Aug. 13, 1946. L. N. MILLER 2,405,596

DIFFERENTIAL CONVERTIBLE GASOLINE-DIESEL ENGINE

Filed March 21, 1942

FIG. 1.

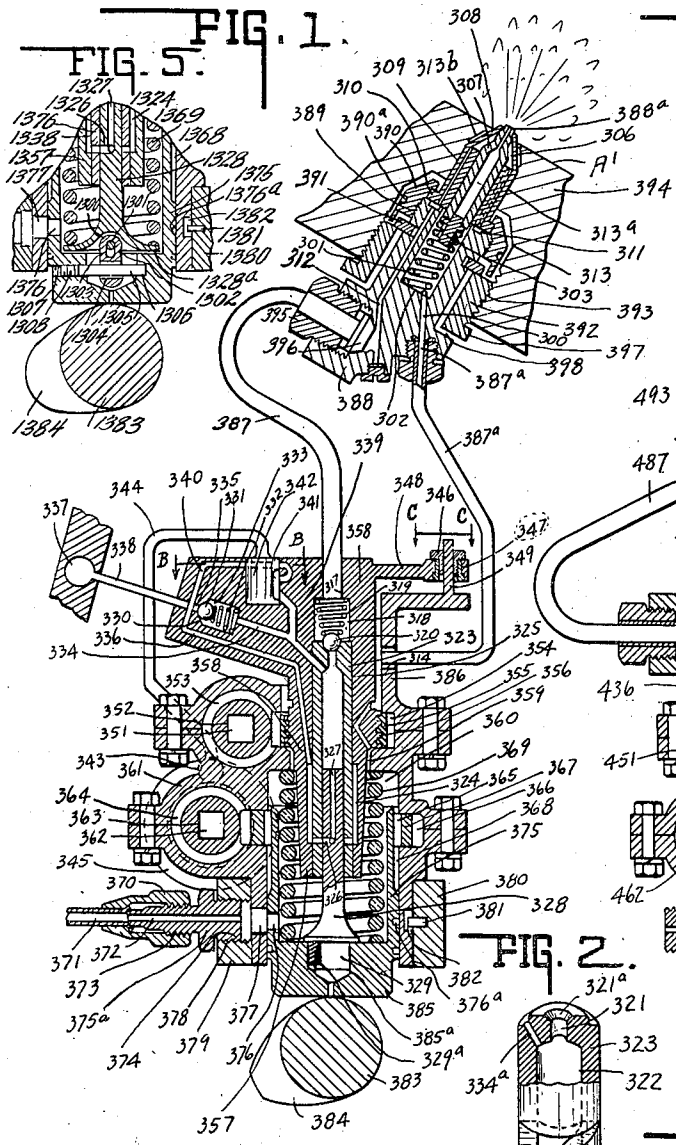


FIG. 5.

FIG. 6.

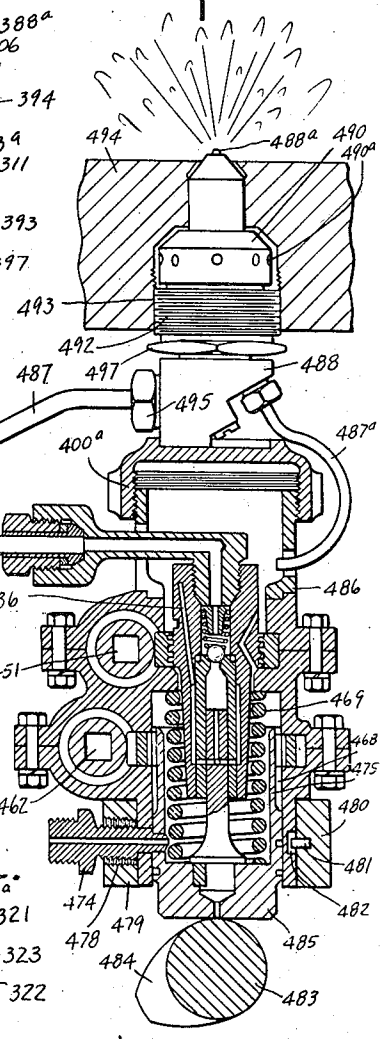


FIG. 2.

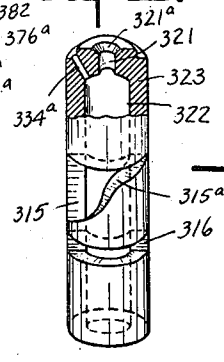


FIG. 3.

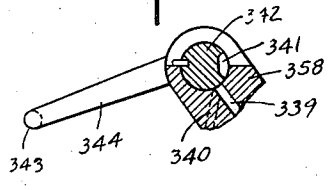
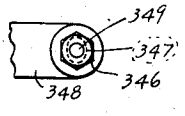


FIG. 4.



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DIFFERENTIAL CONVERTIBLE GASOLINE-DIESEL ENGINE

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3 Claims. (Cl. 103—41)

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This invention relates to internal combustion engines and of multi-cylinder character, if desired, and wherein the advantages of a Diesel engine are included.

The chief object of this invention is to produce an engine which will include a maximum number of advantages and a minimum number of the disadvantages.

One object of the invention consists in its operation under relatively high compression ratio as a Diesel engine.

One feature of the invention consists in providing mechanism whereby the Diesel engine range of compression may be varied.

Another feature of the invention consists in automatically reducing the clearance volume of the engine when it is changed from a gasoline type engine to a Diesel type engine for operation.

Another feature of the invention consists in arranging certain parts of the engine so that the fuel supplied to the combustion chamber when operating as a Diesel engine is completely burned, thereby insuring cleanliness of the fuel nozzle.

Another object of the invention is to provide means for the engine, when operating as a Diesel, to automatically control the fuel supply so as to prevent the engine from attaining excessive speeds and running away.

One feature of the invention for the accomplishment of the foregoing object consists in arranging the mechanism incident to the engine operation so that all or a part of the fuel supplied when operating as a Diesel is bypassed.

Another feature of the invention consists in the improved fuel supply for Diesel operation.

Another feature of the invention consists in providing manually operable means which is arranged so that the time of fuel injection when operating as a Diesel can be varied, depending upon operating conditions so that the most effective time of application can be utilized with reference to the operation of the Diesel at that time. Such adjustment is highly desirable because the character of fuels vary and furthermore, the altitude in which the engine is operating is critical with reference to the absolute compression ratio. When the engine is used for automotive purposes, it will be recognized that the engine may move rapidly from one elevation to a very materially different elevation and, therefore, the aforesaid is highly critical and desirable.

Furthermore, when the engine is used for automotive purposes and operates as a Diesel, it has a characteristic which permits it to operate as a brake which while not impossible with standard

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Diesel engines used for automotive purposes, nevertheless eliminates absolutely the possibility of destruction or damage to the injection system which is an essential inherent characteristic of such Diesel engines when so operated as a brake.

The full nature of the invention will be understood from the accompanying drawing and the following description and claims:

In the drawing,

Fig. 1 is a central sectional view through one form of Diesel fuel injection system.

Fig. 2 is a perspective view of the fuel control barrel shown in Fig. 1 and with a portion being broken away to show the same in central section.

Fig. 3 is a sectional view taken on line B—B of Fig. 1 and in the direction of the arrows.

Fig. 4 is a top plan view of a portion of the mechanism shown in Fig. 1 and is taken in the plane of line C—C of said figure and in the direction of the arrows.

Fig. 5 is a central sectional view of a modified form of the lower central portion of the invention illustrated in Fig. 1.

Fig. 6 is a similar view of a still further modified form of Diesel fuel injection system.

In Figs. 1 and 6, there are illustrated two modifications of an injector and the associated nozzle. These are: one of separated character—see Fig. 1—and the other of unitary arrangement—see Fig. 6. The following description in effect constitutes a disclosure of said injector and nozzle arrangements, respectively.

The cam **384** carried by cam shaft **383** is actuated to supply the fluid fuel under pressure and to the supply lines **387** and **487** in Figs. 1 and 6, respectively.

Numerals of the 300 series indicate like or similar parts in Fig. 1 and numerals of the 400 series indicate like or similar parts in Fig. 6 which are similarly indicated by numerals of the 100 and 200 series in prior figures. The aforesaid statement, however, only applies to the cam shaft, the cam, the operating plunger, the injector itself, supply line from the injector to the nozzle tip, and the waste return line. These numbers are as follows: **83**, **84**, **85**, **86**, **87**, **87***a*, **88** and **88***a*. So far as the numerals of Figs. 1 and 6 are concerned, the same numerals of the 300 and 400 series other than the previously mentioned, indicate like, similar or equivalent parts.

Reference will be had to Fig. 1 specifically, together with the auxiliary Figures 2, 3 and 4. In these figures, **386** indicates a relatively stationary housing structure. It includes a slot **382**

with which is associated a pin 381 carried by a part 380 fixed on the engine. This is a factory locating arrangement. The casing includes in the lower left hand corner, a boss portion 379 having a threaded opening as at 378, said opening registering with the opening 377 in turn arranged to register with an oil discharge opening 376 in the shell or cylinder portion 375 of the plunger portion 385. Fitting 375a has opposite ends threaded as at 374 and 373 and is provided with a passage 372 therethrough, which is arranged to communicate with a return surplus oil line 371, the same being connected together by the coupling 370. Comparison of these parts with those of the 400 series similarly numbered and illustrated in Fig. 6 will show the fitting 474 is reversed end for end.

In factory tuning, it is desirable to have identical clearance between each plunger 385 and the cam 384. This clearance is determined by the use of a shim gauge and the spring 369 within the cylinder or shell portion 375 insures the proper contact or engagement. The fixture 375a is then used as a stop or holding member as shown in Fig. 6. This arrangement then serves for initial locating of the plunger 485 (Fig. 6) in the axial direction. The original location with reference to rotation is obtained by means of pin 381, before mentioned. Following such location, as before set forth, the fixture 375a is reversed and replaced in the position shown in Fig. 1. Figs. 1 and 6, accordingly represent sequential locating steps in factoring tuning.

The exterior of the shell portion 375 of the plunger is suitably grooved as at 368 and a gear 367 having teeth 366 includes internal cooperating portions 365 which are associated with the grooves 368 so that the gear 367 and the shell portion have relative axial movement but relatively no rotative movement. The gear teeth 366 mesh with the worm 364 having the square hole 363 therein which receives a square shaft 362. Thus when shaft 362 is rotated, the gear 367 rotates and, therefore, the plunger 385 rotates. Longitudinal movement of the rod 362 does not effect rotation of the worm 364 and this longitudinal movement of the rod will be hereinafter referred to under the subject of controls and the purpose thereof will be more fully set forth.

It will be obvious that the worm is enclosed within a housing portion and the same includes a chamber arrangement 361. This chamber has a predetermined length of bore and by employing various thicknesses of washers at each side of the worm, the position of the worm may be adjusted at the factory for factory tuning of the device. Such washers, however, are not illustrated herein.

The body portion 386 includes the chamber 360 having a reduced bore extension 359 adapted to receive a tubular portion 358 which has a tubular extension 357 extending into the chamber and serving as a guide for the upper portion of the spring 369, the upper end of which bears against the upper end of the chamber 360 adjacent the bore portion 359.

The member 358 is externally threaded as at 356 intermediate its ends and above the chamber 360. This constitutes a worm portion and the same meshes with an internal worm wheel 355 having the teeth 354 which mesh with a worm 353 having a non-polygonal opening 352 and herein shown square. A rod 351 of complementary formation is slidably supported therein. Longitudinal movement of this rod does not effect rotation of worm 353. Rotation of this rod, however, does insure rotation of this worm. The worm 353 is similarly enclosed by the housing 386 and is similarly positioned in the chamber 350 thereof by means of the washer arrangement, previously described with reference to the worm 362.

The housing 386 includes an upwardly directed extension 349. The member 358 includes an overhanging portion 348 and the latter includes an elongated arcuate slot 347—see Fig. 4—and the pin portion 349 is provided with suitable means 346 for locating at the factory, member 358 so far as rotative relationship is concerned with reference to the housing 386. This locating arrangement, however, does not interfere with relative axial movement therebetween which is necessary as will be hereinafter pointed out.

Mounted on and rigid with the shaft 362 is a pair of spaced discs 345, see Fig. 1. An arm 344, see Figs. 3 and 1, terminates in a ball portion 343 positioned between these discs. The arm 344, therefore, is responsive only to longitudinal movement of the shaft 364 and is not responsive to any rotative movement of said shaft. Furthermore, the discs are of such size that as the member 358 reciprocates, as will be more fully set forth hereinafter and for the purpose to be described hereinafter, the ball member 343 always is in position for operative action if the rod 362 is moved longitudinally.

Reference now will be had to the upper portion of the injector shown in Fig. 1 and to Fig. 3. The arm 344 is rigid with the valve member 342 which includes a passage portion 341. Said valve is arranged to provide communication between the two passages 340 and 339 in the member 358. Passage 339 is a relief passage leading from the interior of the member 358 and when the valve is properly positioned, the fuel intended for the nozzle is bypassed through passage 339 into passage 340 and communicates with the supply line 338 that communicates with a header structure 337 common to all injectors of the engine. Thus, as the plunger 385 is actuated by the cam and when the valve 342 is properly positioned to provide the bypass communication last mentioned, the fuel is cycled and not discharged to the nozzle. This operation it might be here stated, is continuous with engine operation when operating as a gasoline engine.

There is also another passage 336 which is an equalizing supply passage, the purpose of which will be set forth more fully very shortly. The main supply passage to the injector, so that the same may operate as a fuel pump, is passage 335. It is extended as at 334 and this is enlarged to form a chamber 333 which mounts a spring 332 bearing on the ball 331 that engages the seat 330. Normally this ball is seated and constrained in that position by the said spring. Upon the suction stroke of the injector or pump, as will be more fully set forth, the ball is unseated by the liquid fuel supplied under pressure through header 337 and supply line 338 to supply fuel to the main supply line 334.

Reference will be had to the parts within the central portion of the housing 386—see Fig. 1, and more especially Fig. 2. Press fitted into opening 385a in the base of the plunger member is the portion 329 from which there extends upwardly the stem 328. This stem or piston has an axial bore 327 therein which is considerably elongated and has a lateral communicating passage 326

that leads to the cylindrical surface of said stem. The member 358 includes a central bore 325 relieved as at 324.

Press fitted in the bore 325 is the barrel 323 shown most clearly in Fig. 2. It includes a central bore 322 in which reciprocates as well as rotates, the stem 328, before mentioned. The bore 322 includes a passage 334a which registers with the bore or passage 334, see Fig. 1—the main supply passage. It also includes a co-axial discharge passage 321 which terminates in a seat portion 321a adapted to seat a ball 320 normally constrained by spring 319 toward seated position. Said ball and spring are mounted in the chamber 318 in the member 358. The latter also includes a passage 317 to which the conduit 387 mentioned hereinbefore, communicates and this conduit leads to the nozzle structure 388 subsequently to be described.

Referring again to Fig. 2, the barrel includes a semi-circular groove 316. It also includes a modified triangular opening 315, having the lower edge 315a similar to a portion of a hysteretic curve and generated as a portion of a helix.

When the member 385 is positioned as shown in Fig. 1, the passage 326 registers with the semi-cylindrical slot 316, and, therefore, there is an equalization of pressure at this point. As the plunger 385 is elevated, the passage 326 is sealed and from the upper edge of the slot 316 to the lower curved edge of the triangular slot 315 the oil is subject to mechanical pressure and is forced outwardly from the bore 322 passing the check valve 320 into the nozzle supply line 387 until the plunger reaches the end of its stroke, provided further that passage 339 is not connected to passage 340 by valve 341, as previously described. With reference to the end of the stroke, before mentioned, the effective end of that stroke is determined by the lower edge of the modified triangular slot so that the plunger may have further actual movement but the same is ineffective for pumping purposes.

Reference is had to the previous description which describes the rotation of the plunger by means of the lower gear shown in Fig. 1. It will be apparent that when that occurs the effective length of the pumping stroke is varied and since the rotation is limited to approximately 180°, the triangular slot is similarly limited and when the plunger is rotated to that point so that the effective stroke is the smallest, as shown to the left in Fig. 2, between the two slots 315 and 316, the least amount of oil will be pumped. At the opposite end, the slot parts may be so arranged that the maximum stroke is utilized for maximum pumping.

Reference is again had to the raising and lowering of the member 358 carrying with it the bore 323 when the shaft 351 is rotated, and it might be here noted also the pin 349, see Figs. 1 and 4 serves to hold the member 358 against rotation due to the tendency of the part to rotate by reason of the worm arrangement, thereby insuring axial movement instead of rotational movement. This raising or lowering of the barrel 323, as it were, is in effect a retarding or advancing of the time of injection.

Reference now will be had to the upper portion of Fig. 1, to-wit, the nozzle structure designated by the numeral 388. The line 387 supplies fuel thereto. The line 387a constitutes a waste or return line and the same connects to the interior of the housing 386 as at 314 and the oil thus returned by line 387a flows downwardly and is

discharged through port 376, passage 377, passage 372 and conduit 371, to the oil reservoir not shown. Annular groove 376a is the collector channel.

The body portion of the nozzle 388 is shown positioned in a bore 313 restricted as at 313a and provided with a conical portion 313b that opens into the back wall of the injection chamber A1. The body portion 388 includes a passage 312 which terminates in an annular channel portion 311. This channel portion is closed by the flange 310 of a tubular portion 309 having the tapered or conical portion 308.

A sleeve 307 is slidably mounted in the bore of the portion 309 and the exterior of said sleeve is grooved. It terminates adjacent portion 308 forming a chamber 306 between portion 308 and the tapered portion 305 of the tubular member 304. The tubular member 304 projects into the injection chamber and is indicated by the numeral 388a. The rear end of the bore of this nozzle tip is plugged as at 303 and the same extends into the chamber 302 in the member 388. A spring 301 normally constrains the internal tip outwardly into nozzle closing position.

Upon the compression stroke, the air is forced into the opening and into this bore of the tip and thus is stored therein, and following fuel injection, as herein after pointed out, this compressed stored air is released and serves to further clean and cool the tip in addition to the cleaning and cooling action previously described hereinbefore.

The body portion includes a passage 300 which connects the chamber 301 with the conduit 387a and thus any oil that leaks into the chamber 301 and accumulates, discharges as previously described, by way of conduit 344—see lower left portion of Fig. 1—and, therefore, no pressure can be built up in this chamber.

The purpose of the grooving and the chamber 306 is to insure preheating of the fuel previous to injection. It also serves to keep the tip cool, thus preventing warping and the like, of the tip due to excessive heating. The member 388 is threaded as at 389 and threads into a conically pointed member 390 seated in portion 313.

The split collar 391 is clamped between the body portion 388 and the member 390 and provides a stop for engagement by a threaded sleeve 392 having threaded engagement with the threaded portion 393 in the body portion 394 of the engine. The fuel supply conduit 387 by means of the fitting 395 is connected to the body portion 388 of the nozzle and is in communication with the supply passage 312 by means of the passage 396. Upon the fuel being supplied to passage 312 under pressure, the same builds up a pressure in the chamber 306 which forces the inner nozzle portion inwardly in opposition to spring 393 and thus the fuel discharges from the tubular nozzle chamber 306. Upon cessation of pressure, spring 393 becomes effective to shut off the nozzle.

It will also be observed that the member 392 is flanged as at 397 and member 388 is shouldered as at 398 so that in backing out the sleeve 392, the flange 397 engages the shoulder 398 and pulls the entire nozzle with it, thus freeing the nozzle from the engine body portion 394. From the foregoing, it will be apparent the nozzle structure is firmly seated in the engine body portion in as leakproof relation as possible and for that purpose the copper gasket 399 may be interposed

between the nozzle tip and the engine body portion 394.

In Fig. 5 there is illustrated a modified form of the structure illustrated in the lower central portion of Fig. 1. Numeral 1383 indicates the cam shaft with cam portion 1384 for elevating member 1375 in opposition to spring 1369. Herein, the stem 1328 is flared outwardly at its lower end as at 1328a to seat the lower end of said spring.

The lower laterally enlarged end of the stem is recessed at 1300 to nest the upper end of a link member 1302 provided with a longitudinally elongated slot 1303 in which rides pin 1301 carried by and extending across the recess in stem 1328.

The lower end of the link 1302 is provided with a longitudinally elongated slot 1304 at right angles to slot 1303. There is positioned the transverse pin 1305 having one end socketed at 1306 in upwardly directed recess in member 1375 (see 385a in Fig. 1). The other and threaded end 1308 of pin 1305 is threaded into threaded bore 1307 aligned with socket 1306.

Other numerals in Fig. 5 of the 1300 series indicate parts like or similar to those indicated by the 300 series in Fig. 1. The foregoing connection is of lost motion, universal joint character.

Reference now will be had to Fig. 6. In this figure numerals of the 400 series indicate like or similar parts. No detailed description of the same is believed necessary in view of the minute description given with reference to Figs. 1 to 4, inclusive. However, it is here pointed out that the fixture 474 is shown as previously described with reference to the fixture 374 in Fig. 1 in the locating position as distinguished from the normal operative position. Also in this figure, the member 490 is shown provided with recesses 490a, and these are provided for tightening the member 490 to the body portion 388 of the injector. In this form of the invention, the nozzle structure is shown rigidly associated with the injector structure through the fitting 400a.

It is to be observed that the Diesel fuel pump operates as long as the engine operates, although a bypassing is effected during gasoline operation. To start cold, the engine operates as a gasoline engine. When desired, at any time thereafter that the engine is capable of operating as a Diesel engine, the transformation is effected. Should there be air trapped in the Diesel fuel supply, the momentum of the engine flywheel (not shown) together with other parts and their tendency to continue functioning causes the Diesel fuel pump to first discharge or ejects the trapped or locking air and then to discharge fuel. This is because the supply of fuel to the fuel pump is at the lower end thereof, so the air is first discharged from the pump and then the fuel follows.

The resulting engine therefor, is more than a gasoline started Diesel for the gas phase of operation is a true power or load phase and not an incidental low load or starting phase. Therefore, operation as a gasoline engine under load imposes no undue strain or stress upon the engine and the resultant convertible structure as hereinbefore pointed out has the several advantages of each type of engine and be selectively operated as such and has substantially none of the disadvantages of so-called convertible engines or engines arranged solely for starting or light purposes under one phase and normal or heavy operation under the other phase.

This application is a continuation-in-part of application Serial No. 199,210, filed March 31, 1938, now Patent No. 2,277,130, dated March 24, 1942, as to Fig. 5 herein, and said parent application and said patent, now of public record, is made a part hereof for so much as is briefly described and claimed herein.

While the invention has been illustrated and described in great detail in the drawing and foregoing description, the same is to be considered as illustrative and not restrictive in character.

The several modifications described herein as well as others which will readily suggest themselves to persons skilled in this art, all are considered to be within the broad scope of the invention, reference being had to the appended claims.

The invention claimed is:

1. In a Diesel engine fuel injection system, the combination with an engine operable cam, a longitudinally movable cylinder means, a cam reciprocable piston means in one end thereof, a check controlled fuel supply to the opposite end thereof, a check controlled fuel discharge from the last mentioned end, a control chamber adjacent the cylinder means and having operative communication with the supply ahead of the check therein, said piston means including a bore extending from the cylinder means exposed end to the piston means surface remote from the last mentioned end but juxtapositioned relative to the cylinder means, said cylinder means including a triangular like opening in its wall communicating with the chamber and an arcuate opening spaced from the triangular opening and in the wall and similarly communicating, and means for rotating one of the means for the purpose described.

2. A system as defined by claim 1, characterized by the addition of a lost motion including, universal joint type connection between the cam operable piston and cam operable means therefor.

3. In an injection system for a Diesel engine including a fuel supply, a fuel discharge to the engine, a check valve in each, and a pressure chamber with which the supply and discharge communicate through the check valves, the latter permitting uni-directional flow from the supply to the discharge, the combination of a cycling controlled bypass including pump comprising a cylinder provided with said chamber, a variable stroke piston in said cylinder and longitudinally ported from the cylinder exposed end thereof and projecting from the cylinder opposite the chambered end, the piston having a laterally directed passage in free communication with the longitudinally directed port, bypass providing means from the chambered end of the cylinder to the piston including end thereof, valve means in the bypass, the last mentioned end of the bypass means having operative association with the piston lateral passage, said last mentioned bypass end being of adjustable character.

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