DOE/CE/15533--T2

Received by OSTI

JUL 31 1992

SECOND QUARTER REPORT

DOE/CE/15533--T2

DE92 018556

For Period April 1, 1992 to June 30, 1992

Invention #533

Contract # DE-FG01-92CE15533

Project Title

HIGH EFFICIENCY SHALE OIL RECOVERY

Submitted to

The U. S. Dept. of Energy

Office of Energy Related Inventions

By

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Date 7-18-92

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ENERGY RECOVERY TECHNOLOGY

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Project Objective

The overall project objective is to demonstrate the high efficiency of the Adams Counter-Current shale oil recovery process. The efficiency will first be demonstrated at bench-scale, in the current phase, after which the demonstration will be extended to the operation of a small pilot plant. Thus the immediate project objective is to obtain data on oil shale retorting operations in a small **batch** rotary kiln that will be representative of operations in the proposed **continuous** process pilot plant. Although an oil shale batch sample is sealed in the batch kiln from the start until the end of the run, the process conditions for the batch are the same as the conditions that an element of oil shale would encounter in a larger continuous process kiln. For example, similar conditions of heatup rate, oxidation of the residue and cool-down prevail for the element in both systems.

This batch kiln is a unit constructed in a 1987 Phase I SBIR tar sand retorting project. The kiln worked fairly well in that project; however, the need for certain modifications was observed. These modifications are now underway to simplify the operation and make the data and analysis more exact.

Previous Accomplishments and Status of Project

Last quarter we reported on certain design changes undertaken to improve the operation of the batch rotary kiln and on the acquisition of equipment and sample materials. While we were delayed with the project some weeks (primarily due to the delayed funding at the project initiation) the now completed modifications and refurbishments provide a much more sophisticated analytical device than the very rushed six-months 1987 project allowed. Some of the modifications were slower than expected, but overall the project is progressing very well.

Accomplishments During Second Quarter

The second quarter agenda consisted of (a) kiln modifications (not completed in the previous quarter), (b) sample preparation (proposal task number 2) and (c) Heat Transfer calibration runs (part of proposal task number 3 -- to be completed by the end of month 7).

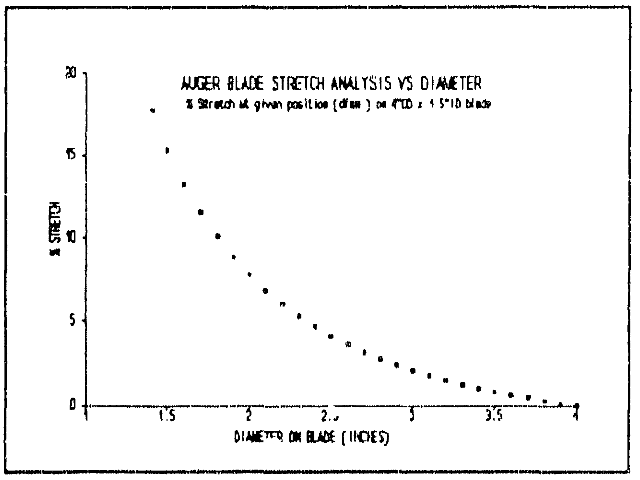
The following tasks have been completed (kiln modifications are listed in order of procedure difficulty):

Double Auger System: Construction of the newly designed auger blade system required more time and remakes than anticipated. The auger blades were made by cutting a series of annular-shaped rings from stainless steel sheet metal, each with a single radial cut, and then stretching and spotwelding them together so that they formed a continuous helical blade.

The original design used a series of short baffles each separated from the next. The kiln was set at a 7 degree angle so that the blades moved the granular material uphill and into the center of the cylinder, then gravity moved the material downhill, without central auger blades. Continuous helical auger blades both on the outside and inside of the cylinder (see Fig. 1) will be a simpler configuration to study because the particle movement is a more exact function of kiln rotation.

Construction of the outer blade was fairly simple. However, a first trial construction of a continuous outer helix (making a continuous outer helix then spotwelding it to the cylinder) demonstrated the need to spotweld each rung of the helical blade to the center cylinder before being attached to the succeeding ring. Following this procedure on the second trial, the outer blade was assembled without further problem.

The inner auger presented significantly more problems because of the greater relative difference in the inner and outer diameters and the greater swaging or stretching required in the inner diameter. (A consulting machinist commented that we needed a large press and die system to swage the blades into the desired shape whereas our small project justified no more than a hammer and anvil.) Several weeks were involved in the double auger blade construction, some of it due to our misunderstanding the proper dynamics of the blade swaging operation. A stretch analysis of the swaging operation was helpful to observe how the swaging should proceed. When an annular ring stretches to form a helical shape, the inner diameter of the annulus must stretch while the outer diameter is constant or is compressed. We initially erred in supposing that the stretch was a simple linear function of position between the two diameters. Reference to the Blade Stretch Analysis Plot at the right indicates that the function is not linear but a curved function requiring proportionally much more stretch close to the inner diameter. After completing this analysis, the swaging operation was completed without difficulty.



Thermocouple Installation: Eight new thermocouples were installed in the kiln in the positions noted in Fig. 1. Thermocouples were 1/16 inch OD sheath over type J wires (iron and constantan--see thermocouple cross section shown in Fig. 2). Connections were made by cutting each sheathed assembly to be the right length, stripping a short length of the sheath from the iron and constantan leads, then connecting the leads to the slip rings. The resistance of the leads were measured and a Breakdown Voltage Current Leakage tester was used to finally assure that the delicate leads were still insulated very well from each other and from the sheath. The thermocouple was replaced and/or the sheath stripping operation was repeated when the lead resistance or current leakage changed. In all cases, a final high integrity thermocouple was indicated by consistent lead resistance and by a final breakdown voltage above 500 volts.

Heated Gas Filter Assembly (Figs. 1 and 2): The filter assembly consists of a perforated cylinder which was fitted with a coil heater, then the unit was wrapped with 500 mesh stainless steel wire cloth. The coil heater was constructed as a 0.09"OD x 48" length rod heater by ARI Industries, Addison, IL. The rod was wrapped around a mandrel in our lathe forming it into a coil. A strip of wire cloth 4" x 8" was formed into a 4" long x 2.5" OD cylinder. The seam was "sewn" together by the use of our portable spotwelder coupled with a 250 volt variac which enabled very fine adjustments of the welding heat. The wire cloth cylinder was then pleated and fitted over the assembled heater coil. The ends of the wire cloth cylinder were wire-lashed firmly to the assembly, forming a high surface area filter into a small, 3/4" OD unit.

Miscellaneous Kiln Parts (Item numbers refer to Fig. 1): Alteration/re-furbishment of other parts of the kiln has also been completed and includes: (a) Thermocouple Slip Ring assembly--Item #2; (b) Power Slip ring assembly--Item #3; (c) Heater #4 and Insulation Bulkhead with nickel rod electrical conductors, bringing power from the Power Slip Ring; (d) Thermocouple Slip Ring assembly, used in the 1987 project, moved to exit end of kiln--Item #10; (e) Installation of new Gas Inlet and Outlet Tubes. (New longer tubes were welded on the kiln to accommodate an additional slip ring on each end of the kiln.) (f) Construction and installation of Closure Removal Ring--Fig. 3.

Automated Controller and Data Logger: The Batch kiln has now been automated with the help of an IBM compatible 286 computer. The computer interface to the kiln system consists of a "ComputerBoard" CIO-AD08 analog to digital converter and a thermocouple input board MUX-32. The same CIO-AD08 also controls the power and temperature heat-up by means of control of a series of 14 Solid State Relays.

Sample Preparation: Six of nine primary oil shale samples were crushed and reduced to a minus 7 mesh, according to the procedure in the proposal. These consist of two eastern oil shales and two Piceance (pronounced Pea-ahnse) Creek, Green River Basin oil shales obtained from the US DOE Laramie Project Office. A fifth sample from Hell Hole Canyon, Uinta Basin, Utah, was obtained from the University of Utah. Lawrence Livermore National Labs sent us the sixth sample which originally was obtained from Occidental Oil Co., from their property in Colorado. Secondary samples, approximately 1 pound each, are being submitted to a commercial testing lab for analyses. The three additional samples, also obtained from the University of Utah, are intact cores (3.5"diam.) from the Uinta Basin, taken from near the 1800 foot depth. If these are not necessary to use in the project we will not crush them (to -7 mesh) since some of the value as specimens will be lost if they are crushed.

Heat Transfer Calibration Runs: The heat transfer calibration runs will be completed and reported on during the next quarter.

Expenses

The total project expenses through the end of June are shown in the accompanying form 272.

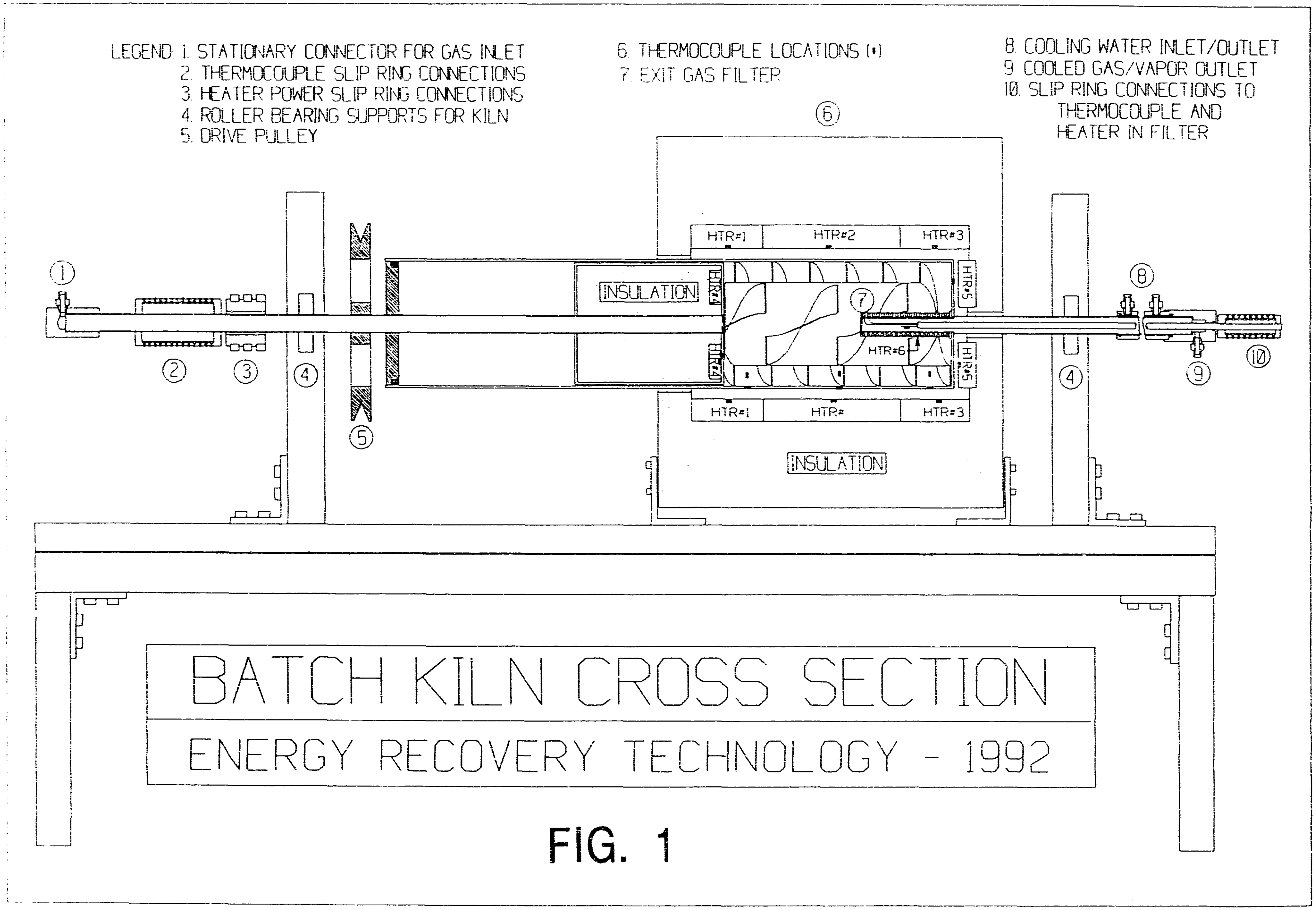
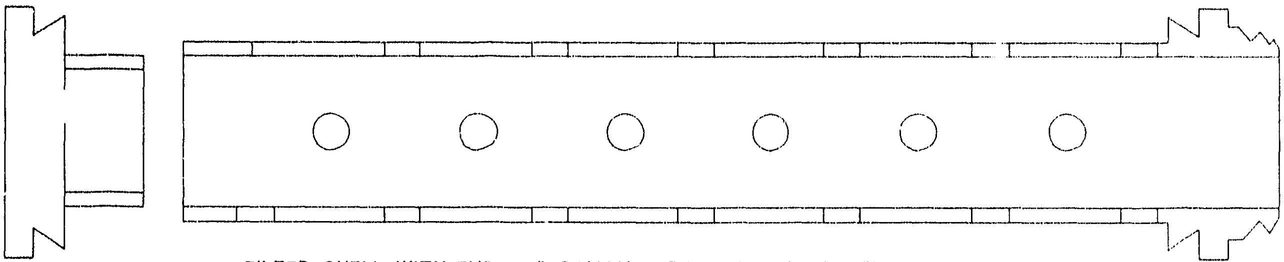

LEGEND: 1. STATIONARY CONNECTOR FOR GAS INLET
2. THERMOCOUPLE SLIP RING CONNECTIONS
3. HEATER POWER SLIP RING CONNECTIONS
4. ROLLER BEARING SUPPORTS FOR KILN
5. DRIVE PULLEY
6. THERMOCOUPLE LOCATIONS (•)
7. EXIT GAS FILTER
8. COOLING WATER INLET/OUTLET
9. COOLED GAS/VAPOR OUTLET
10. SLIP RING CONNECTIONS TO THERMOCOUPLE AND HEATER IN FILTER
HTR#1
HTR#2
HTR#3
HTR#4
HTR#5
HTR#6
INSULATION
BATCH KILN CROSS SECTION
ENERGY RECOVERY TECHNOLOGY - 1992

FIG. 1

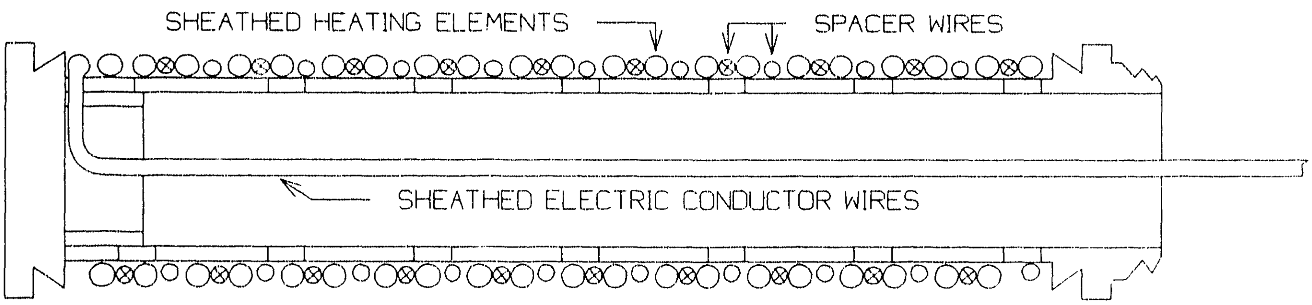
FIG. 2

FILTER CROSS SECTIONS

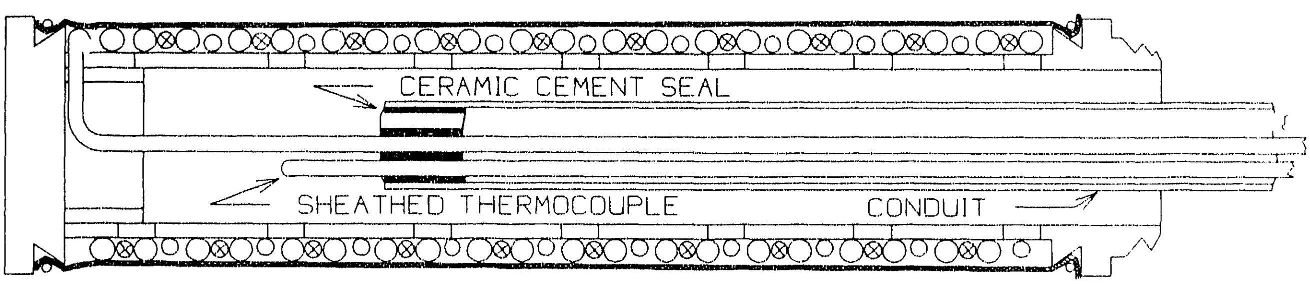
INCLUDING ASSEMBLY DETAILS



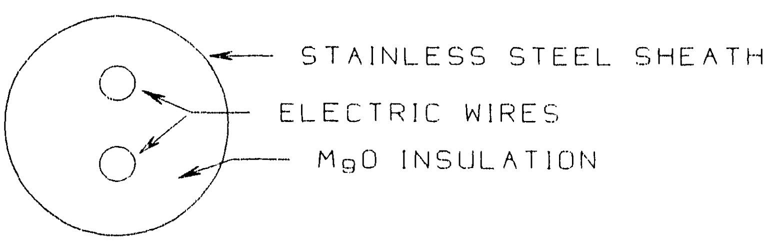
FILTER SHELL WITH END CAP REMOVED TO ASSEMBLE HEATER COIL



FILTER SHELL WITH HEATER COIL AND CONDUCTOR WIRES IN PLACE



FINISHED FILTER ASSEMBLY WITH FINE WIRE CLOTH ON OUTSIDE



CROSS SECTION OF SHEATHED HEATER, CONDUCTOR & THERMOCOUPLE WIRE

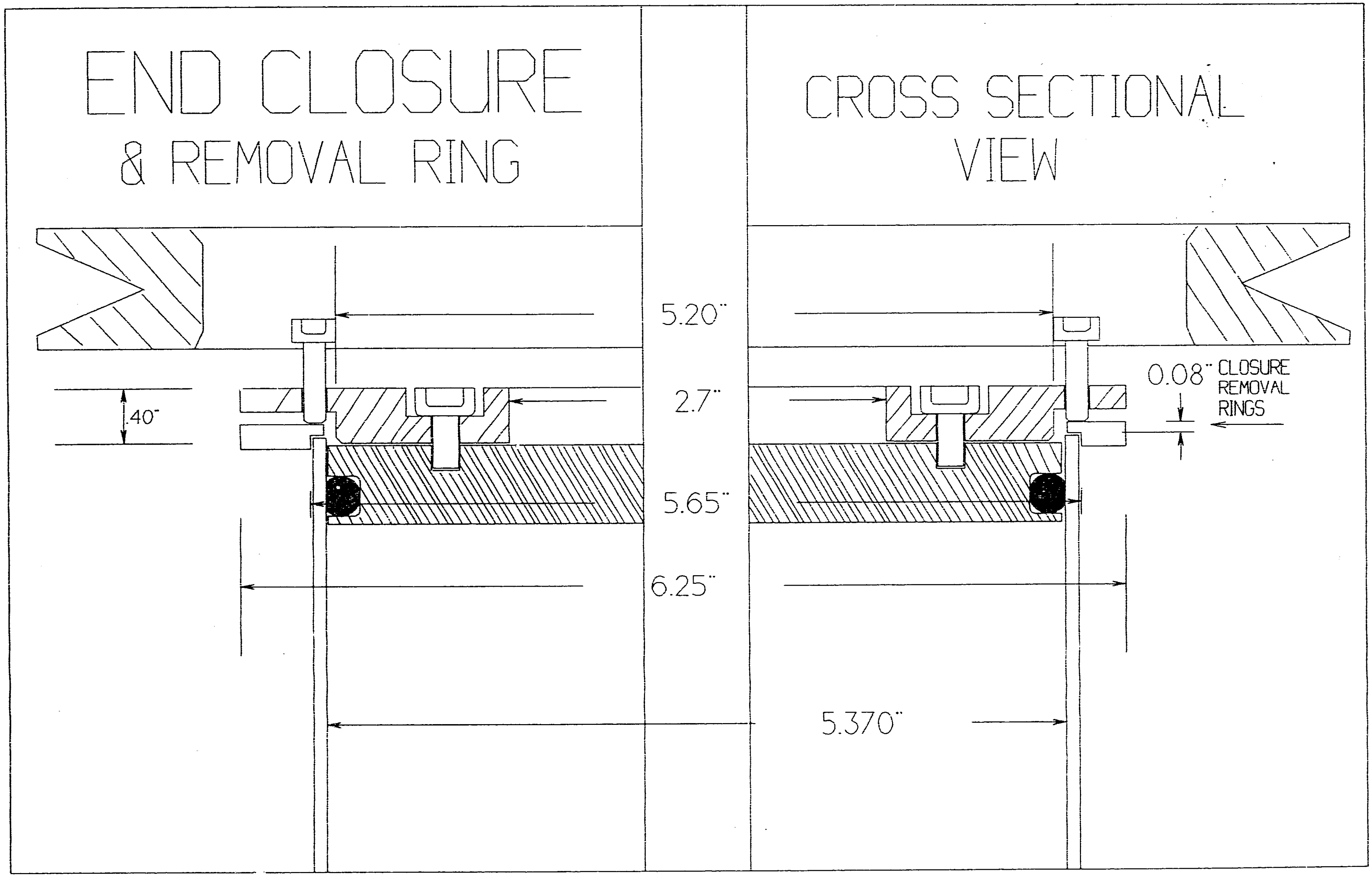

END CLOSURE
& REMOVAL RING
CROSS SECTIONAL
VIEW
5.20"
2.7"
.40"
0.08" CLOSURE
REMOVAL
RINGS
5.65"
6.25"
5.370"

FIG. 3

END

DATE FILMED

10 /21 /92