Sept. 30, 1958 J. W. PAYNE 2,854,156

HYDROCARBON CONVERSION

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Fig. 1.

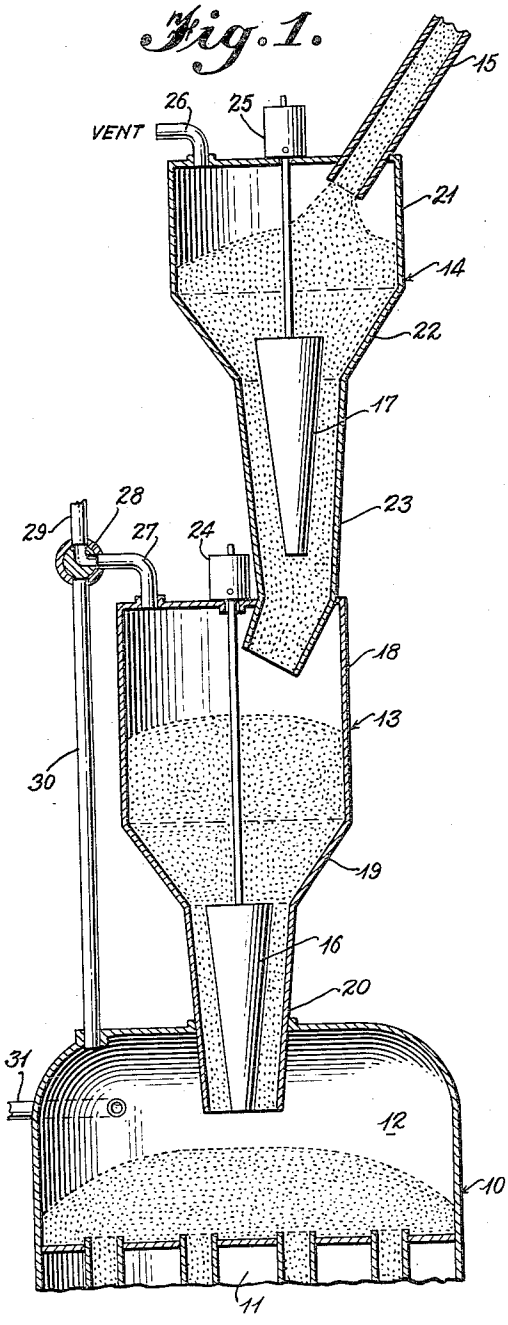
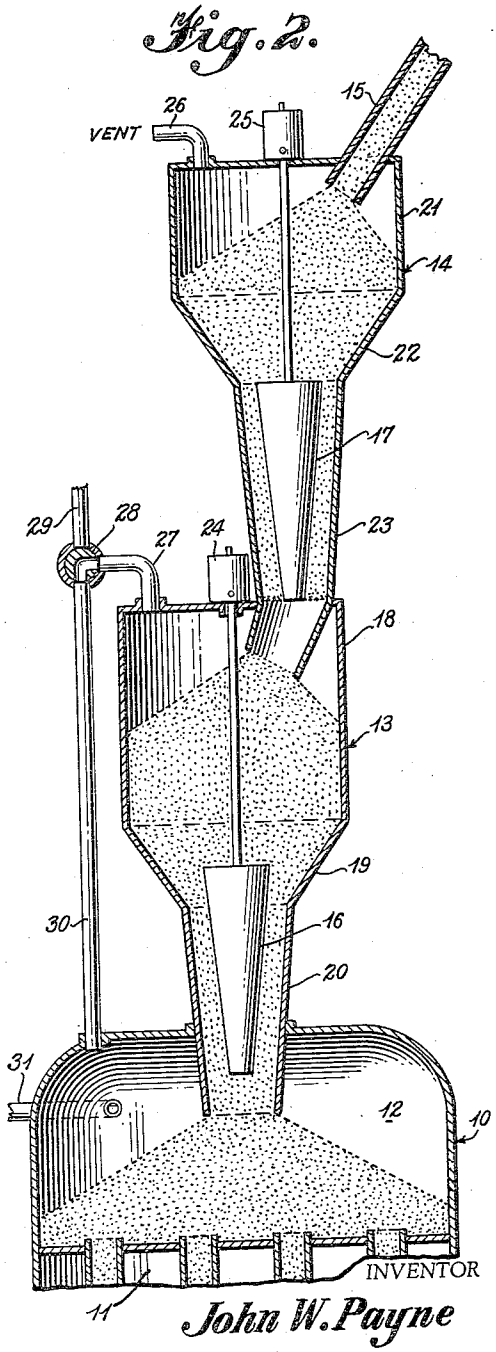


Fig. 2.



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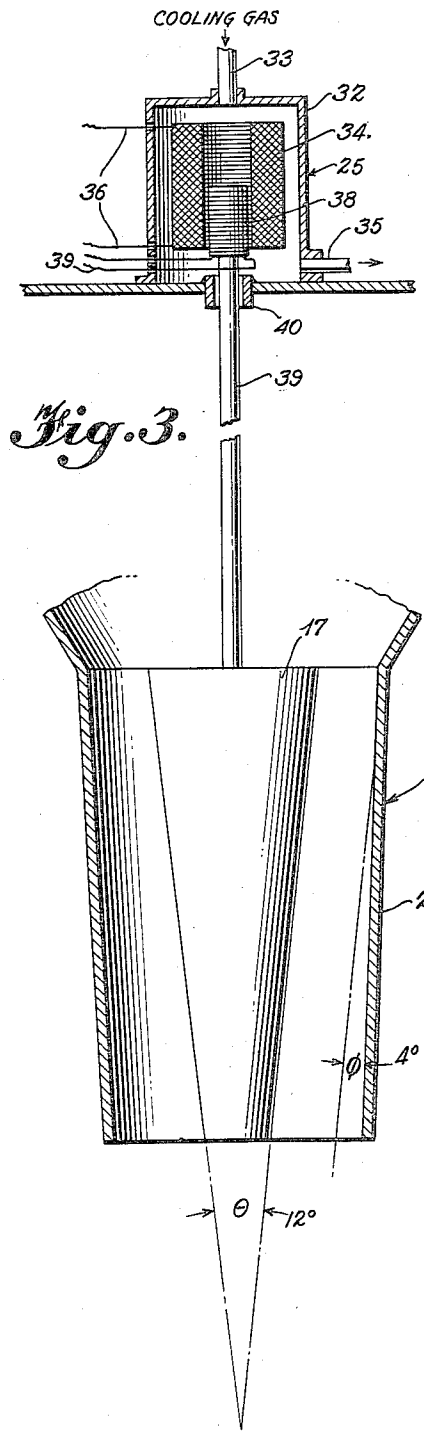


Fig. 3.

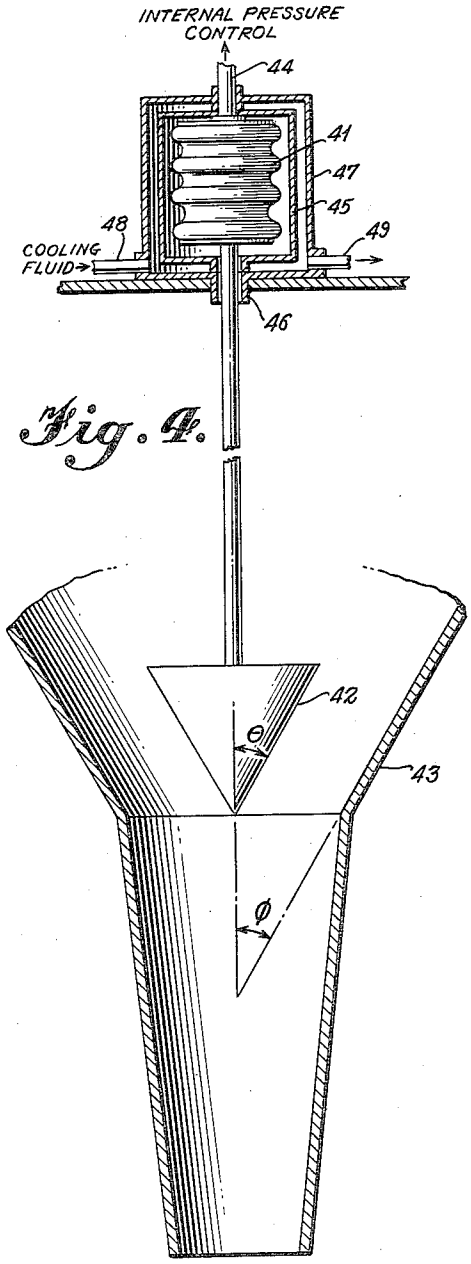


Fig. 4.

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HYDROCARBON CONVERSION

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Application November 8, 1954, Serial No. 467,501

2 Claims. (Cl. 214—17)

This invention relates to the conversion of hydrocarbons by systems of the type which involve moving beds of granular contact material and more particularly to the use of the contact material to maintain seals between zones of different pressures.

In the cracking of hydrocarbons to produce an increased yield of hydrocarbons boiling in the gasoline range it is customary to employ a continuously moving bed of granular catalyst material. Succeeding portions of this material flow through a reactor in which the conversion of the hydrocarbon material takes place. During this reaction the contact material becomes contaminated and provision is therefore made to deliver the moving bed to a regenerator wherein the contaminants are burned off. Succeeding portions of the regenerated contact material are then returned to the reaction or conversion zone.

It is desirable that the hydrocarbon conversion take place under pressure and that the regeneration of the contact material take place at atmospheric pressure. Accordingly, the problem is presented of continuously feeding contact material into a reaction zone while maintaining a positive pressure above atmospheric within that zone. One way to effect the seal is to use valves. These are, however, discontinuous in operation, expensive to install and maintain, and damaging to the contact material. Accordingly, resort has been had to feed legs of granular contact material which are long enough to maintain a head of contact material sufficient to keep the desired pressure level within the reactor. Recently there has been a tendency to resort to higher and higher pressures in the reaction zones and this creates a requirement for longer and longer feed legs in order to maintain the seals with an adequate factor of safety.

In an effort to overcome this problem, resort has been had to feed legs containing zones of increased cross sectional area along their length. The presence of these zones reduces the length of feed leg required to hold any given pressure. The effect of the wide zone is to increase the static pressure of the gas being held back while reducing its dynamic pressure. This prevents the gas from reaching a bed disrupting velocity at the top of the bed of contact material. The actual volume of the intermediate zone of increased cross section is, of course, dependent upon the pressure to be held and there must be maintained a sufficient amount of contact material above the plane where the gas falls below bed disrupting velocity to keep the bed density constant so that flow resistance will be stable. If these conditions are met, it is found that the length of the leg necessary to hold a given pressure may be reduced.

It is an object of this invention further to improve the invention briefly described in the preceding paragraph by still further shortening the length of leg which is required to contain a given pressure. It is proposed according to the present invention to employ a feed leg system having portions of increased cross sectional area

and to operate these in a cyclic manner with periodic compacting of the contact material to increase its capacity to hold reactor pressures. Other objects and advantages of this invention will be apparent upon consideration of the following detailed description of several embodiments thereof in conjunction with the annexed drawings wherein:

Figure 1 is a fragmentary view in section showing a preferred form of the present invention in one part of its cycle of operation;

Figure 2 is a view of the apparatus of Figure 1 in another part of its cycle of operation;

Figure 3 is a detailed view in vertical section of a tamping plug designed according to the present invention, one form of driving means therefor also being shown; and

Figure 4 is a view in vertical section of another type of tamping plug according to the present invention with a different type of actuator.

Referring now to Figures 1 and 2, the numeral **10** designates a reactor in which hydrocarbons are treated in the presence of granular contact material flowing continuously as a moving bed through a reaction zone generally designated at **11**. Above the reaction zone there is a contact material receiving zone **12** which always contains enough contact material to maintain a continuously moving bed in the zone **11**. The zone **12** is supplied with contact material from a hopper **13**. The hopper **13** is supplied with contact material from a hopper **14** and the hopper **14** is supplied with contact material from a chute **15**. The chute **15** receives contact material from a regenerator not shown and an elevator which raises the contact material from the regeneration to the top of the chute. It is customary to regenerate at atmospheric pressures and accordingly the contact material delivered to and issuing from the chute **15** is at atmospheric pressure. On the other hand, the pressure within the reactor **10** is about **15** p. s. i. g. This being the case, it is apparent that if pressure leakage from the reactor **10** is to be avoided, the material in the hoppers **13** and **14** must be of such density as to prevent the escape therethrough of fluids under such pressure as prevail within the reactor.

The foregoing objective is achieved by the using of tamping plugs **16** and **17**. It will be noted that the hopper **13** contains an upper cylindrical portion **18** of wide cross section, a tapering frusto conical portion **19**, and a narrow slightly tapering portion **20** discharging funnel-like into the top zone **12** of the reactor **10**. The hopper **14** is similarly constructed including an upper cylindrical portion **21** of large cross section, an intermediate frusto conical portion **22** and a tapering funnel-like portion of small cross section **23** leading into the top of hopper **13**. Tapered plugs **16** and **17** are actuated by solenoid assemblies **24** and **25**, respectively, which vertically reciprocate the respective plugs through a relatively short stroke. The effect of a downward stroke of one of the tapered plugs **16** or **17** is to compact the granular material into the narrow portion **20** or **23** respectively.

The hopper **14** is vented to atmosphere by a pipe **26**. A pipe **27** places the interior of the hopper **18** in communication with a valve **28** which is rotatable to connect the conduit **27** to atmosphere through a pipe **29** or to the reactor **10** through a pipe **30**. A sealing gas under pressure is supplied to the reactor through a pipe **31**.

The operation of the invention depicted in Figures 1 and 2 is cyclic and hence is best understood by a description of a complete cycle. For purposes of this description, let it be assumed that the zone **12** contains an adequate amount of contact material to maintain the moving bed in the zone **11** until the hopper **13** can be refilled. Under these conditions, which are depicted in

Figure 1, the solenoid **24** is actuated to drive the plug **16** downwardly to compact the contact material in the narrow portion **20** of the hopper **13**. Valve **28** is adjusted to the Figure 1 position to vent the hopper **13** to atmosphere. Hopper **14** is continuously vented to atmosphere so that there is no appreciable difference in pressure between the interior of the hoppers **13** and **14** at this stage of the operation. The length of the compacted leg of contact material in the portion **20** of the hopper **13** is enough to hold back the pressure within the reactor **10**, bearing in mind that somewhere in the portion **19** of the hopper **13** the gas velocity falls below bed disrupting value and bearing in mind that even at the beginning of the refill of hopper **13** there is sufficient contact material above the plane where the bed disrupting velocity no longer exists to hold the contact material in position.

In Figure 1 the plug **17** is shown in its upper or retracted position so the contact material can and does flow freely out of the hopper and into the hopper **13**. When the hopper **13** has been adequately filled the flow cycle is changed from that shown in Figure 1 to that shown in Figure 2.

In changing over the first thing that is done is to project the plug **17** downwardly to increase the density of the contact material in the portion **23** of the hopper **14**. Thereafter the valve **28** is moved to the Figure 2 position and the plug **16** is pulled upwardly or retracted to establish a connection between the reactor **10** and the hopper **13**. The pressure in the hopper **13** is quickly equalized with that prevailing in the reactor. The plug **16** being withdrawn, the contact material can and does flow out of the hopper **13** and into the upper zone **12** of the reactor. While this is happening the pressure drop across the portion **23** is held by exactly the same phenomenon as was described in connection with the portion **20** in the Figure 1 position. The hopper **14** can be filled because its upper empty spaces are at atmospheric pressure. By the time the hopper **14** is adequately filled, hopper **13** will be low and the zone **12** will be high. Thereupon the operation is again restored to the Figure 1 position for refilling of the hopper **13**. Repetition of these cycles is continued throughout the operation of the device.

By way of an example, a uniformly tapered seal leg 5' long (part **20—23**) with a maximum diameter of 27.3" and a minimum diameter of 18.6" can be used in catalytic cracking process having a catalyst circulation rate of 350 tons per hour. The bed level in the hopper is never less than 3' (height of part **19—22**), this being to maintain an adequate head above the plane where the bed disrupting velocity ceases. In such a hopper, a tapered plug 5' long actuated by a solenoid was used. The plug tapered from a maximum diameter of 18" at the top to a minimum of 6" at the bottom. The tapered plug forced into the seal leg brought a 10% reduction of bed volume. In order to make the resistance to blowout nearly uniform, it is desirable to use a tapered plug in a tapered leg as shown in Figure 3. The most effective taper is an acute angle theta with the angle phi of the portion **23** greater than zero. In the example shown in Figure 3 theta equals 12° and phi 4°. The apex angle of the frusto conical walls of the portion **23** of the hopper **14** is therefore 4°.

It is to be understood that the compacting which is effected by the plugs such as **17** and **42** is done in a single stroke accomplished normally in about $\frac{1}{10}$ of a second. Retraction of the plug is also effected in $\frac{1}{10}$ of a second. A typical catalyst feed or hopper fill will consume about 10 seconds while adjusting the pressure in the hopper **13** takes about 5 seconds. It will be appreciated therefore that a cycle of the type described above is completed in just over ½ a minute.

In a system of the type described, the contact material leaving the regenerator and entering the hopper **14** is very hot, being from 900° to 1300° F. Electric and mechanical parts need to be protected at these temperatures and

for this reason it is proposed to surround the operating mechanism for the plugs with a cooling jacket. If reference is made to Figure 3, it can be seen that the solenoid **25** is surrounded by a jacket **32** supplied with a cooling gas through the conduit **33**. The cool gas bathes the windings **34** of the stator of the solenoid and then leaves the container **32** through the pipe **35**. The electrical leads to the stator are suitably protected by means known to the art outside of the container **32** and within the container these leads **36** are protected by the cooling gas. Similar protection is afforded to the leads **37** to the armature **38** of the solenoid. The armature **38** is fixed on one end of a rod **39** which at its other end is connected to the plug **17**. A rather long guide bearing is provided at **40** and this bearing is subjected to the cooling action of the gas entering the container **32**.

While the foregoing description has been concerned with the solenoid **25**, it is to be understood that the identical arrangement will be used with solenoid **24**.

In reference to Figure 4, there is shown a Sylphon bellows **41** as an operator for a conical plug **42** in a hopper **43**. The Sylphon bellows is actuated by the application of a pressure fluid thereto through the conduit **44**. The bellows is encased in a housing **45** containing a shaft bearing **46** and the housing **45** lies within a jacket **47** to which the cooling fluid is supplied through conduit **48** and withdrawn through the conduit **49**. The plug shown in Figure 4 can be used in installations such as are shown in Figures 1 and 2. It acts as a piston at the top of the seal leg preventing expansion of the catalyst and subsequent loss of seal against reactor pressure. For this design to be effective the conical point of the plunger **42** must have angle θ (measured from the axis of symmetry of the plunger) which is not less than the angle ϕ of the conical bottom of the hopper. When these two angles are equal the sides of the plunger and the hopper walls are parallel and an advance of the plunger along the axis for symmetry in the direction of the hopper wall will place the catalyst particles in compression. Note in Figure 4 that the angle θ is larger than the corresponding angle in the Figure 3 construction, θ in Figure 4 being greater than 12° but less than 45°.

While the Sylphon bellows is shown as the actuator for the form of tamping plug shown in Figure 4, it is also suitable for actuating a plug of the Figure 3 type as is the solenoid for actuating a plug of the Figure 4 type.

What is claimed is:

1. Apparatus for transferring solid material of palpable particulate form from one location to another, the combination which comprises: a supply hopper, a depending conduit attached below said supply hopper, a pressuring hopper attached to the bottom of said conduit, means for alternately increasing and decreasing the pressure in said pressuring hopper, means defining a discharge outlet from said pressuring hopper for the withdrawal of solid material, means for supplying solid material to said supply hopper, and tamping means located within said conduit and supply hopper adapted for downward movement to compact the solid material at approximately the same time that the pressure in said pressuring hopper is increased, whereby the pressure sealing capacity of the apparatus is increased.

2. Apparatus for introducing solid material of palpable particulate form into a high pressure vessel, the combination which comprises: a supply hopper located above the high pressure vessel, a pressuring hopper located between the supply hopper and the high pressure vessel, a first connecting conduit of restricted cross-section connected between the supply hopper and the pressuring hopper, a second connecting conduit of restricted cross-section connected between the pressuring hopper and the high pressure vessel, a first tamping means located within the supply hopper and the first connecting conduit adapted for downward movement substantially simulta-

neously with the increase of pressure in the pressuring hopper, whereby the solid material in said first connecting conduit is made more compact, and a second tamping means located within the pressuring hopper and the second connecting conduit adapted for downward movement substantially simultaneously with the reduction of pressure in the pressuring hopper, whereby the solid material in said second connecting conduit is made more compact.

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