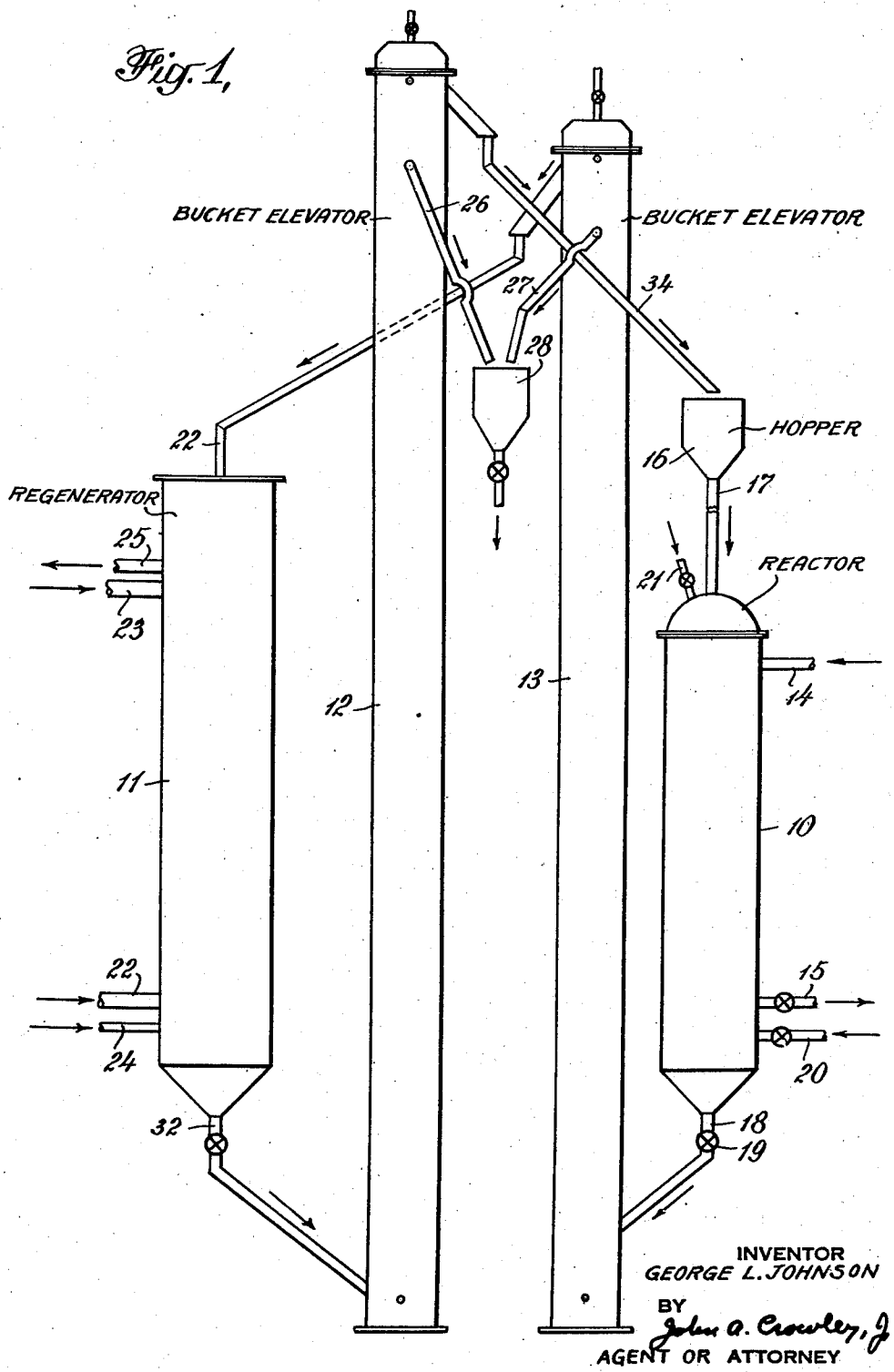
June 29, 1948. G. L. JOHNSON 2,444,258

METHOD AND APPARATUS FOR CONVERSION OF FLUID HYDROCARBONS

Filed Aug. 14, 1946 4 Sheets-Sheet 1

Fig. 1,



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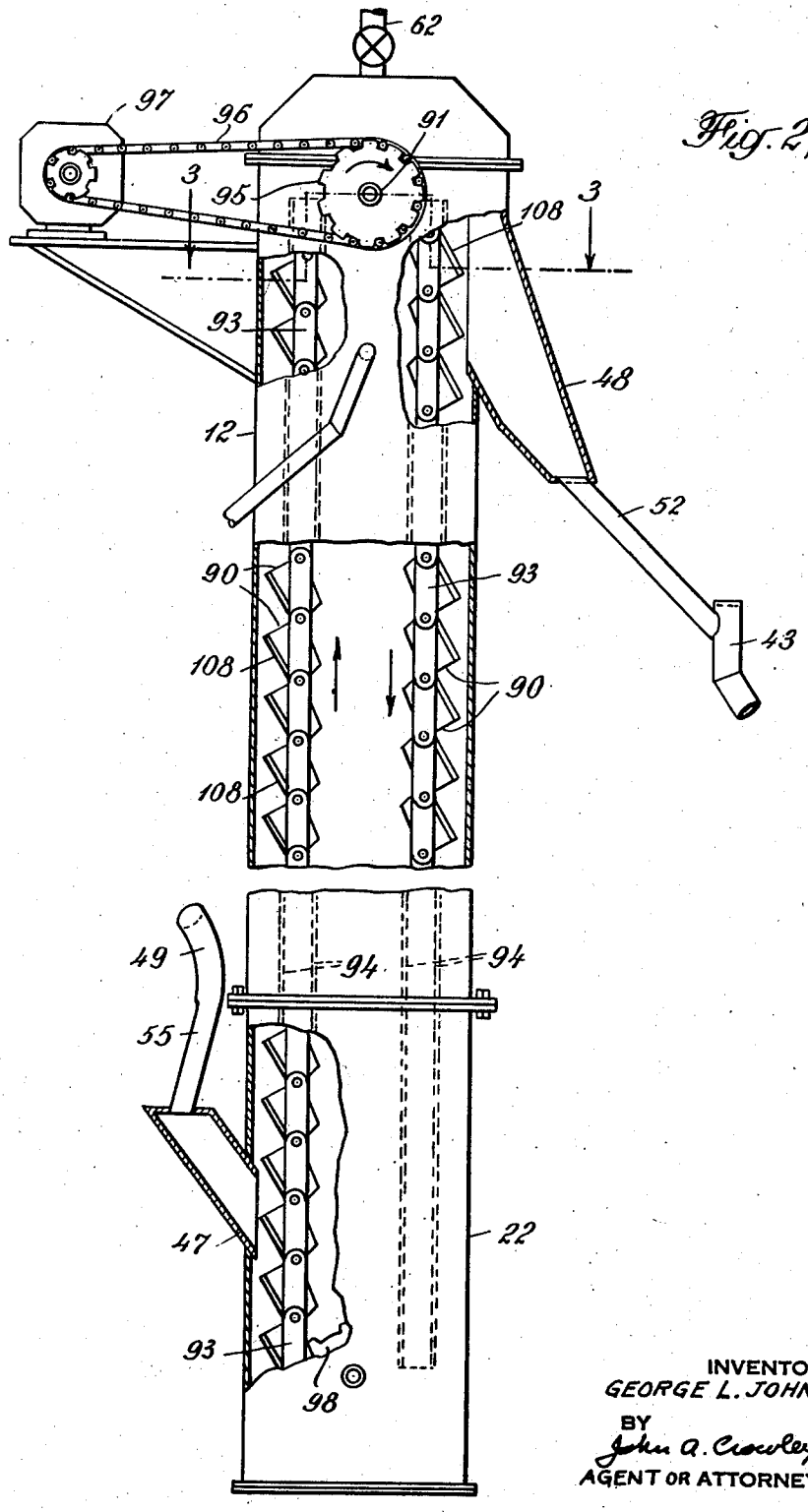
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METHOD AND APPARATUS FOR CONVERSION OF FLUID HYDROCARBONS

Filed Aug. 14, 1946

4 Sheets-Sheet 2

Fig. 2,



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METHOD AND APPARATUS FOR CONVERSION OF FLUID HYDROCARBONS

Filed Aug. 14, 1946 4 Sheets-Sheet 3

Fig. 3,

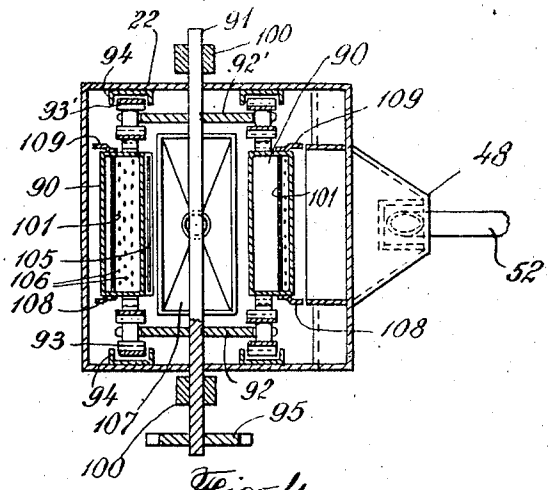
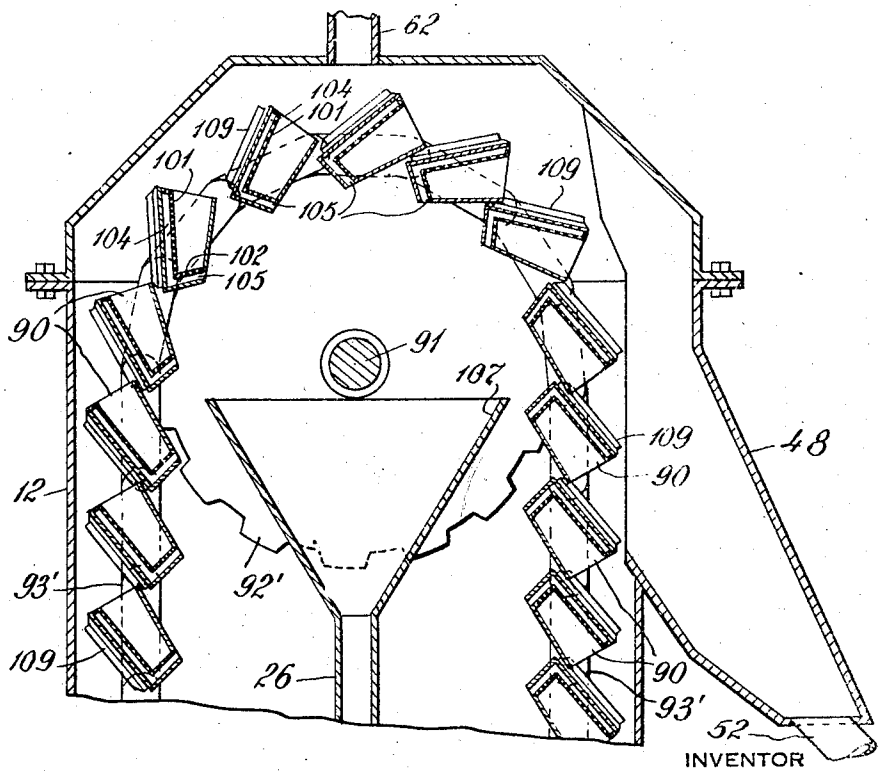


Fig. 4,



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METHOD AND APPARATUS FOR CONVERSION OF FLUID HYDROCARBONS

Filed Aug. 14, 1946 4 Sheets-Sheet 4

Fig. 5,

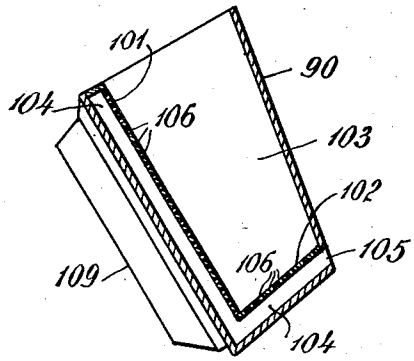


Fig. 6,

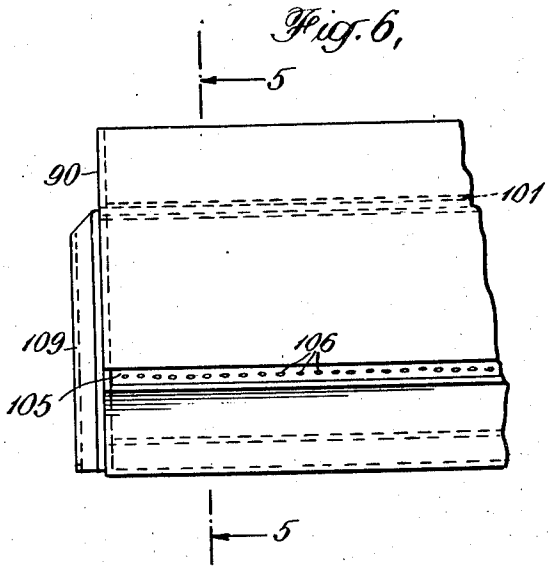
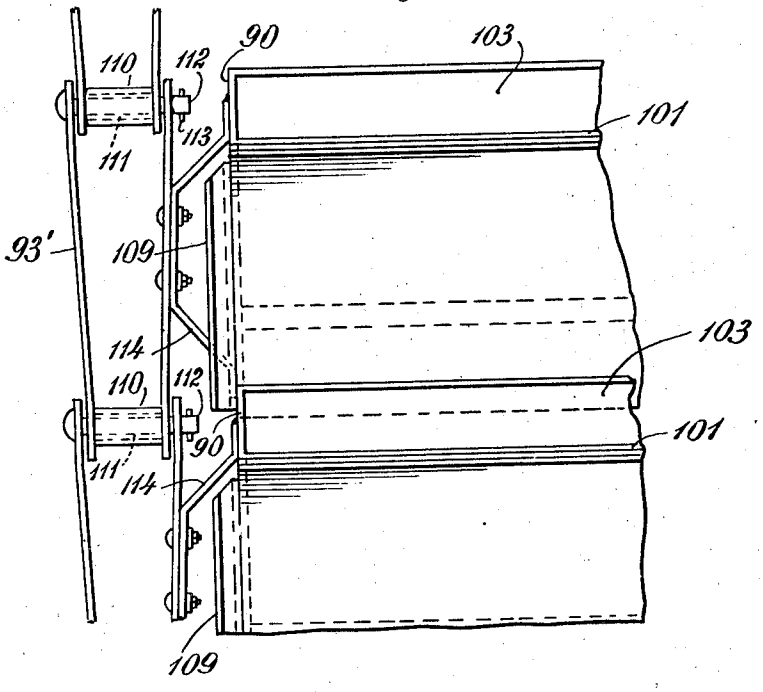


Fig. 7.



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METHOD AND APPARATUS FOR CONVERSION OF FLUID HYDROCARBONS

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Application August 14, 1946, Serial No. 690,377

9 Claims. (Cl. 196—52)

1

This invention has to do with a method and apparatus for conversion of fluid hydrocarbons in the presence of a moving particle form solid contact material which may or may not be catalytic in nature. Exemplary of the hydrocarbon conversion which may be conducted by this method and apparatus are the catalytic aromatization, hydrogenation, dehydrogenation, polymerization, isomerization, alkylation, reforming, hydroforming, treating, desulfurization, and cracking of hydrocarbon fractions. Also exemplary are the viscosity breaking, cracking and coking of heavy liquid hydrocarbons in the presence of a hot solid inert material. This invention is particularly concerned with processes wherein the contact material moves cyclically through a conversion zone wherein it flows as a substantially compact column of moving solid particles while being contacted at suitable elevated temperatures with fluid hydrocarbons either in the gaseous or liquid phase or both to effect their conversion and then through a revivification zone wherein it flows as a substantially compact column while being contacted with a suitable revivifying gas which in many instances may be air acting to burn off from the contact material a carbonaceous contaminant deposited thereon during the hydrocarbon conversion. When the contact material employed is catalytic in nature it may take the form of natural or treated clays such as fuller's earth and Super Filtrol, bauxites, activated alumina, activated charcoal, inert carriers bearing deposits of catalytic metallic oxides, or synthetic associations of silica, alumina or silica and alumina to which may be added small percentages of other materials such as certain suitable metallic oxides. When the contact material employed is non-catalytic in nature, i. e., inert to the reaction, it may take any of a number of forms such as granules or balls of metallic material or refractory material such as corhart material, mullite, Carborundum or zirkite; the material used preferably having a high thermal heat capacity and being highly resistant to breakage, cracking and abrasion. In any case the particle size of the solid material employed should fall broadly within the range .007 to 0.75 inch and preferably within the range of about 0.25 to 0.50 inch.

One of the most important processes for which this invention is adapted is the cracking conversion of high boiling fluid hydrocarbons to lower boiling gaseous hydrocarbon products containing gasoline and/or lower boiling hydrocarbon products in the presence of a hot particle

2

form contact mass material. During this particular reaction as is the case with many other hydrocarbon conversions, a carbonaceous contaminant is deposited upon the particle form solid. If the contact material is catalytic in nature, the contaminant deposit substantially reduces its catalytic activity. If the contact material is non-catalytic in nature, the contaminant deposit may gradually increase the particle size of the contact material to an undesirable degree while at the same time small particles of coky material having an undesirably small diameter tend to accumulate in the moving contact mass. In any event, it is usually desirable to effect the removal of the contaminant deposit from the contact material. This may best be accomplished in a revivification chamber separate from the conversion chamber. In the case of inert contact materials, the carbonaceous contaminant may in many cases tend to break off the contact material particles and be susceptible to removal from the mass by entrainment in a suitable gas passed through the mass. On the other hand steam and/or air may be introduced into the hot contaminant bearing contact mass to cause the carbonaceous contaminant to undergo a producer or water gas reaction. Other reactions are also available. In the case of catalysts, it has been found best to regenerate the catalyst by blowing an oxygen containing gas therethrough to burn off the contaminant, while withdrawing excess combustion heat from the mass in order to prevent the catalyst temperature from rising to a heat damaging level. Commercially, in order to permit a practical overall unit structural height, it has been found desirable to position the conversion and revivification vessels side by side at substantially the same elevational level and to provide two contact material conveyors, one for conveying used contact material from the conversion vessel to the revivification vessel and one for conveying revivified contact material from the revivification vessel back to the conversion vessel.

In such cyclic processes catalyst fines gradually accumulate in the cyclically moving stream of catalyst due to gradual attrition of the particles falling within a predetermined normal size range. Such fines interfere with the proper operation of the conversion and regeneration apparatus and seriously reduce the capacity thereof. For this reason the average percentage of fines in the cyclically moving stream of catalyst should be maintained very low, for example, of the order of 1 to 5 per cent by weight. Since the fines

formed from attrition become distributed in the moving stream of catalyst, and since the total amount of catalyst circulation is very high and the percentage of fines therein very low, the continuous removal of fines from the cyclically moving stream of catalyst is a costly and difficult process.

A major object of this invention is the provision in a continuous conversion process wherein a stream of contact material passes cyclically through a hydrocarbon conversion zone and a regeneration zone of an improved method and apparatus for removal of fines formed by attrition from the cyclically moving stream of contact material. Another object of this invention is the provision of an improved conveyor for conveying hot particle form contact materials in a cyclic conversion system. These and other objects will become apparent in the following discussion of the invention.

The instant invention broadly involves the provision in a cyclic conversion process of method and apparatus wherein particle form contact material is passed through a downwardly sloping feed chute into buckets in a continuous bucket elevator. Foraminate partitioning in the buckets defines a separate settling compartment in each bucket into which fines carried in the contact material separately settle. The fines and normal-sized contact material are separately discharged from the buckets at the upper end of the elevator.

The invention may be best understood by reference to the attached drawings in which

Figure 1 is an elevational view showing a cyclic conversion process arranged according to the teaching of this invention;

Figure 2 is an elevational view, partially in section, showing an assembly view, of one of the elevators shown in Figure 1;

Figure 3 is a sectional view taken along the line 3—3 in Figure 2;

Figure 4 is a vertical sectional view of the upper end of the conveyor shown in Figure 2;

Figures 5 and 6 are detailed views of the buckets used in the conveyor shown in Figures 2–4 inclusive, and

Figure 7 shows details of the bucket attachment to a conveying chain. All of the these drawings are highly diagrammatic in form.

Turning now to Figure 1, we find a conversion vessel 10, a regeneration vessel 11 and elevators 12 and 13 for transferring solids from one vessel to the other. Hydrocarbon reactants heated in a conventional external system (not shown) may be introduced into the upper section of the conversion vessel through inlet 14. Gaseous conversion products may be withdrawn near the lower end of vessel 10 through outlet 15. Particle form contact material may be supplied to the upper end of the vessel 10 from supply hopper 16 through a gravity feed leg 17. Used contact material may be withdrawn from the lower end of vessel 10 through outlet conduit 18 bearing flow control valve 19. The outflowing contact material may be purged free of reactant gases by means of a purge gas such as steam or flue gas introduced into vessel 10 through conduit 20. A seal of steam or flue gas, etc. may be maintained adjacent the upper end of the reaction zone by introduction of a suitable seal gas through conduit 21. The regenerator 11 is provided with a solid inlet 22 at its upper end and a solid outlet 32 on its lower end. Regeneration gas such as air may be introduced to vessel 11 through conduit 22 near its lower end, and gaseous regeneration products may be withdrawn through conduit 23 near the upper end of vessel 11. When desired a suitable heat exchange fluid may be passed through heat transfer tubes (not shown) within vessel 11 for the purpose of controlling the temperature of the contact material during its regeneration. The heat exchange fluid may be introduced to the tubes through inlet 24 and withdrawn through outlet 25. It will be understood that the invention is not restricted to any particular reactor and regenerator construction. These vessels may, if desired, be adapted for countercurrent flow of gas and solids and they may be of the multi-stage variety.

In operation used contact material passes through sloping conduit or chute 18 from reactor 10 to elevator 13 by which it is conducted to conduit 22 feeding the regenerator. Regenerated contact material passes from regenerator 11 through sloping conduit 32 to elevator 12 by which it is conducted to duct 34 feeding the reactor supply hopper 16. Separated fines may be withdrawn from the upper sections of elevators 12 and 13 through conduits 26 and 27 respectively delivering into accumulator 28.

Turning now to Figures 2, 3 and 4 which may be best considered together for a more detailed study of the construction of the elevators. It will be seen that the casing of each elevator is made up of a foot portion, a head portion and an intermediate portion. The casing may be made up in a single section but it is preferably made up of a plurality of flanged sections and generally at least of three sections, namely, a head section, an intermediate section and a foot section. Within the casing is provided an endless series of buckets 90 which preferably overlap to a limited extent substantially as shown in Figure 2. Referring to Figure 3, a head shaft 91 passes through the casing in the head portion and two spaced apart wheels 92 and 92′ are provided on the head shaft. Continuous chains 93 and 93′ are trained over the wheels 92 and 92′ so as to form a loop in the head portion of the casing and a second loop in the foot portion. The chains may be guided by guides indicated by the dotted lines 94 attached along opposite sides of casing 12 and by means of the guide wheels 98 at the foot loop. In some constructions the wheels 98 may be omitted. The head shaft is driven by an externally located drive wheel 95 driven in turn through chain 96 by motor 97. The buckets 90 may take any of a number of cross-sectional shapes, a preferred shape being approximately that indicated in Figures 5 and 6. The buckets are attached on their opposite ends to the two chains 93 and 93′ in such a manner as to open outwardly of their closed path of travel and in such a manner as to open outwardly and upwardly as they move upwardly adjacent that side of the casing 12 into which the feed chute 47 connects and as to be inverted as they move downwardly adjacent that side of the casing 12 into which the discharge chute 48 connects. The buckets are further so shaped and fastened to the chains 93 and 93′ that in passing over the head loop or the wheels 92 and 92′, each bucket discharges contact material onto one side of the inverted bucket moving immediately before said first named bucket and the side of the last named inverted bucket is so sloped as to direct the contact material into the discharge chute 48. It will be noted that the discharge chute extends into the conveyor casing to such an extent that

the chute opening is close to the edges of the buckets as they pass downwardly in their path. The arrangement is such that the contact material is poured from the buckets into the discharge chute rather than being thrown as is the case in centrifugal type bucket elevators. The construction described hereinabove permits discharge of contact material from the buckets into the discharge chute with very little spillage of contact material occurring. The feed chute 47 similarly extends a short distance into the casing 22 so as to terminate just opposite the edge of the open tops of the buckets 90 so that contact material pours directly from chute 47 into the upwardly moving buckets 90 without substantial spillage of contact material into the foot section of the casing.

For a study of the bucket construction, Figures 5 and 6 should be considered along with Figures 2, 3 and 4. Within each bucket are positioned foraminate partitions 101 and 102 which extend the horizontal length of the buckets. These partitions define within the bucket 90 an inner compartment 103 for receiving and carrying the contact material and an outer compartment 104 for receiving the fines. The partitions 101 and 102 are perforated with holes 106 having a diameter approximately equal to that of the fines which are to be removed from the contact material. An opening 105 through that side of the bucket wall which is on the inside of the path of travel is provided across the horizontal length of the bucket below the level of partition 102, thereby providing a discharge from the outer compartment 104. As will be seen from Figure 4, the opening 105 is on the up side of the bucket during the upward travel of the bucket in the casing 12. However, as the buckets pass around the head wheels 92 and 92', the opening 105 faces downward so that the fines in compartment 104 are spilled into that portion of casing 12 within and just below the head loop formed by the chains and buckets. A receiving funnel 107 which extends across the casing 22 the full horizontal length of the buckets 90 is positioned within the casing head section to catch the discharge fines. The fines may then be withdrawn through conduit 26. It will be clear from Figure 4, that while the fines are discharged within the head loop, the normal sized contact material is separately discharged into discharge spout 48 on the outside of the head loop. It will be noted that vanes 108 and 109 are provided on both ends of each bucket on that side of each bucket onto which contact material is poured from the next bucket on the chain in the conveyor head section. These vanes provide a passage for discharged normal sized particles into the discharge chute 48 and prevent the solid material from falling off the ends of the buckets.

Turning to Figure 7, there is shown a detailed view of a section of one elevator chain 93' and of the bucket attachment thereto. It will be seen that the chain is a knuckle chain of the offset type. Each link has near one end a knuckle 110 in which is a bushing indicated by dotted lines at 111. A chain pin 112 fits through the bushing 111 and through holes in the offset side bars of the next link. A keeper pin 113 may be employed to hold the chain pin in place. To each end of the bucket is welded or bolted an attachment bar or bracket 114 which in turn is bolted to one of the elevator chains such as chain 93'.

This invention takes advantage of the tendency of undersized solid material to segregate along the

underside of a stream of solid particles flowing downwardly in an inclined chute and the tendency of undersized particles to concentrate near the bottom of an accumulation of contact material maintained in a vessel which is subjected to agitation or vibration. Thus a contact material stream containing some fines passes from vessel 11 in Figure 1 through a downwardly sloping chute 32 into the buckets 90 in elevator 12. By the time the contact material stream reaches the lower end of chute 32 some of the fines have settled on the underside of the stream and are directed into that portion of the buckets 90 nearest the foraminate partitions 101 and 102. As the buckets pass upwardly through casing 12 they are subjected naturally to considerable vibration and agitation which results in the settling of more fines to the bottom of the solid accumulation in bucket compartment 103. Fines pass through the holes 106 in partitions 101 and 102 into the fines receiving compartment 104, and the fines are then separately discharged from the elevator as has been described hereinabove. The method and apparatus of this invention may be applied to both elevators in a cyclic system as described or to either elevator alone. It will be apparent that since conveyors and the sloping solid feed chutes thereto are already a portion of conventional cyclic conversion systems, the method and apparatus of this invention permits the removal of fines from the cyclically moving contact material stream in such systems by an easily made improvement in conveyor construction and without the requirement of any added classification apparatus.

It should be understood that while the particular form of elevator and conveyor construction shown diagrammatically in the drawings is a preferred form of the invention, nevertheless the form shown is intended as illustrative and it is contemplated that this invention may be applied to bucket elevators of modified construction. It should be further understood that the examples of the application of this invention given hereinabove are illustrative and that the invention is not to be limited by the illustrations of apparatus design and application except as it may be limited by the following claims.

I claim:

1. The method for conducting a cyclic process for the conversion of fluid hydrocarbons in the presence of a moving particle form contact material which comprises: passing said contact material through a conversion zone wherein it contacts fluid hydrocarbons under conversion conditions to effect the conversion of said hydrocarbons and through a reconditioning zone wherein it is contacted with a suitable gas to recondition it for reuse in said conversion zone, removing used contact material from said reconditioning zone, continuously flowing it through an elongated downwardly sloping passage into the lower section of a confined, elongated conveying zone, conducting said used contact material upwardly through said confined elongated conveying zone, subjecting said contact material to classification to separate undersized particles from normal sized particles during the upward passage of said contact material in said conveying zone, separately discharging the separated undersized contact material from the upper section of said conveying zone and removing it from the cyclic process, separately discharging the remainder of the contact material from the upper end of said conveying zone and passing it to said conversion

zone and returning used contact material from said conversion zone to said reconditioning zone.

2. In a process for conversion of fluid hydrocarbons in the presence of a particle form solid contact material wherein the contact material is passed cyclically through a conversion zone while contacting it therein with a fluid hydrocarbon charge to effect its conversion and through a revivification zone while contacting it therein with a suitable gas to restore the contact material to a state suitable for is reuse in said conversion zone, the improved method for transferring contact material from one zone to another while eliminating undersized fines from the cyclic system which method comprises: passing contact material containing fines from one of said zones in said cyclic system through a downwardly sloping confined passage into the lower section of an elongated, confined conveying zone, conveying said contact material upwardly through said conveying zone, subjecting said contact material to screening to separate the fines from the remainder of said contact material during its upward passage in said conveying zone, separately withdrawing fines from the upper section of said conveying zone, separately withdrawing the remainder of said contact material from the upper section of said conveying zone and passing it to the other of said zones in said cyclic system.

3. A method for the catalytic cracking conversion of fluid petroleum hydrocarbons which comprises: passing a particle form catalyst downwardly through a confined conversion zone at a suitable conversion supporting temperature as a substantially compact column, passing heated fluid hydrocarbons into contact with said catalyst in said conversion zone to effect conversion of said hydrocarbons to lower boiling gaseous hydrocarbons, disengaging gaseous hydrocarbon products from said catalyst and withdrawing said gaseous products from said conversion zone, passing spent catalyst from said conversion zone to a regeneration zone, contacting said catalyst in said regeneration zone with an oxygen containing gas to regenerate said catalyst passing spent catalyst from said regeneration zone through a downwardly sloping chute into the upwardly moving containers within a confined, upwardly extending conveying zone, conveying said catalyst upwardly through said conveying zone in such a manner as to cause fines to settle and separate from the normal sized catalyst particles in said containers, separately discharging fines and normal sized catalyst from the upper section of said conveying zone, removing discharged fines and passing the discharged normal sized catalyst particles to said conversion zone.

4. In a hydrocarbon conversion system wherein a particle form contact material is passed cyclically through a conversion chamber and a reconditioning chamber, an improved conveyor for transferring contact material from one of said chambers to the other which comprises: an elongated upwardly extending conveyor casing, an endless series of articulated buckets adapted to travel in a closed path in said casing with said path looping in the upper portion and in the lower portion of said casing, means to move said series of buckets in said closed path, perforated partitioning in each of said buckets adapted to define an inner compartment for receiving contact material and an outer compartment for receiving fines from said inner compartment, said outer compartment being in communication with said inner compartment through the perforations in said partitioning and being so positioned relative to said inner compartment as to be generally below said inner compartment during the passage of the buckets through the upward portion of their path of travel, an outlet from said outer compartment so positioned as to permit gravity discharge of fines from said outer compartment in the upper section of said conveyor casing, means defining a downwardly sloping feed passage for the flow of contact material into the buckets as they pass upwardly in their path within the lower section of said conveyor casing, means to direct the flow of contact material from one of said chambers in said conversion system into said feed passage, means adapted to separately catch solid material discharged from said inner and outer compartments of said buckets near the upper end of said conveyor casing, means to pass the separately caught contact material from the inner compartment of said buckets to the other of said chambers in said conversion system and means to withdraw the separately caught solid material from said outer compartment of said buckets to an external location.

5. In a hydrocarbon conversion system wherein a particle form contact material is passed cyclically through a conversion chamber and a reconditioning chamber, an improved conveyor for transferring contact material from one of said chambers to the other which comprises: an elongated upwardly extending conveyor casing, an endless series of articulated buckets adapted to travel in a closed path in said casing with said path looping in the upper portion and in the lower portion of said casing, means to move said series of buckets in said closed path, perforated partitioning in each of said buckets adapted to define an upper compartment for receiving contact material and a lower compartment communicating through the perforations in said partitions for receiving fines from said upper compartment, said lower compartment being provided with a discharge opening so positioned as to permit separate discharge of fines therefrom as the buckets pass over the loop in the upper portion of said conveyor casing, means to separately withdraw fines discharged from said opening in the upper portion of said casing, means to separately catch contact material discharged from said upper compartments in said buckets in the upper portion of said casing and passage defining means to direct flow of said contact material to one of said chambers in said conversion system, and means defining a downwardly sloping contact material feed passage adapted to direct contact material from the other of said chambers in said conversion system into the upper compartments of said buckets as said buckets move upwardly in the lower portion of said conveyor casing.

6. In a conversion system wherein a particle form contact material is moved cyclically through two or more chambers, an improved conveyor for transporting contact material from one chamber to another which comprises: a substantially vertical elevator casing having a head portion and a foot portion, an endless series of articulated buckets in said casing, means to support said buckets and to move them in a closed path forming a loop in both the head and the foot portions of said elevator casing, in which path downwardly moving buckets are inverted and

upwardly moving buckets open upwardly and toward the outside of their path of travel, partitioning within each bucket providing in each bucket an upper contact material receiving pocket and generally therebelow a fines accumulation chamber, said chamber communicating with said receiving pocket through a plurality of small openings in said partitioning, an opening for removal of fines from said chamber so positioned as to prevent flow of fines from said chamber as long as said buckets move in their upward path of travel, but as to permit the gravity flow of fines through said opening as said bucket passes over the upper loop in its path of travel, a receiving basin positioned within the head loop in said casing for receiving fines poured from said fines accumulation chamber as said buckets pass over said head loop, conduit means to withdraw fines from said basin, a discharge spout connected into the upper portion of said elevator casing in a position to receive contact material poured from the receiving pockets of said buckets means to pass contact material from said discharge spout to one of said chambers in said conversion system, and a downwardly sloping, elongated feed spout connected into the lower section of said elevator casing in a position to feed contact material into said receiving pockets in said buckets and means to pass contact material from another of said chambers in said conversion system into said fed spout.

7. In a system of the type described a contact material conveyor and classifier which comprises in combination: a substantially vertical, elongated elevator casing having a head section and a foot section, a downwardly sloping contact material feed spout connecting into one side of said casing near its lower end, a discharge spout connecting into the opposite side of said casing near its upper end, an endless series of articulated buckets within said casing, perforated partitioning within each of said buckets defining a receiving compartment open on one end to receive contact material and generally therebelow a fines accumulation compartment, communicating with said receiving compartment through the perforations in said partitiong means to support said series of buckets and to cause the buckets to travel in a closed path, said path forming a loop in said head section above said discharge spout and a loop in said foot section below said feed spout, said buckets being so supported by said support means as to open outwardly toward the side of said casing into which said feed spout connects during their upward movement in said closed path and as to be inverted during their downward movement adjacent the side of said casing into which said discharge spout connects and said buckets being further so supported that each bucket in the upper section of said casing discharges contact material from its receiving pocket onto a side of the inverted bucket moving in the closed path immediately before said bucket and said side of said latter bucket is so sloped as to direct flow of contact material into said discharge spout, vanes fastened along that side of each bucket onto which contact material is discharged from the bucket moving immediately thereafter in the closed path of travel, said vanes being adapted to provide a lane for contact material flow on the side of the inverted bucket, means to withdraw contact material from said discharge spout, means to supply contact material to said feed spout, an outlet from said fines accumulation compartment in each bucket adapted to retain the fines in said compartment during the upward movement of said buckets and to permit gravity discharge of fines from said compartment in each bucket as the bucket passes over the head loop, an accumulation basin positioned within the head loop in said casing for separately receiving discharged fines, and means to withdraw fines from said basin.

8. A contact material conveyor and classifier which comprises in combination: an elongated upwardly extending conveyor casing, and endless series of screen containing buckets adapted to travel in a closed path in said casing with said path looping in the upper portion and in the lower portion of said casing, the screen in each bucket dividing it into an upper feed receiving compartment and a lower fines accumulation compartment, said lower compartment being provided with a discharge opening so positioned as to permit separate discharge of fines therefrom in the upper portion of said casing, means to move said series of bucket in said closed path, means to deliver particle form contact material into said receiving compartments in the lower section of said conveyor casing, means to withdraw fines discharged from said accumulation compartments in said buckets in the upper portion of said casing and means adapted to separately catch and withdraw contact material discharged from the receiving compartments in said buckets in the upper portion of said casing.

9. A contact material conveyor and classifier comprising in combination: an elongated upwardly extending conveyor casing, an endless series of articulated buckets in said casing, means to support said buckets and to move them in a closed path forming a loop in both the head and the foot portions of said elevator casing, in which path downwardly moving buckets are inverted and upwardly moving buckets open upwardly, partitioning within each of said buckets providing in each bucket an upper contact material receiving pocket and generally therebelow a fines accumulation chamber, said chamber communicating with said receiving pocket through perforations in said partitioning, said accumulation chamber being provided with a discharge opening positioned to permit separate discharge of fines therefrom as the bucket passes over the loop in the upper portion of the conveyor casing, means in the upper portion of said casing to separately withdraw fines discharged from said opening, means in the upper portion of said casing to separately withdraw contact material discharged from said receiving pockets in said buckets.

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