

PAN AMERICAN PETROLEUM CORPORATION

Tulsa, Oklahoma
November 22, 1967

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Re: Retorting Ideas Submitted
to the Engineering Appraisal
Team, November 27, 1967

Gas Combustion Retort

There are five cases presented for the gas combustion retort in Anvil Points Technical Memorandum No. 67-39. Pan American prefers a modified Case 3 for the engineering appraisal team evaluation of the retort as conducted during the Initial Program as requested by paragraph 2a of R. W. Schiessler's letter of October 27, 1967. Case 3 is based on charging 1/4 by 2-1/2 inch shale to a rectangular retort at a 500 lb./hr./sq.ft. mass shale rate, resulting in 82.3 volume percent Fischer assay oil yield from 30 gal./ton shale. A 17-day run was achieved on Retort 3. However, since this run was forced down by a deliberate increase in gas rates, it is concluded that the demonstrated operation is still subject to operational shutdowns due to upsets. Therefore, before accepting this as the base case for the gas combustion retort, it appears desirable to add certain features designed to improve operability as follows:

1. Mechanical anti-segregation feeding device which will scatter shale particles at random over the entire cross-sectional area of the retort.
2. Mechanical chunk breakers such as are in use on iron ore pellets shaft furnaces.
3. Bayonet recycle gas distributors.
4. Mechanical-grate spent shale draw-off.

With the above additional features, it is believed that the gas combustion retort as developed in the Initial Program, charging about 96.7% of mine run shale as a wide-range 1/4 by 2-1/2 inch fraction, would be capable of achieving a 90% on-stream operating factor. An experimental program of about two years' duration might be required to develop the equipment and prove out operability. Such a program would be justified only if studies show that the gas combustion retort with 82% of Fischer assay oil yield is competitive with other retorting schemes.

In accordance with paragraph 2b of R. W. Schiessler's letter of October 27, 1967, we suggest the following items for evaluation:

1. Recovery of light ends from the vent gas stream.

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No. 2

2. Develop a circular-shaped retort vessel.
3. Develop an artificial nucleation method to improve yield and operability with richer shales.

If the engineering evaluation studies should show that any of these ideas might have merit, it would be necessary to obtain data from an experimental program. Such a program might be carried out in conjunction with the program for operational improvements foreseen above.

Pan American Retort A

The principle disadvantages of the gas combustion retort have been observed to be the loss of light ends from the shale oil due to dilution with gases from the internal combustion zone, and formation of agglomerates which disrupt shale and gas flows. Impaction of oil and dust may cause agglomeration and such impaction may be worsened as higher gas velocities are employed to transfer heat from the combustion zone to the retorting zone.

It is proposed to overcome these disadvantages by the processing scheme shown by Figure 1. The combustion zone within the retort is eliminated and the heat necessary to accomplish retorting is supplied by injection of a hot gas. This gas would consist mostly of light hydrocarbons, C₆ and lighter, produced from the retorting reaction itself. The molal specific heat for light hydrocarbons is much higher than for the combustion gases. For example, a specific heat at 1000°F for butane vapor is about 48 Btu/lb. mol/°F, which compares with 7.5 Btu/lb. mol/°F for nitrogen. Accordingly, the volumetric flow of recycle gas required to accomplish heat transfer within the retort can be substantially reduced. The elimination of combustion gases from the system allows greater economic recovery of the lower boiling constituents of the shale oil.

In the middle section of the retort, a light hydrocarbon recycle stream is injected at about 1100°F to supply the externally generated heat required for the process. This stream, together with the product shale oil vapors, is withdrawn at a point where the gases are in the neighborhood of 700 to 900°F. The oil vapors are then cooled and fractionated so as to effect a separation of heavy oil product from the light hydrocarbon vapors, part of which are recycled. By accomplishing the retorting within a relatively narrow controlled temperature range, it is anticipated that the decomposition of carbonates will be substantially reduced compared with the gas combustion retort with resultant decrease in retorting heat requirement.

A second recycle gas stream is employed to accomplish transfer of sensible heat to and from the inert rock which comprises about 80% of the weight of the oil shale. This recycle stream is taken off the top of the retort at a temperature of about 125°F to 175°F, and recirculated to the bottom of the retort in order to recover heat from the hot spent shale by countercurrent transfer. The composition of the second recycle stream

can be controlled by injecting a liquid hydrocarbon reflux stream in the upper portion of the retort. The liquid hydrocarbon reflux stream is intended to reduce heavy oil being carried to the spent shale cooler where losses due to adsorption might occur.

It is desirable to control the composition of the recycle streams to prevent buildup of light hydrocarbons (C₂ and lighter) and other light gases which tend to reduce the molal heat capacity, and also to eliminate heavier hydrocarbons (C₇+), which tend to crack more readily at elevated temperatures. For this reason a depropanizer tower follows the dhexanizer tower to ensure that the recycle streams consist mostly of C₄, C₅, and C₆.

Pan American Retort B

A proposed three-section vertical shaft oil shale retort is shown by Figure 2. In the upper section, raw oil shale is preheated to about 600°F by a stream of flue gas which issues from the lower section of the retort, wherein spent shale is burned and cooled. If necessary, an auxiliary gas flame can be used to increase the heat to this stream in order to accomplish the preheating of the oil shale. After the oil shale has been preheated to about 600°F, it passes to the middle or retorting section of the retort, wherein a stream of superheated steam or steam plus light hydrocarbon vapors are injected to accomplish retorting. The amount of gases injected is only that necessary to raise the temperature of the raw shale from 600°F to the retorting level of about 950°F. The shale oil vapors and other off-gases are removed from the retort at about 700°F. The oil vapors and other gases are cooled to form the condensed shale oil product, and the steam plus light hydrocarbon vapors are recycled to the furnace which supplies the heat for raising the gases to retorting temperature. In the lower section of the retort, a separate compartment is used to extract the sensible heat from the spent shale, and in addition part of the organic carbon residue remaining on the shale will be burned to supply heat for the upper preheating section.

The 700°F off-gas temperature means that only a small fraction of the shale oil vapors will have reached their dewpoints prior to removal from the retort. In addition to this advantage of avoiding wetting of the oil shale particles with the bulk of the shale oil vapors, the total gas flow in the retorting section will be less than in the gas combustion retort due to the higher molal heat carrying capacity of steam and light hydrocarbon vapors.

Various alternatives are apparent for the operation of the oil recovery system. For example, the 700°F off-gas could be air-cooled to a point just above the water dewpoint, thus keeping the bulk of the heavier oil separated from water and preventing any emulsifying of the heavy oil. The remaining light oil and steam vapors may be completely condensed with recycle plus makeup water being fed to a steam generator, or alternatively only the make stream of light oil vapors and steam might be condensed, keeping recycle steam plus light oil vapors to be fed back through a fired heat exchanger.

Petrosix Retort

The Petrosix retorting process is shown by Figure 3. In the Petrosix process, which has been developed to the pilot plant stage by the Brazilian oil company Petrobras, the retorting is accomplished by heating recycled retort gas. Compared to the gas combustion retort, the Petrosix process avoids the disadvantage of dilution of the retort product gas with products of combustion. However, the disadvantage in the gas combustion process wherein the oil vapors in the upper portion of the retort may wet the raw oil shale particles still exists in the Petrosix retort. To ensure reliable operability, mechanical chunk breakers are suggested just above the hot gas injectors to avoid agglomerates disrupting the flow of shale and gas in the bed.

The Brazilians claim to have achieved 100% of Fischer assay oil recovery in a 24-inch diameter pilot plant. They have not experienced agglomerate problems in this small retort but the 20 gpt shale may not be rich enough to cause any problem. Petrobras is now constructing an 18-foot diameter retort as part of a grass roots prototype mine and plant costing about \$20,000,000 and due for completion in mid-1969.

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KLB:sr

Propos
No. 5

PAN AMERICAN PETROLEUM CORPORATION

ENGINEERING CHART
(TRACING)

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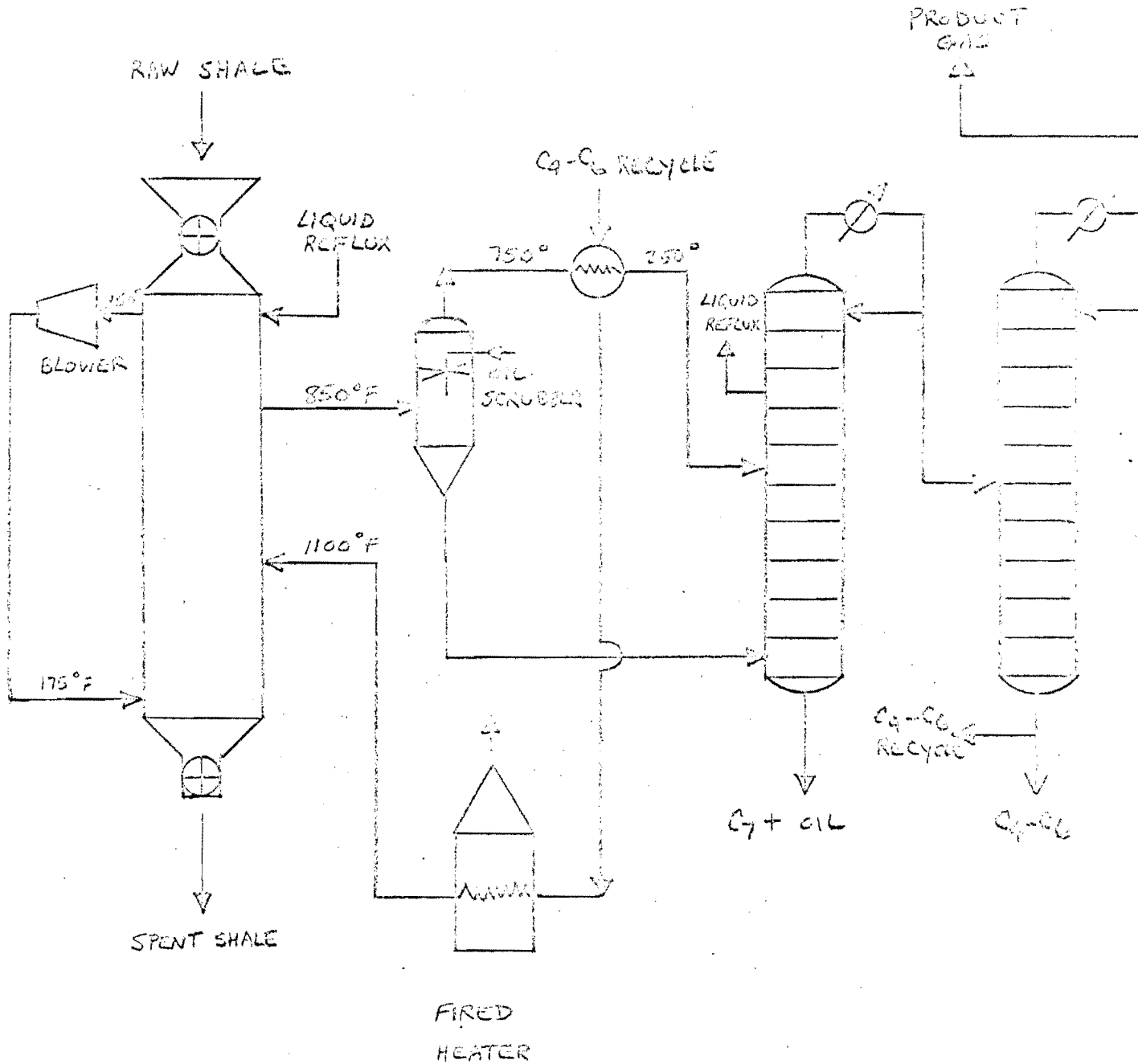


FIG I - PAN AMERICAN RETORT A

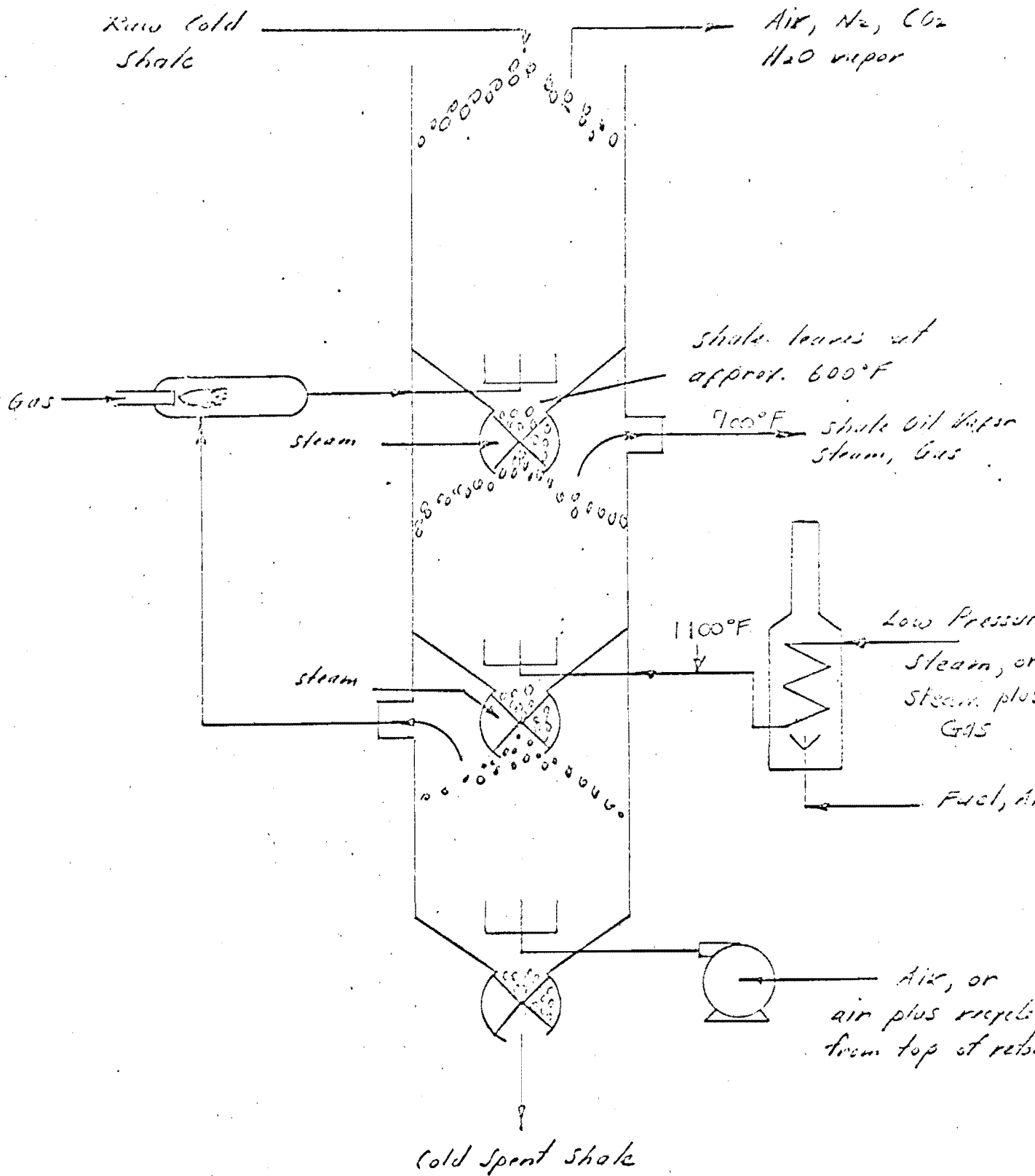


FIG 2 - PAN AMERICAN RETORT B

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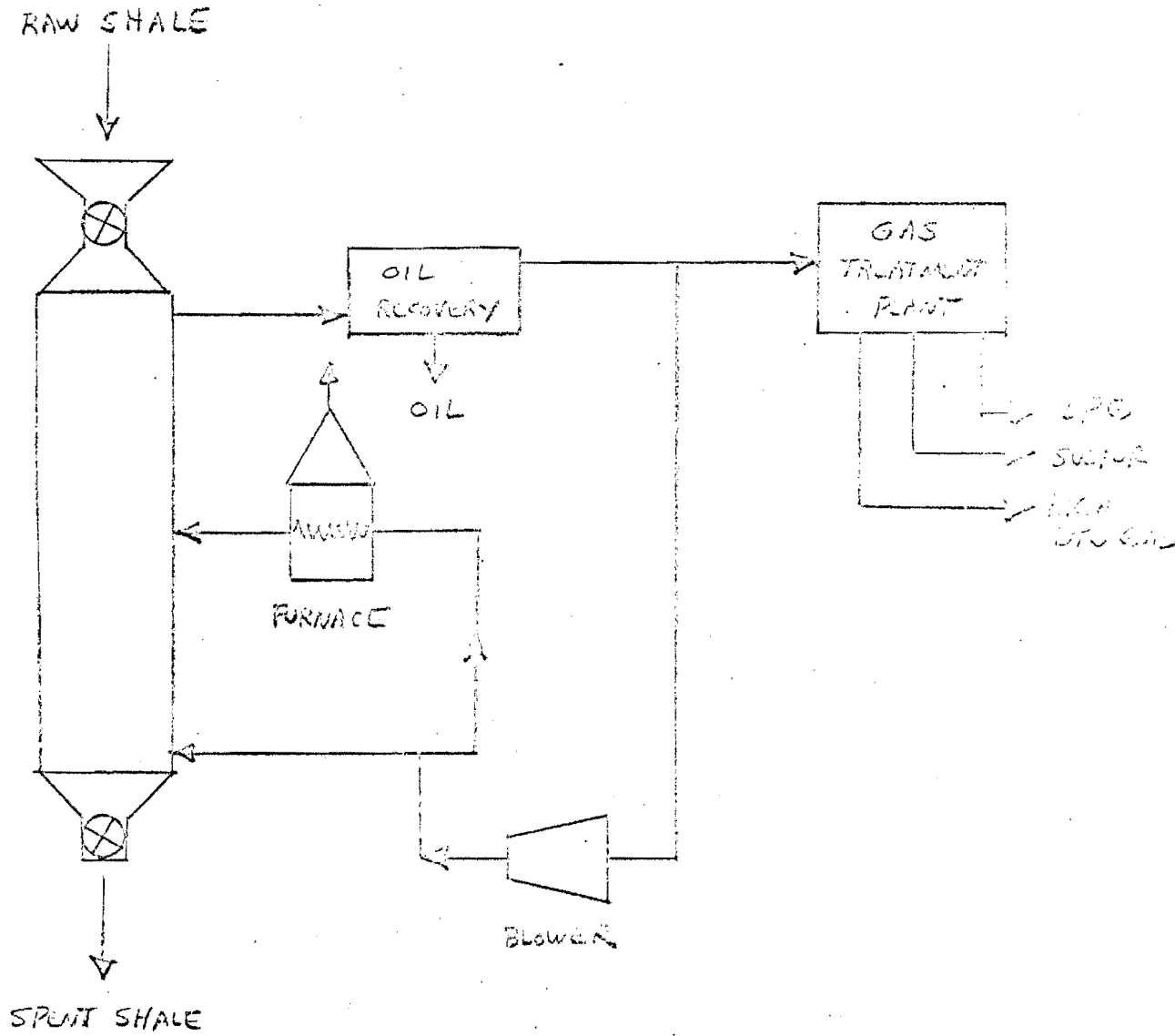


FIG. 3 - PETROSIX RETORT