poor results, apparently because the present Darcova cups quickly disintegrate in the 350° F. oil. The original single-ring, expander-type pistons give poor service, both pistons and liners wearing out quickly. An effort will be made to find or develop Darcova cups of suitable material.

7. The horizontal continuous centrifuge continued to operate satisfactorily throughout the run at rates of 5 to 20 g.p.m. Quality of filtrate improves slightly at extremely low rates. However, in the range cited, the solids in the filtrate remained substantially uniform at 15 percent when feeding a material containing 17 to 18 percent solids at 350° F.

8. Several difficulties were experienced with the wash-oil scrubber system. As there was considerable carry-over of heavy material from the cold catchpot, need for further adjustment to the tangential flow mist-vapor separator used in the cold catchpot is indicated. It will be necessary to increase the vapor space below the packing rings, so that both top and bottom connections of the level controller can be made from this free space below the packing, as the packing imposes a variable resistance that interferes with level indication.

9. The plant was under pressure and operated satisfactorily for 34 days before a serious lens-ring leak developed in the hot stall. As a result of this experience and a rather similar incident during run No. 3, the general piping layout was redesigned to eliminate about 75 percent of the flanged joints; new pipe supports were added to permit greater movement of the piping under thermal stresses, and the method of tightening the flanged joints was revised.

After September 11 the liquid-phase unit was down for cleaning, inspection, and repair of fire damage to piping, electrical wiring, and structural steel. During this time, operators and maintenance personnel readied the vapor-phase unit for operation early in October, and all distillate oils were rerun through the liquid-phase still to vapor-phase feed specifications.

Vapor-Phase Run No. 2

Preparation consisted primarily of revision to the instrumentation similar to that that worked best in the liquid phase, extensive repairs to the double-tube feed-product heat exchanger, and installation of improved pump blocks for the vapor-phase feed service. After the usual inert gas-pressure test, hydrogen was introduced, and the unit was heated from October 1 through October 4 to reactivate the catalyst at 925° F. before starting up at a 2 g.p.m. feed rate at 815° F. converter temperature on October 5. The feed rate and converter temperature were slowly raised to 15 g.p.m. and 910° F. maximum during the next 7 days. During this time the feed, containing 8 to 9 percent tar acids, resulted in a product containing 1 to 2 percent, rather than 0.+ percent, tar acids, despite the increased feed rate and temperatures. The distilled gasoline contained 0.4 to 1 percent tar acids and was slightly sour to the usual doctor test. A sample of the hydrogenated material taken from the product line between the converter and exchanger on October 12 showed excellent catalyst activity, was light in color and sweet, indicating that 30 to 40 percent of the feed was bypassed in the exchanger direct to the cold catchpot product. Despite the reduced and somewhat unsteady flow through the preheater and converter, reaction conditions proceeded quite smoothly.

After the development of a small leak on the converter inlet piping, the unit was shut down on October 13 for inspection and repair of the heat exchanger. The 1-1/4-inch tubes were rerolled and withstood a 300-pound differential nitrogen cold test.

Before operations were resumed, it was necessary to dismantle all of the hot piping in the stall for refacing of tube ends and installation of new lens gaskets and new bolts.

Upon completion of this work the unit was pressure-tested, the fires lighted, and production of 77 to 78 octane-number (motor method), 8 to 10-pound vapor-pressure gasoline was resumed on October 24. The product-feed heat exchanger continued to give considerable trouble with uneven outlet temperatures on the feed side. This exchanger is composed of a number of double-pipe hairpin units hung in a vertical position. The product entering the hot side is partly condensed, and the resulting liquid tends to collect in the annular space between the pipes until the column of liquid is high enough to be forced out ahead of the vapor stream. When the liquid column is forming, the heat-transfer coefficient falls off, resulting in a drop in temperature of the feed leaving the exchanger. These changes in temperature were so large that they were not compensated by the preheater, which caused a 10° to 20° F. variation in the temperature of the feed entering the converter, thereby reducing somewhat the efficiency of the reaction. There also was a tendency for the preheater tubes to run hot (1,050°-1,075° F.) owing to the erratic and low efficiency of the exchanger and to the parallel flow arrangement of the preheater. Consideration is being given to designing a new tubular exchanger and to series flow in the preheater. The injection pumps equipped with improved blocks and better lubrication gave good service, and packing life increased to 15 days. Approximately 300,000 gallons of vapor-phase feed stock was converted to finished gasoline during the successful 30-day run. The principal flows, temperatures, and yields are shown in table 3. Figure 6 is a flow diagram of operating conditions, and table 4 contains analytical data illustrative of the quality of the streams.

Mechanical Features and Plant Improvements

Preparation of Coal and Paste

Coal grinding and drying usually is done in a mill swept with hot air or flue gas. However, it was found that a minimum of oxidation and low-drying temperatures as well as a minimum of either very coarse or very fine particles was desirable for the hydrogenation process. Accordingly, the design was changed to include recirculation of the gases and drying in a gas of less than 8 percent oxygen content at 300° to 400° F. Experience in grinding Rock Springs coal also disclosed the need for much closer control of temperatures, pressure drops, and flows than in the usual installation.

To reduce the carry-over of coarse particles in the finely ground coal, it was necessary to use a fixed, inverted V-type diffuser in a large double-cone classifier. Additional studies are under way to improve the quality of the ground coal and increase the capacity to design rates.

The use of a Waytrol to feed the coal has presented many problems. First, the coal entering the Waytrol from the storage bin is hot and contains fines (through 200-mesh) in the range of 50 to 70 percent; various devices have had to be used to prevent flooding of this coal onto the Waytrol belt. At present, a system of baffles in the chute from the Star feeder on the pulverized-coal bin, together with a canvas skirt, has proved the most successful. Recently, a variable-speed motor has been used on the Star feeder in conjunction with the Waytrol to prevent flooding.

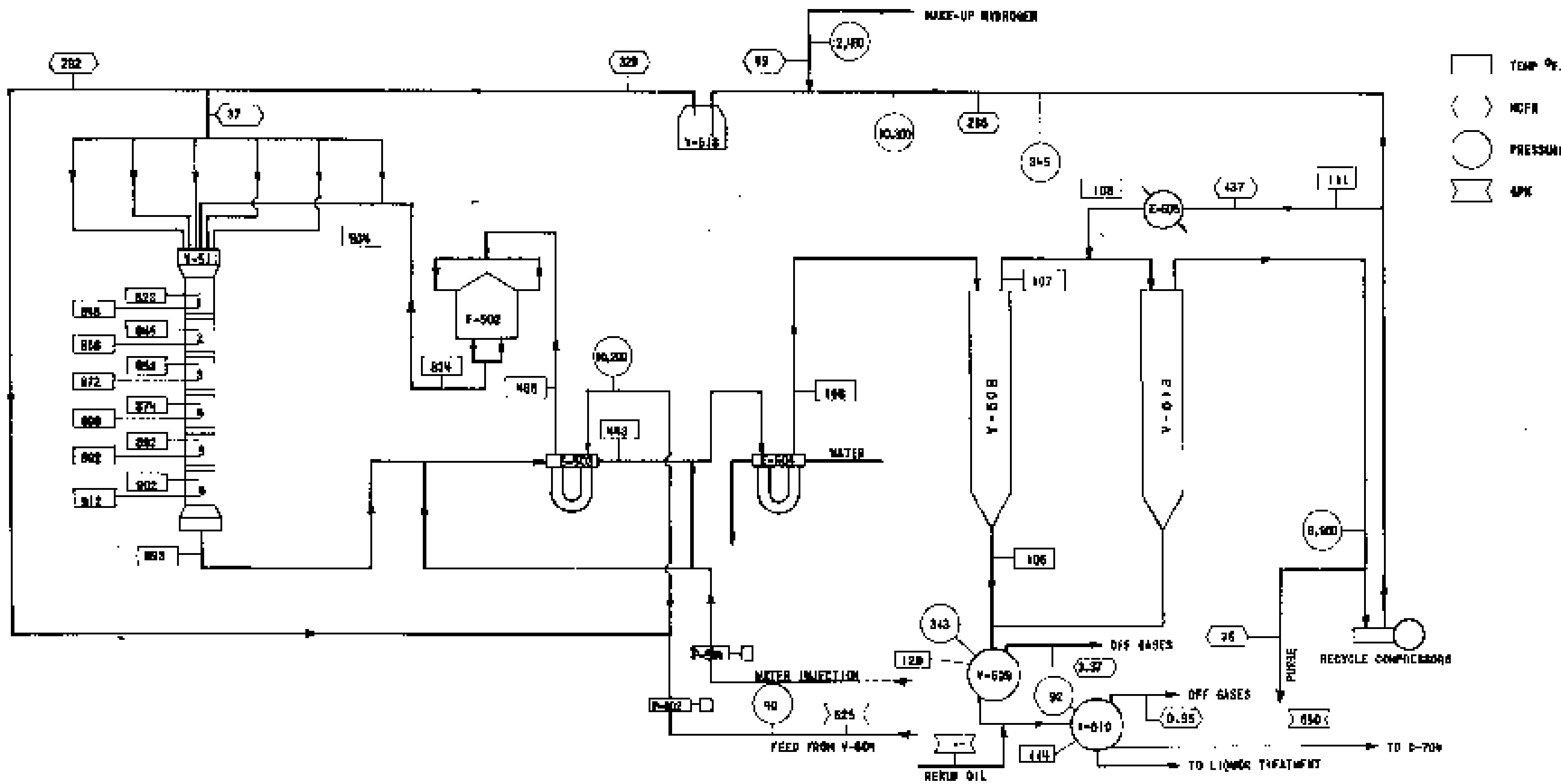

Figure 6. - Vapor-phase hydrogenation unit - typical operating conditions - Rock Springs coal hydrogenation.

TABLE 3. - Initial operating conditions for vapor-phase run No. 2

Pressure, p.s.i.g.	10,150
Recycle hydrogen, percent hydrogen	86
Feed, gal./day:	
Injection	15,000
Virgin	9,400
Recycled bottoms	5,600
Catalyst, type	Zn-Cr-Mo
Volume catalyst beds, cu. ft.	100
Gas flows, cu. ft./day:	
Make-up hydrogen gas	1,040,000
Total hydrogen to stalls	7,900,000
Compressor recycle	10,500,000
Gas to preheater feed inlet	7,030,000
Total cooling gas	850,000
Purge gas	650,000
Temperatures, °F.:	
Feed:	
Inlet of feed-product exchanger	95
Preheater inlet	458
Preheater outlet	834
Converter reaction:	
Average of middle of catalyst beds	866
Average of bottom of catalyst beds	878
Product:	
Converter outlet	893
Outlet feed-product exchanger	443
Catchpot, liquid	107
Products from hydrogenation, gal./day:	
Catchpot:	
Liquid, net	15,480
Gasoline	9,140
Wash oil	810
Bottoms	5,530
Final stabilized gasoline, bbl./bbl. virgin feed	0.99
Gasification (C_4 and lighter)	
Cu. ft./day	88,000
Weight percent on vapor-phase feed consumed	9.3

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TABLE 4. - Analysis of feed and product streams during initial operation of vapor-phase run No. 2

	Feed	Products				
	To hydro	Raw gaso-line	Wash oil naphtha	Bottoms	Cold catchpot	Stripping still gasoline
Distillation, °F.:						
I.B.P.	149	66	184	408	142	75
5 percent.............	217	114	280	426	191	111
10 percent.............	275	135	311	433	215	157
20 percent.............	364	168	336	440	249	249
50 percent.............	459	228	371	462	358	360
90 percent.............	553	338	397	532	492	-
E. P.	609	378	425	608	576	464
Recovery, percent...........	98.7	94.2	99.1	99.1	98.5	50.5
Gravity......................	25.5	55.8	33.1	24.6	37.6	51.3
Tar acid.....................	7.2	0	-	0.5	0.8	-
Color........................		+30				

Average tests on gasoline prepared for fleet road tests

Octane rating (ASTM D908-48 T C.F.R. Research Method).........	83
Octane rating (ASTM 357-48 C.F.R. Motor Method)...............	78
Vapor pressure, p.s.i.	9.0
A.P.I. gravity at 60° F.	54.8
Sulfur content, percent...	0.03
Doctor test (FSB520.31)..	Negative
Corrosion test (ASTM D130-30)..................................	Negative
Tar acids..	Nil
Existent gum, mg./100 ml.	1.0
Induction period, min.	720 + min.

Distillation

	°F.
I.B.P., percent..........................	92
10..	136
50..	225
90..	318
95..	336
E.P.	366
Recovery....................................	99.0%
Residue.....................................	1.0%

Pumps

In the first run, performance of the low-pressure, valveless, modified screw-type, paste-circulating pumps was very poor, resulting in low delivery rates and discharge pressures after short operation. The excessive wear of the stators and rotors is believed to be due in part to the service and the partial plugging of the suction line. New stators and rotors were installed, the suction lines to the individual pumps were simplified, and the performance of the pumps has been fairly