chest and a piston in said cylinder for adjusting the clearance space therein.

28. A steam engine comprising a cylinder having an exhaust outlet, a piston in said cylinder arranged to over-run and open said exhaust outlet at the end of its working stroke, a steam chest forming the end of said cylinder, admission valve mechanism controlling the flow of steam from said chest to said cylinder, a cylindrical clearance chamber arranged within said chest and at right angles to the axis of said cylinder and communicating therewith, the walls of said piston being exposed to the live steam in said steam chest and a piston in said cylindrical clearance chamber for adjusting the clearance space therein.

29. A steam engine comprising two single acting cylinders arranged in tandem and having exhaust outlets at their outer ends, an intake steam chest interposed between the inner adjacent ends of said cylinders and communicating therewith through valve controlled admission ports, clearance chambers communicating with the inlet end of said cylinders and means for controlling said clearance chambers, said chambers being arranged within said steam chest and having their walls exposed to the live steam passing therethrough.

30. A steam engine comprising two single acting cylinders arranged in tandem and having exhaust outlets at their outer ends, an intake steam chest interposed between the inner adjacent ends of said cylinders and communicating therewith through valve controlled admission ports, cylindrical clearance chambers arranged within said steam chest and communicating at opposite ends with said chest and with said cylinders, and pistons in said cylindrical clearance chambers for adjusting the clearance spaces therein.

31. A steam engine comprising two single acting cylinders arranged in tandem and having exhaust outlets at their outer ends, an intake steam chest interposed between the inner adjacent ends of said cylinders and communicating therewith through valve controlled admission ports, two cylindrical

clearance chambers arranged within said steam chest at right angles to the axis of said cylinders and communicating respectively therewith, and pistons in said cylindrical chambers for adjusting the clearance spaces therein.

32. A steam engine comprising two single acting, terminal exhaust cylinders arranged in tandem, said cylinders having exhaust ports at their outer ends and inlet ports at their inner adjacent ends, separate exhaust passages in contact with the outer ends only of said cylinders, a hollow intake steam chest arranged between said cylinders and forming a steam jacket for the inner, inlet ends thereof, and valve mechanism disposed in said steam chest for controlling the flow of steam through said inlet ports, whereby the inner cylinder ends, said steam chest and valve mechanism are protected against radiation to the atmosphere and to the exhaust.

33. A steam engine comprising two single acting, terminal exhaust cylinders arranged in tandem, said cylinders having exhaust ports at their outer ends and inlet ports opening through the inner end walls thereof, separate exhaust passages in contact with the outer ends only of said cylinders, a hollow intake steam chest arranged between and forming a steam jacket for the inner inlet ends of said cylinders, two valves arranged side by side within said steam chest for respectively controlling the inlet ports of said cylinders, means for mechanically operating said valves, and connected pistons in said cylinders for controlling said exhaust ports.

34. A steam engine comprising two terminal exhaust, single acting cylinders arranged in tandem and having inlet ports at their inner adjacent ends and exhaust ports at their outer ends, said cylinders having heads at their outer ends and said exhaust ports being formed in the side walls of said cylinders adjacent said outer heads, pistons in said cylinders controlling said exhaust ports, a piston rod connecting said pistons and extending through one of said outer heads, the cylinder adjacent said latter head having a flange intermediate its ends and a semi-cylindrical flanged section removably bolted to said head and to said flange.

35. A steam engine comprising two terminal exhaust, single acting cylinders arranged in tandem and having inlet ports at their inner adjacent ends and circular series of exhaust ports and exhaust passages at their outer ends, said cylinders having heads at their outer ends and said exhaust ports and passages being formerd in the side walls of said cylinders adjacent said heads, pistons in said cylinders controlling said exhaust ports, a piston rod connecting said pistons and extending through one of said outer heads, a relatively short section of the cylindrical side wall adjacent said latter head being removably secured in position, said removable section having portions of said exhaust ports and one of said exhaust passages formed therein.

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