Sept. 13, 1955 E. V. BERGSTROM 2,717,439

METHOD OF ERECTING HYDROCARBON CONVERSION APPARATUS

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Fig. 1

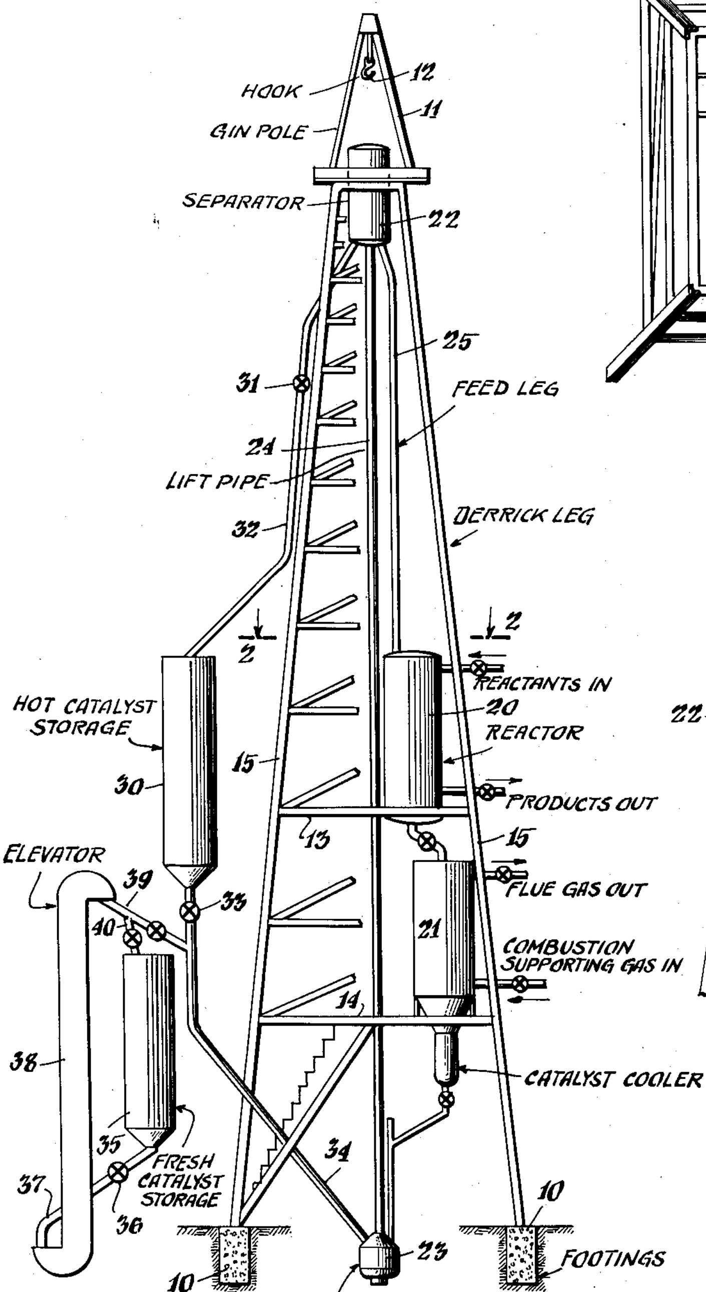


Fig. 2

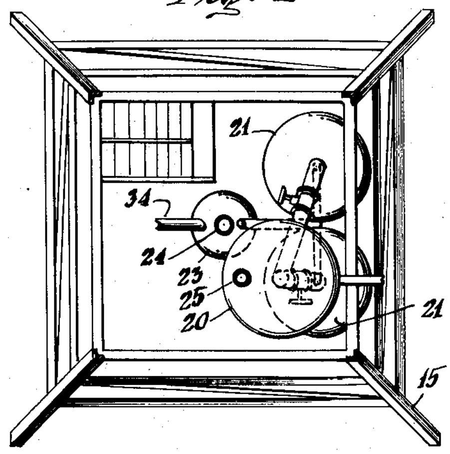
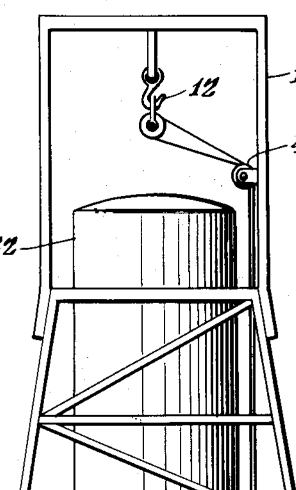


Fig. 3



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METHOD OF ERECTING HYDROCARBON CONVERSION APPARATUS

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2 Claims. (Cl. 29—428)

This invention is directed to a hydrocarbon conversion system and method of erecting such a system. It is more particularly directed to a catalytic cracking system of small size and economical erection.

It is well known in the petroleum art to convert suitably prepared hydrocarbons to more desirable products by bringing them, at suitable conditions of temperature and pressure, into contact with an adsorbent particle-form material. These conversion processes are known as polymerization, alkylation, desulfurization, dehydrogenation, cyclization, hydrogenation and catalytic cracking. By far the most important process, at least at present, is the catalytic cracking of heavy hydrocarbons in the presence of a particle-form adsorbent to produce lighter hydrocarbons in the gasoline boiling range. By this expedient, portions of the crude oil, after the straight run gasoline has been removed, are cracked to produce an increased yield of gasoline.

In addition to increasing the yield of gasoline from each barrel of crude, the catalytic cracking process has the added advantage that the gasoline produced generally has a higher octane number. This fuel is thus more attractive for use in high compression internal combustion engines to prevent undesirable knocking or detonation. Internal combustion engine compression ratios have gradually increased over the years, necessitating a fuel of increasing octane number. The current high compression engines and those to be produced in the near future have caused the fuel octane number requirements to reach unprecedented levels and this demand is being met, by the large refiners, at least, by the increased use of catalytic cracking systems. This has resulted in an octane race among the petroleum refiners in which small as well as large refiners must compete successfully.

Present commercial catalytic creacking systems are large, tailor-made units of about 10,000–15,000 and even approaching 50,000 barrels per stream day. At these outputs, the expense of piecemeal field erection can be met and the cost paid out in a reasonable and practical period of time. When these units are scaled down, however, to provide systems having a capacity of about 1,000–6,000 barrels per stream day, as required by the bulk of small refiners, the excessive cost of piecemeal erection at the site of the structure becomes prohibitive, and although small refiners must have cracking capacity for survival, they cannot obtain it, at present, in the small sized units because of the exorbitant cost. When the vessels are scaled down in size, they are not found to be proportionately less expensive. In addition, erection costs in the field vary only slightly with difference in size of the units erected. Present erection procedure requires the moving into position of a large amount of expensive rigging, for example, $25,000 worth or more. This rigging, which generally includes a gin pole capable of lifting heavy bulky objects to high elevation, is erected by field crews brought to the erection site. It is common knowledge that such a use of skilled labor, in our present economy, is exceedingly expensive. After the erection of the rigging, the structure for the cracking system is commenced adjacent thereto and the unit built from the bottom up. The vessels are assembled piece by piece in the field during erection and in place. After the completion of the unit, the rigging used during erection must be dismantled and removed to the location of the next cracking system, which may be a distance of hundreds of miles.

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In the petroleum industry four-legged, pyramid-shaped derricks are available in many sizes between 100–200 feet tall. These structures are ordinarily mounted over well drilling equipment, designed primarily to support the drill rod as it bores into the earth in search for oil. These structures are available commercially at an economical price, because of the miracle of mass production. For example, they can be obtained in sizes 189 ft., 178 ft., 140 ft., 136 ft., 129 ft., and 122 ft. tall from the floor level to the crown block beam. The crown block beams are horizontally located at the top of the derrick and are adapted to support a heavy crown block or series of sheaves for use in supporting the drill rod. Around the crown block beams is attached a protected platform known as the water table. The aperture through which the crown block is raised is termed the water table opening. Some of the larger sized derricks have water table openings of 7 ft. 6 in. square and the remainder are standardized at 5 ft. 6 in. square. At the top of the derrick is mounted an A-frame or gin pole. The gin pole comprises a horizontal support beam carried on four legs and it is adapted to be used in raising the heavy crown block into position in the water table opening. The prefabricated parts of the derrick are assembled rapidly in the field by bolting or riveting the parts together. The four angle iron legs are braced by appropriate horizontal and angular braces which form so-called panels. On one side of the derrick the bracing members at the bottom are so arranged that an enlarged inverted V-shaped opening is left through which objects can be sucked into the derrick structure. If the load on the derrick is high, the legs can be braced or stiff-legged by the addition of casing which is bolted into the inside of the angle iron legs, the holes in the legs being provided for that purpose.

One favored system of hydrocarbon conversion requires elongated vertical vessels, known as the reactor and the kiln, through which substantially compact columns of particle-form catalyst are gravitated. In this moving bed process the particles are gravitated through the reactor wherein they are contacted with a suitably prepared charging stock at a temperature and pressure appropriate for the desired conversion. The converted hydrocarbons are continuously withdrawn from the vessel and transported to further processing equipment. During the conversion a carbonaceous deposit is formed on the catalyst particles which impairs their catalytic activity. The spent catalyst is removed from the bottom of the vessel and transported to the top of the regenerator or kiln. The catalyst particles, gravitating through the kiln, are contacted with combustion supporting gas for burning the coke deposits from the surface. The reactivated particles are withdrawn from the bottom of the kiln and transported to a location above the reactor. Generally the reactor is operated under advanced pressure while the kiln is operated at or near atmospheric pressure. Therefore, the reactivated catalyst is usually transported to a surge vessel located a substantial distance above the reactor. The catalyst is then gravitated from the surge vessel through an appropriately shaped, elongated feed conduit or leg downwardly into the top of the reactor. The feed leg permits the introduction of the catalyst into the reactor against the advanced pressure maintained therein without the use of valves or seals of a mechanical type. Although less preferred, it is sometimes desired to operate the kiln at a greater or the same pressure as found in the reactor. In this case the kiln may be located above the reactor, with the gravitating feed leg attached to the top of the kiln. When little or no pressure differential is used between the vessels the feed leg can be short and hence the structure materially reduced in height.

The contact particles may partake of the nature of natural clays, treated clays or synthetic associations of silica, alumina or silica and alumina or chromia, any of which may have other constituents added, such as certain metallic oxides. These particles may be regular or irregular in shape, but regular shapes are preferred, such as, spheres or beads, pellets, pills, etc. The size may range from 3–60 mesh, Tyler Screen Analysis, but may preferably range 4–15 mesh.

When the vessel size is limited to about 12 ft. diameter and 50 ft. length or less, the vessel can be transported by rail intact. All the parts and vessels of a moving bed system can be shop fabricated and assembled at a substantial saving in time and money over that required for field assembly. Therefore, by limiting the vessels to a size maximum which is transportable by rail from the fabrication factory to the erection site, a substantial saving can be effected.

This invention proposes, broadly, the erection of a standard oil well derrick, with only minor modifications, at the site of a moving bed system. The vessels and parts of the system are all shop fabricated and shipped to the site as units by rail. The derrick is first used as the erection rig, in that the parts of the moving bed system are sucked in through the inverted-V opening and hoisted upwardly into the structure. The parts are locked in place in the structure end, therefore, the derrick serves the dual purpose of the erection rigging and the moving bed system support means. By this procedure a substantial saving is effected over the cost of a moving bed system scaled down to the size of the unit above described, but assembled in the former manner in tailor-made fashion.

The object of this invention is to provide a simplified moving bed system of catalytic cracking.

It is a further object to provide a "package-type" moving bed catalytic cracking system within the price range of small refiners.

It is a further object to provide a simplified method of assembling a moving bed catalytic cracking system.

These and other objects will be made apparent in the following description, read in conjunction with the attached drawing.

Figure 1 is a diagrammatic sketch of a simplified "package-type" moving bed catalytic cracking system assembled.

Figure 2 is a plan view of a cross section of the system shown in Figure 1 as seen on plane 2—2 of Figure 1.

Figure 3 is a fragmentary view of the top of the system shown on Figure 1 and indexed 90 degrees from the view of Figure 1.

Referring to Figure 1, the footings **10** are first installed, preferably deep enough to reach a firm bed rock. The parts of the derrick are bolted together from the bottom up, the first pieces being placed in position by means of a small gin pole mounted adjacent the derrick structure, and subsequent pieces being located by a gin pole attached to the derrick structure which is moved up as the work progresses. The A-frame **11** is mounted atop the derrick and the hook **12** is attached. The A-frame and hook are adapted to support the sheaves and rigging used in erecting the moving bed system. The derrick is then modified by the addition of cross-members, such as I beams **13**, **14**, to provide a transverse mount for the reactor and kiln. The legs **15**, or at least one of them, are reinforced or stiff legged up to the level of the top cross beam **13**, by bolting or welding reinforcing means, usually tubular casing, into the angle of the legs. This provides additional support for the heavy moving bed and the system vessels.

The reactor **20**, kiln **21**, separator **22**, and related parts of the moving bed system are all fabricated and assembled in factories under conditions which make the fabrication economical. These completely assembled vessels are then shipped by rail, as units, to the site of erection. The reactor **20** is introduced through the inverted V-window at the bottom of the derrick and hoisted upwardly to its support position on the cross-beams **13**. The kiln **21** is then introduced into the derrick in the same manner and located on cross-beams **14**. The lift pot **23** is mounted in a centrally located place and the related conduits are built up, generally from the bottom upwardly. The lift pipe **24** and feed leg **25** assembly is stopped near the top and the separator **22** is lifted into position. The lift pipe **24** and feed leg **25** can then be completed up to the separator **22**. The gin pole **11** and hook **12** are left in position for servicing the unit after the installation of the system is complete. Therefore, there is no rigging to dismantle and remove at the conclusion of the assembly. Related vessels and piping can be quickly connected to the system and the unit placed immediately on stream.

It is seen that, by following the above indicated techniques and erection procedure, the cost, and particularly the field costs, are greatly reduced. The erection time is materially reduced, placing high octane gasoline in the hands of the small refiner at the earliest time after decision to build, thereby helping him to hold his position in the race to high octane motor fuel. In the present highly competitive fuel market this may be an exceedingly important factor for the small refiner requiring a unit of about 1000–6000 bbls. per stream day.

As an illustration, a 189 ft. standard derrick is selected having a 38 ft. 6 in. square base, 17 ft. gin pole atop the structure, and a water table opening of 7 ft. 6 in. The V-window has a clearance of 27 ft. 7¼ in. at the center. The gin pole has a vertical lifting capacity of 20,000 lbs., which is adequate for the loads involved in erecting the vessels and piping of the moving bed system. The kiln may conveniently be 12 ft. in diameter x 37 ft. 8 in. long, and the reactor may conveniently be 10 ft. in diameter by 34 ft. 6 in. long. The cross beams are appropriately placed at about 88 ft. and 45 ft. elevations and the reactor and kiln are lifted and locked in place. The kiln supports a catalyst cooler below it for cooling the catalyst withdrawn from the kiln. The lift pot is installed and the conduits built up to an elevation somewhat below the top of the derrick. The separator may be a vessel of about 7 ft. diameter and 24 ft. long. This vessel is lifted into place so that a substantial portion of the vessel projects through the water table opening under the gin pole. The conduits are then completed and the external vessels and pipes are connected into the system.

It is seen that there results a feed leg about 50 feet long, which, when properly shaped, can introduce catalyst into the reactor against a pressure differential of about 10 pounds per square inch. It is desirable to operate the kiln near atmospheric pressure to avoid expensive gas pumping equipment and gas sealing means. When the pressure differential between kiln and reactor is small, as in the less preferred form of operation, the feed leg can be reduced, and hence, the smaller derricks, such as, for example, 120 foot derrick, can be used. A satisfactory catalyst circulation rate is found to be about 80–90 tons per hour, and hence, the lift pot and lift leg are designed to provide this flow. A hot catalyst storage vessel may be suitably mounted adjacent the derrick having a diameter of about 12 ft. and length of about 95 ft., as indicated by detail **30** on Figure 1. When valve **31** is opened, catalyst from the separator feeds into the hot storage vessel **30** through the conduit **32**. When the valve **33** is opened, the catalyst is returned from the hot storage vessel to the lift pot **23** through the conduit **34**. A fresh catalyst vessel 35 is also suitably located outside the derrick below the hot catalyst storage vessel. When fresh catalyst is needed the valve 36 is opened allowing catalyst to feed through the conduit 37 to the elevator 38. The catalyst discharges from the top of the elevator through the conduit 39 into the conduit 34, thereby reaching the lift pot 23. The fresh catalyst vessel 35 can be filled by using the elevator 38, which may suitably be a 10 ton per hour bucket type conveyor, to introduce catalyst into the top of the vessel through the conduit 40.

When processing a crude which deposits large amounts of carbon on the surface of the catalyst, a larger regeneration vessel may be required than the maximum prescribed hereinbefore. The increased burning capacity can be provided by using two kilns in parallel arrangement. Referring to Figure 2, a plan view of the derrick as seen on plane 2—2 of Figure 1, the two kilns 21 are shown in side by side relationship. It has been found desirable to have the lift pipe of gas lifts adapted for raising granular contact material substantially vertical and straight. Hence, the lift pipe is centrally located in the derrick as shown on the Figure 2. The corners of the derrick are referred to as bays. In Figure 2, therefore, two bays are occupied by the kilns and a third bay is occupied by the stair well. This leaves an empty bay through which repair and replacement parts can be lifted. Figure 3 shows a front view of the top of the derrick and the gin pole, as seen from a position indexed 90 degrees from the view in Figure 1. The hook 12, as previously indicated, is left in position after assembly. A guide sheave 40A or series of them is used to route the cables around the separator, and into the open bay so that loads can be lifted to any desired level. It is seen therefore that the shape of the derrick is ideal as a support structure for the simplified or "package-type" moving bed catalytic cracking system. The lower wide base provides ample space for the kiln and reactor, which are mounted near the ground. The empty bay provides working space in the structure, whereas, in the former moving bed systems, rigging had to be built alongside the unit when repairs or exchange of parts was required.

These package-type moving bed cracking systems may range in size from 1000–6000 barrels per stream day and preferably 1500–3000 barrels per stream day. The kiln and reactor both may range 10–12 ft. diameter by 35–50 feet long. Using the larger sized kiln, the burning rate will be approximately 1600–2000 pounds per hour of coke. Hence, when the burning demand is greater than 1600–2000 pounds per hour, two kilns must be used in parallel circuits. The 189 foot derrick is found to be suitable for all simplified moving bed systems now contemplated; however, smaller derricks can be used for smaller cracking systems. The support strength of the standard 189 foot derrick is approximately 1,000,000 pounds. The weight of the largest package-type moving bed system including catalyst is approximately 1,000,000 pounds. The 12 foot diameter vessel is substantially the largest vessel that can be used without displacing the centrally located lift pipe. As previously indicated, it is desirable to keep the lift pipe in the center. Hence, this adds a further limitation on the size of the vessel.

Approximately one-third of the time required for setting up a moving bed system is saved by using the method of erection herein disclosed when erecting a moving bed catalytic cracking system of equivalent size. There results an overall saving of about $100,000 for a 3000 barrel per stream day unit built as hereinbefore disclosed over building a 3000 barrel per stream day unit in the former manner. This saving is sufficient to enable the small refiner to produce cracking capacity at a reasonable and economical price, thereby preventing the small refiners from being forced out of business or into combination with other refiners as a result of the present highly competitive octane race.

The above-indicated examples are included for explanatory purposes and are not intended to limit the scope of the invention. The only limitations intended are those found in the following claims.

What is claimed is:

1. The method of erecting a simplified moving bed hydrocarbon cracking system which comprises erecting a well derrick, comprised of frame means defining a space of a cross sectional area that decreases with height, attaching a gin pole to the top of the derrick, attaching a support member to the gin pole, attaching substantially horizontal supporting means to the derrick in the lower section thereof adapted to support a reactor, stiff-legging at least one of the legs of the derrick up to the level of the horizontal support means, introducing a prefabricated reactor through one of said frame means near the bottom thereof, hoisting said reactor within the derrick by means of rigging attached to the support member to said horizontal support means, supporting said reactor from said support means, said reactor being located in one corner of the derrick, attaching a second substantially horizontal supporting means to the derrick in the lower section thereof adapted to support a kiln, similarly introducing and hoisting a prefabricated kiln within the derrick by means of rigging attached to the support member to said second horizontal support means, supporting said kiln from said support means, said kiln being located in the same corner of the derrick as the reactor at a level below the reactor, locating a lift pot at the bottom of the derrick in a central location, building a lift pipe from prefabricated sections upwardly from the lift pot to a location near the top of the derrick, connecting the bottom of the reactor and top of the kiln with a communicating conduit, connecting the bottom of the kiln and the lift pot with a communicating conduit, building a gravity feed leg above the reactor to a location near the top of the derrick, hoisting a prefabricated separator into position at the top of the derrick, attaching said separator to the top of the derrick, and connecting the lift pipe and feed leg to the bottom of the separator.

2. The method of erecting a simplified moving bed cracking system which comprises erecting a well derrick comprised of frame means defining a space of a cross sectional area that decreases with height, attaching a gin pole to the top of the derrick, attaching a hook to the gin pole, attaching substantially horizontal supporting means to the derrick in the lower section thereof adapted to support a first vessel, stiff-legging at least one of the legs of the derrick up to the level of said horizontal supporting means, introducing a first prefabricated vessel through one of said frames near the bottom thereof, hoisting said first vessel within the derrick to said horizontal supporting means by means of rigging attached to said hook, supporting said first vessel from said supporting means in one corner of the derrick, attaching a second substantially horizontal supporting means to the derrick in the lower section thereof adapted to support a second vessel, similarly introducing and hoisting said second vessel within the derrick to said second horizontal supporting means by means of rigging attached to said hook, supporting said second vessel from said horizontal support means in the same corner of the derrick as the first vessel at a level below the first vessel, locating a lift pot at the bottom of the derrick in a central location, building a lift pipe from prefabricated sections upwardly from the lift pot to a location at the top of the derrick, connecting the bottom of said first vessel and the top of the second vessel with a communicating conduit, connecting the bottom of the second vessel and the lift pot with a communicating conduit, building a gravity feed leg above the first vessel to a location near the top of the derrick, hoisting a prefabricated separator into position at the top of the derrick, attaching said separator to the top of the derrick and

connecting the lift pipe and feed leg to the bottom of the separator.

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