

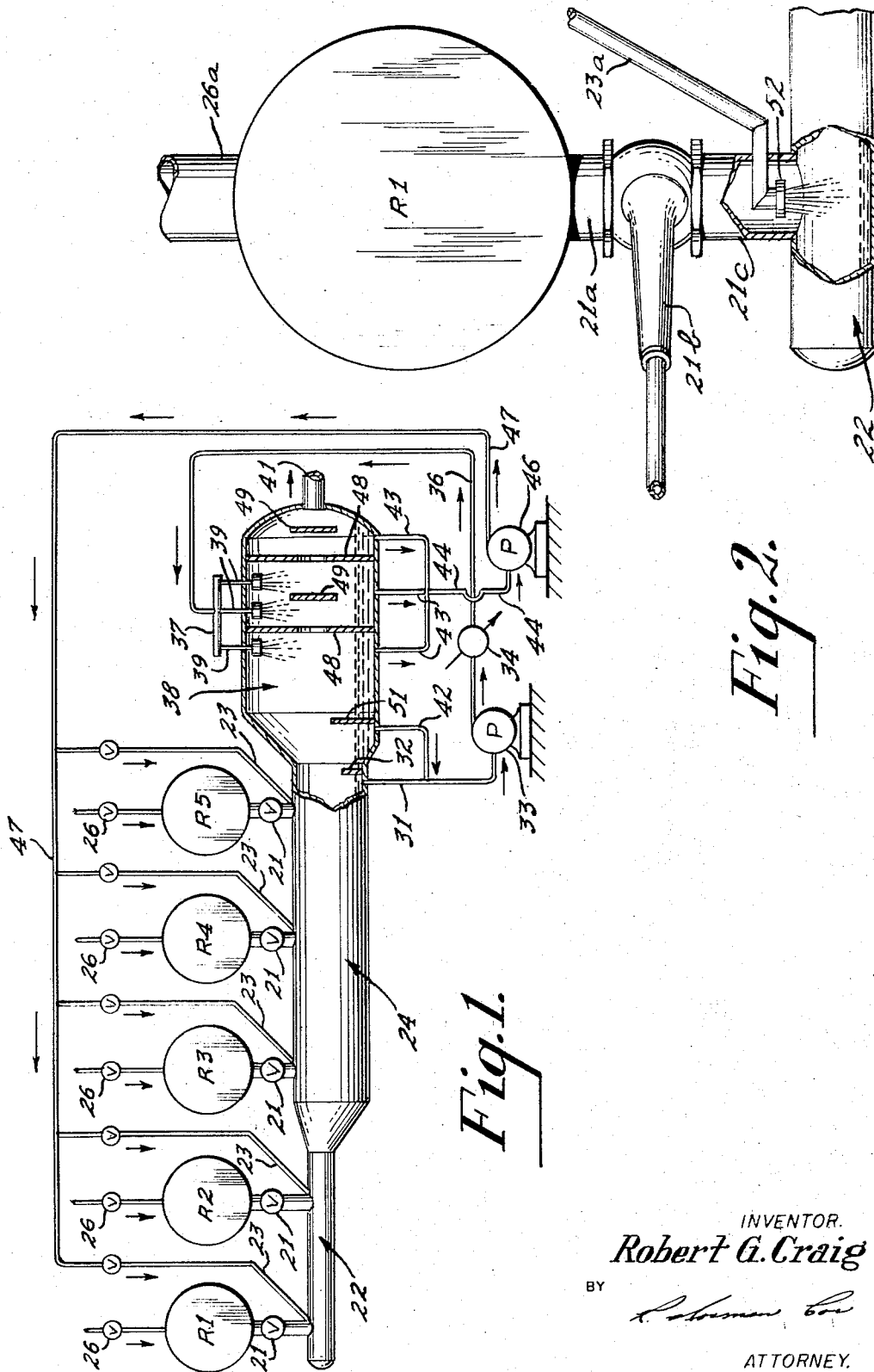
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QUENCH SYSTEM AND CHAMBER

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QUENCH SYSTEM AND CHAMBER

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5 Claims. (Cl. 261-149)

This invention relates to high temperature reaction systems and particularly to systems requiring quenching of the reaction effluent so as to arrest any further reaction which might occur at the higher temperatures and to prevent reactions leading to formation of products of an undesired nature and which possibly could adversely affect the operation of down stream equipment. This invention has particular utility in hydrocarbon conversion systems, for example in a dehydrogenation system where the quenching of the reactor effluent prevents the polymerization of dehydrogenated hydrocarbons and diminishes the danger of possible coking of the down stream equipment.

In present day operations in hydrocarbon conversion systems the quench is customarily performed in separate or combined prequench and quench towers. Thus it is the practice to pass the reactor effluent at its emergent high temperature into a prequench area as rapidly as possible and therein to effect a rapid initial temperature decrease, such as from about 1100° F. to about 300° F., by contact with a relatively cool quenching medium in order to reduce the possibilities of loss of dehydrogenated product to undesirable polymer. The partially cooled effluent is passed from the prequench region into the main quench region wherein more thorough and effective temperature reduction is obtained by more extensive contact with a relatively cooler quench liquid which may be the same or different from the quench liquid employed in the prequench section. Thus in a relatively short time period the temperature of the stream from the reactor to its exiting from the quench system may be reduced from above about 1100° F. to 125° F. more or less, as desired and/or required. Such quench systems are shown in U.S. Patent Nos. 2,935,541 and 3,080,153.

As is well known in the art of dehydrogenating hydrocarbons to less saturated products, such as for instance dehydrogenation of C₄ saturates and olefins to diolefins, by contact with a dehydrogenation catalyst such as the well known 20% chromia on alumina at temperatures in the order of about 1100° F., improved yields and operating conditions generally result when the reaction pressure is less than atmospheric. There is measurable increase in yield of desired products as the pressure is decreased down to the practical operating pressures obtainable with present commercial equipment. Such pressure is generally in the range of about 5 to 7 inches Hg absolute. Pressures lower than this and even at the lower indicated range have certain advantages but are obtained and maintained with such a degree of difficulty that under normal operating conditions the advantages are outweighed by the disadvantages such as increased power costs, size and cost of equipment, etc.

One of the factors contributing to the difficulties of obtaining lower operating pressures is the well known "bugaboo" of pressure drop throughout the system. An area contributing a relatively high degree of pressure drop is the present type of prequench and quench system which

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may easily account for up to 2" Hg or more of pressure drop between the inlet to the prequench tower and the outlet from the main quench tower.

It has been found now that a substantial reduction in the pressure drop difficulties is obtained by quenching such effluent gases in a quench system and at quenching conditions which differ both in apparatus and flow of materials from systems previously employed.

In accordance with the invention the effluent gases are transferred into a horizontally extending quench area wherein they are immediately contacted by the prequench fluid under conditions to effect a substantial and substantially immediate temperature reduction by contact with the quench medium moving substantially across the direction of flow of the effluent gases. After separation of the bulk of the quench fluid from the partially cooled gases the gases then enter an area for further cooling and quenching, again through the medium of a relatively cooler quench medium passed also at substantially cross flow with relation to the flow pattern of the reactive gases. By thus eliminating the normal cascade trays and many of the flow baffles in normal quench tower operation much of the cause leading to the higher pressure drop situation is alleviated. It is also possible to reduce the structure height substantially in that the present structure is horizontally disposed and eliminates the need for tower systems that generally rise over 100 feet above the ground. This in turn permits reduction in the length of pipe runs and in other substantial savings attendant to low rise structures.

A fuller understanding of the invention may be had through reference to the following description and the drawing in which FIGURE 1 is a schematic representation of a typical embodiment suitable for use in a hydrocarbon dehydrogenation operation; and FIGURE 2 is an enlarged view of one area of initial contact of reactor effluent with the first quench medium.

With reference to FIGURE 1, there is shown a diagrammatic representation of a multiplicity of reactors R. Five reactors (R.1 to R.5) have been illustrated. Each of these reactors is individually piped and valved for operation separately or in combination with any or all of the other reactors in accordance with well known and well established practice which forms no part of the present invention. For simplicity of consideration the further description is to the operation of a single reactor (R.1) particularly as it is concerned with the present invention.

When the reactor is on stream, charge is introduced through valved line shown generally as 26 and reactor effluent passes through valved line 21 directly into the quench area at 22. The effluent in so doing passes through a suitable spray mist or the like of quench fluid introduced through line 23 in the direction of effluent flow for initial prequench cooling and flows thence into expanded area 24 wherein it may be, if so desired, contacted with further quantities of prequench medium introduced through one or more of the other prequench inlet system lines 23. During the horizontal passage of reactor effluent through areas 22 and 24 the bulk of the quench medium, which is preferably of relatively high density with respect to the gaseous effluent, is separated by gravity and flows along the bottom of areas 22 and 24 for removal through line 31 positioned before internal

baffle or weir 32. The dropout of most of the remaining cooling quench fluid from the effluent gases, upon their entry into the further expanded chamber area 38, is aided by the presence of baffle 51 positioned and sized to cause no substantial increase in pressure drop while simultaneously creating a circular or eddy type pattern of the flowing gases contributing to a centrifugal effect tending to throw the quench fluid out of the gas for collection and flow along the walls of the cooling area. A demister or similar liquid droplet removal system may be employed down stream if necessary or desirable. This collected quench liquid may be removed through line 42 for combination with the liquid in line 31 and then moved by pump 33 into and through suitable heat exchange means 34 for temperature adjustment, and from thence through line 36 into distributing manifold 37.

The precooled gaseous flow exiting from expanded chamber area 24 is further cooled in chamber area 38, both by expansion and by cross flow contact with quench fluid introduced through lines 39, to the desired temperature and is removed through exit line 41 for further down stream processing as may be desired and required but which forms no substantial part of the present invention.

The quench medium introduced at the top of chamber area 38 for cross flow downward contacts the effluent gases which are moving generally horizontally at relatively low velocity such that lateral displacement of the quench liquid is relatively limited and which under the influence of gravity collects in a lower region of chamber area 38 for removal through lines 43 which lead into line 44 and pump 46 for transfer through line 47 which may or may not include suitable heat transfer devices, not shown, for adjustment of temperature as may be desired or required. The quench medium from line 47 in turn passes for recycle use, as controlled by suitable valves into lines 23.

In chamber area 38 widely spaced baffles, such as doughnut baffle members 48 and disc baffle members 49 which may be of varying sizes, with large free flow areas therebetween provide a mild mixing and flow direction change for the low velocity gases while presenting relatively little pressure drop.

Quench fluid may be either removed from or supplied to the quench system by any suitable means, not shown, to meet operational requirements.

In FIGURE 2 an expanded schematic drawing of one embodiment of the preliminary quench system is shown. Reactor effluent passes through line 21a and open valve 21b and exit line 21c into chamber area 22 at which point it is contacted with the cool quench liquid introduced through line 23a for discharge through suitable nozzle means 52.

All of the quench fluid omission nozzles in chamber area 38 are designed to give a vertical spray curtain effectively normal to the flow direction of the reactor effluent. The disc and doughnut baffle members at no point occupy a cross sectional area within the substantially horizontal quench region of less than 50% and preferably their area is in the order of 55% of the cross section in said region. The separation of these disc and doughnut baffle members on their lateral dimension is such that not less than 120% of the cross sectional opening around the disc member or in the doughnut member is available for cross flow.

It should be noted that for systems involving only one to three reactors, normal operation of these reactors would not require chamber area 24 to be enlarged over chamber area 22.

Apparatus designed and operated in accordance with this invention in a system having a throughput yielding approximately 100,000 STYP butadiene can operate at reaction pressures as low as 5" Hg absolute or less with no change in the auxiliary equipment previously required

to provide operation at 7" Hg absolute. A pressure reduction of this magnitude would result in an increase in yield of up to 20 percent of desired product or a reduction of feed requirements of up to 10 percent over dehydrogenation systems operating at 7" Hg pressure.

Example

Comparative runs were made in a large scale pilot plant at simulated commercial plant operation. The catalyst was standard chromia (18.5 wt. percent) on alumina (81.5 wt. percent) dehydrogenation catalyst which had been removed from a commercial dehydrogenation plant after 205 days of use. The operating conditions of the several comparative runs were substantially similar with the exception of variations in liquid hourly space velocity (LHSV) and variations in pressure as shown in the table below.

TABLE

Run.....	A	B	C	D
Charge Stock Composition:				
Wt. percent n-Butane.....	68	68	51	51
Wt. percent Butylenes.....	32	32	49	49
Pressure, Inches Hg Absolute.....	5	7	5	7
Yields:				
Wt. percent Butadiene at—				
2 LHSV.....	18.4	15.2	18.9	18.4
4 LHSV.....	16.0	15.9	15.9	13.4
Wt. percent Selectivity to Butadiene at—				
2 LHSV.....	59	57	64	65
4 LHSV.....	66	70	70	65

The foregoing data demonstrate the desirability of the lower pressure operation. Not only is more of the desired butadiene produced but the selectivity to the desired product is better.

Obviously many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, therefore only such limitations should be imposed as are indicated in the appended claims.

What is claimed is:

1. A quench system for the gaseous effluent of a grouped plurality of reactors having an in-line arrangement of valved downflow effluent outlets comprising:

- (a) an elongated hollow vessel forming a chamber extending laterally below and beyond one end of the row of effluent outlets, said chamber having at one end a prequench section communicating along its upper side with said effluent outlets and at the other end a substantially enlarged quench section beyond the row of effluent outlets;
- (b) means for introducing a spray of prequench liquid into said prequench section at locations adjacent and individual to the discharge ends of said effluent outlets in a manner to effect good heat exchange contact with the incoming effluent;
- (c) first baffle means in the path of initial flow of the prequenched effluent through said quench section to disengage entrained prequench liquid from the flowing effluent stream;
- (d) means for withdrawing prequench liquid from the bottom of said prequench section and from the initial portion of said quench section, cooling said liquid, and thereafter reintroducing the same as a spray of quench liquid into the enlarged quench section of said chamber in a manner to effect good heat exchange contact with the prequenched effluent;
- (e) second baffle means in said quench section down stream of said first baffle means to provide low velocity, tortuous flow of said effluent and mild mixing thereof with said spray of quench liquid;
- (f) means for withdrawing said quench liquid from the bottom of said quench section and recycling the same as prequench liquid into said prequench section;
- (g) and means for discharging the cooled effluent from the down stream end of said chamber.

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2. Apparatus as in claim 1, in which said first baffle means comprises a low weir at the juncture of said pre-quench and quench chamber sections.

3. Apparatus as in claim 1, in which said second baffle means comprises a doughnut-and-disc arrangement of baffle members substantially perpendicular to the direction of normal effluent flow through said chamber.

4. Apparatus as in claim 3 in which said second baffle means occupies at least 50% of the cross sectional area of the quench chamber section.

5. Apparatus as in claim 3 in which said doughnut-and-disc baffle members are separated on their lateral dimen-

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sions such that at least 120% of the cross-sectional flow area around said members is available for cross flow.

References Cited by the Examiner

UNITED STATES PATENTS

2,747,847	5/1956	Otto	-----	261—116	X
2,781,251	2/1957	Howell	-----	261—117	X
2,906,791	9/1959	Baumann et al.	--	260—681.5	X
2,935,541	4/1960	Kapp	-----	260—683.3	X

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