TABLE 25A. - Estimated metals, manpower, and time requirements for 250,000-barrel-per-calendar-day operation; case II - oil-shale processing with mild hydrogenation

Item	Crude oil production	Colorado refining	Trans-portation	California refining	Total
Construction metals					
Steel .....tons	110,000	174,000	155,000	47,000	486,000
Alloy steel ..... do.	19,000	46,000	400	3,600	69,000
Nonferrous alloys.. do.	2,300	6,000	250	500	9,050
Construction period					
Months to 1/5 capacity.	18	18			
Months to 1/3 capacity.				24	
Months to 2/5 capacity.	30	30			
Months to 3/5 capacity.	42	42			
Months to 2/3 capacity.				36	
Months to 4/5 capacity.	54	54			
Months to full capacity	66	66	24	54	66
Construction manpower					
Man-shifts (total)	6,500,000	7,300,000	700,000	1,000,000	15,500,000
Operational manpower					
All employees	8,600	3,800	250	650	13,300

Plant Service Laboratory

The laboratory staff has met most of the station's analytical requirements, has developed methods for special tests, has made analytical investigations of plant products and processes, and has improved the utilization of available working space.

Oil-Shale Assays

In line with previously reported experience, foot-by-foot assays of diamond-drill cores show reasonably good correspondence of oil yields between drill cores in the Demonstration Mine benches and at hole A, about 700 feet to the northeast in the Selective Mine. Similarly, average oil yields of run-of-mine shale from both mines are in line with the exploratory core assay data. These observations are exemplified by table 26.

TABLE 26. - Assays of oil shale from mining operations

Mine	Demonstration						Selective
Bench	Upper	Upper	Middle	Middle	Lower	All	All
Vertical section ....ft.	27	27	23	23	23	73	70
Type of shale	Mine run	Drill core	Mine run	Drill core	Drill core	Drill core	Mine run
No. of samples	84	27	10	23	23	73	34
Ave. oil yield .... gal. per ton	20.9	21.3	37.3	39.2	23.6	27.6	26.7
Oil yield of corresponding section, hole A .. .. gal. per ton	22.4	22.4	35.9	35.9	25.7	27.4	28.0

Analyses of Crude Shale Oil

Oils from the three principal plant retorting processes have been characterized by conventional tests supplemented by distillation within the limits of thermal stability at a pressure of 1 mm. of mercury (fig. 42); determination of tar acids and tar bases in the distillate by extraction with dilute sodium hydroxide and dilute sulfuric acid, respectively; and hydrocarbon-type analysis of the light distillate in a silica-gel column. Both the N-T-U oil and the gas-combustion oil samples are considered reasonably representative. The gas-flow oil is heavier than average, so that the contrast between this and the other oils is emphasized.

As is apparent from table 27, the physical properties of the N-T-U oil do not differ markedly from those of the gas-combustion oil. The gas-flow oil is more viscous and less volatile than the other two. Sulfur and nitrogen contents of the three oils are quite similar. The hydrocarbon analysis of the light distillate shows a general predominance of olefins. The tar acids in the crude shale oils must be largely high boiling, since the bulk of them appear in the heavy distillate. The tar bases, on the other hand, tend to be concentrated in the light distillate. Appreciably more high-boiling tar acids and less low-boiling tar bases have been found in the gas-flow oil than in the other oils. For all three oils, however, the volumes of extractable tar bases are small compared with that predictable from the nitrogen content.

Development of Methods

For determinations of efficiency of oil recovery in pilot-plant retorting operations, a method was required that would measure the oil-mist content of the carrier gas without including any organic material present in the vapor phase. This requirement has been met by a spectrophotometric procedure, based on absorption in the ultraviolet at 2,730 Å., at which wavelength the volatile constituents in crude shale oil have a small absorptivity. The oil mist is separated from an aliquot portion of the carrier gas by diatomaceous earth filters and recovered as a solution in spectrographic grade iso-octane. The oil content of this solution is determined by usual spectrographic procedures, liquid oil from the pilot-plant recovery system being used for calibration.

212685 O - 52 - 9

TABLE 27. - Characterization of crude shale oils

Test	Retorting method		
	N-T-U	Gas-combustion	Gas-flow (filtered)
Gravity ..... °A.P.I.	20.3	21.0	15.8
Pour point ..... °F.	90	90	85
Viscosity ..... S.U.S. at 130° F.	130	102	345
S.U.S. at 210° F.	48.4	47.1	78.5
Conradson carbon ..... wt. percent	4.5	2.8	7.5
Ash ..... do.	0.02	0.21	0.08
Sulfur ..... do.	0.79	0.65	0.73
Nitrogen ..... do.	2.10	1.98	2.22
Distillation at 1 mm. Hg (corrected to 760 mm.)			
I.b.p. ..... °F.	356	360	434
2 percent at ..... do.	430	410	490
5 percent at ..... do.	475	463	541
10 percent at ..... do.	523	520	600
20 percent at ..... do.	605	612	690
30 percent at ..... do.	684	685	768
40 percent at ..... do.	756	748	840
50 percent at ..... do.	822	807	-
60 percent at ..... do.	881	862	-
Cut point ..... do.	900	903	900
Distillation yields, volume percent			
Light distillate, I.b.p.-600°F./760 mm....	19.2	18.7	10.0
Heavy distillate, 600-900°F./760 mm.	44.5	48.8	39.7
Total distillate to 900°F./760 mm.	63.7	67.5	49.7
Analysis of light distillate			
Tar acids (by extraction) ... vol. percent	2.8	3.8	6.2
Tar bases (by extraction) ..... do.	9.3	8.4	10.0
Saturated hydrocarbons ..... do.	29.0	14.1	20.8
Olefins ..... do.	42.2	39.4	37.1
Aromatic hydrocarbons, S and nonbasic N compounds ..... do.	16.7	34.3	25.9
Total	100.0	100.0	100.0
Analysis of heavy distillate			
Tar acids (by extraction) ... vol. percent	2.8	3.5	6.8
Tar bases (by extraction) ..... do.	2.0	2.4	2.2
Tar acids in crude oil, vol. percent			
Recovered in light distillate below 600°F.	.5	.7	.6
Recovered in heavy distillate 600-900°F...	1.3	1.7	2.7
Total recovered from distillate	1.8	2.4	3.3
Tar bases in crude oil, vol. percent			
Recovered in light distillate below 600°F.	1.8	1.6	1.0
Recovered in heavy distillate 600-900°F...	.9	1.2	.9
Total recovered from distillate	2.7	2.8	1.9

Among the other methods developed, techniques have been worked out for rapid laboratory rerunning of acid-treated gasoline in quantities adequate for evaluation, including engine testing.

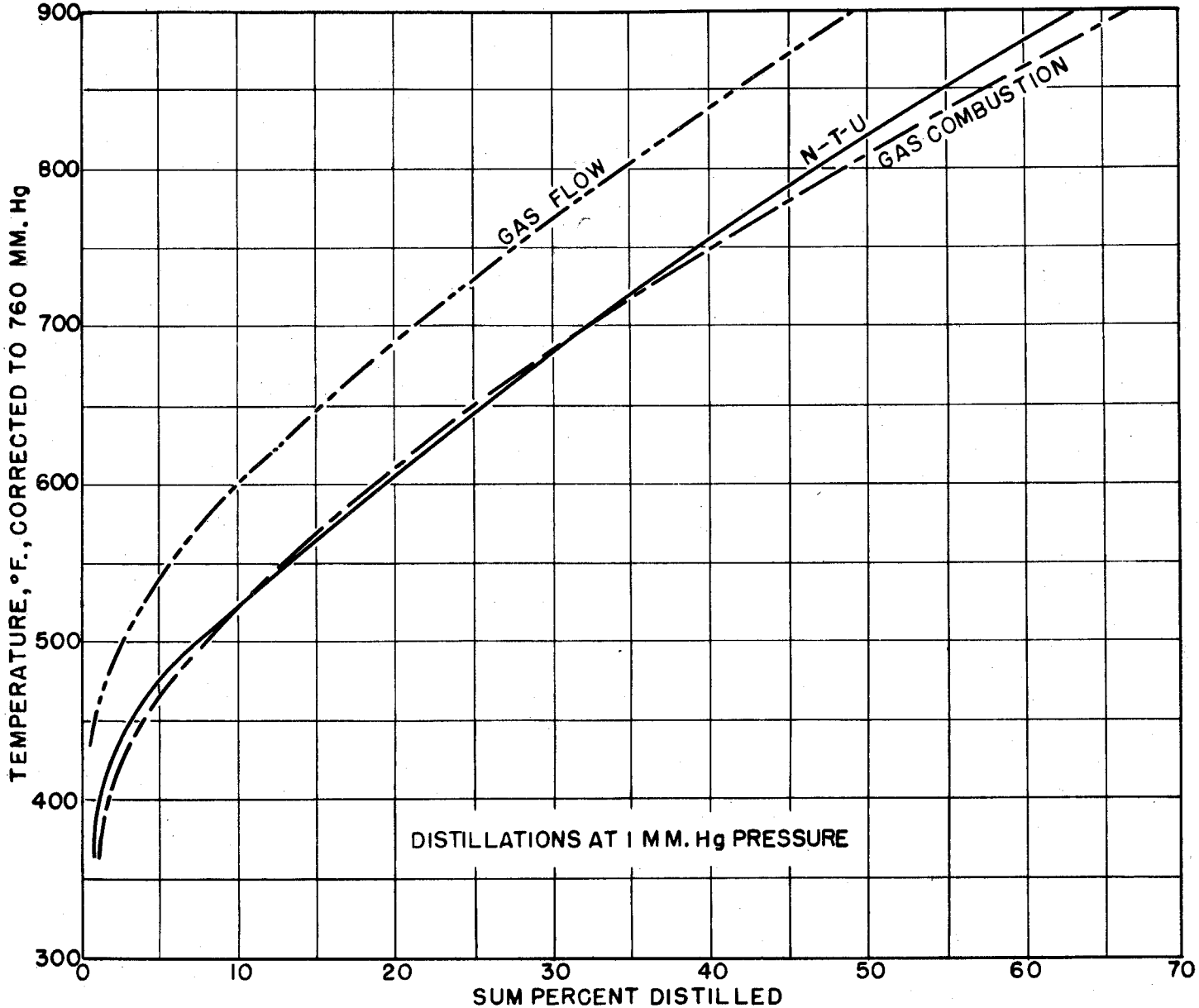

Figure 42. - Comparison of vacuum Engler distillations of various crude shale oils.

Process Studies

Analyses of available refinery stocks have indicated the possibility of producing, from thermally cracked shale oil, jet fuels that could pass all military specifications except bromine number.

Exploratory laboratory tests show that contact clay treatment of shale gasoline in liquid phase at room temperature can result in improvement of color stability without improvement of stability toward gum formation. Vapor-phase clay treatment, on the other hand, may yield a fairly gum-stable gasoline.

Laboratory Facilities

A 30-foot extension to the laboratory and instrument shop building has been in full use since May 1951. It houses a physical testing laboratory, a basement oil-shale laboratory with an independent crusher foundation, an enlarged instrument shop, and storage and sample receiving space. The original laboratory rooms now are used for chemical analysis. The former stockroom has been converted into a general laboratory with a dual, 14-foot metal-rod framework for supporting complex assemblies of apparatus. Carefully planned laboratory and instrument shop arrangements have eliminated many steps, reduced crowding, and increased efficiency (see figs. 43 to 45).

Functions and Facilities Other Than Mining and Processing

Design, Construction, and Maintenance

Design of a proposed water system was completed for supplying the industrial and domestic needs that will arise when the oil shale of Naval Reserves 1 and 3 is mined and processed on an industrial scale. The plans include facilities and structures for withdrawal, filtering, treating, pumping, and distribution of 48 million gallons of Colorado River water a day. It is expected that this design will be useful not only as a plan for constructing a water system when industrial plants are built, but also as a basis for water-right filings.

Other important design work included plans for the demonstration gas-combustion retort and related shale storage, weighing, conveying, and sampling facilities, commercial-scale plant designs for cost-estimating purposes, and the design of an improved system for storing, weighing, and distributing crushed shale to the various pilot-plant units.

Extensions to four buildings that had been started last year and four new building structures were completed.

Building	Size, ft.
Laboratory extension	30 x 41
Pilot-plant extension	42 x 45
Boilerhouse extension	24 x 39
Garage extension	15 x 41
Administration-building extension ...	28 x 48
Processing-Section office building ..	28 x 48
Change-house extension	12 x 24
Tetraethyllead blending building	7-1/2 x 16

The loop road in the housing area was resurfaced with a mat of graded gravel and shale road oil.

Approximately 2,200 feet of schedule 40 steel pipe was laid to supply water to the plant-area storage tanks. Formerly "invasion" pipe had been in use for this service but had failed in several places. Another improvement in the water system was construction of a new intake crib in the Colorado River, with larger intake and discharge lines to the desedimentation pond and a bypass around the pond to permit the intake of raw water directly from the river during low turbidity.

Health and Safety

No radical departure has been made from the safety program of the previous year. Craft safety meetings, employee' safety-suggestion programs, and equipment, property, and area inspections have been continued.

Though this year's accident frequency remains about the same as last year, which is somewhat below the average for both the Bureau of Mines and the United States Department of the Interior, there was an increase in accident severity.

Until it has been proved that shale oil has no carcinogenic properties, personnel exposure to higher-boiling fractions is being kept to an absolute minimum. As a further precaution, the United States Public Health Service has been requested to conduct periodic physical examinations of all exposed employees to detect the earliest stages of skin lesions, should they develop.

Under a cooperative agreement, investigation of possible therapeutic properties of shale-oil preparations with respect to certain skin diseases is being continued by the University of Cincinnati College of Medicine.

Administration

Administrative work of the Oil-Shale Demonstration Branch consists mainly of executive and public relations functions, purchasing, warehousing, and distribution of supplies and equipment, keeping account of Government property, fiscal and cost accounting, stenographic, messenger, custodial and protective services, and personnel and employee relations activities.

Approximately 2,450 purchasing documents were issued, totaling about $700,000, and 2,500 payment vouchers and schedules were executed. Proper

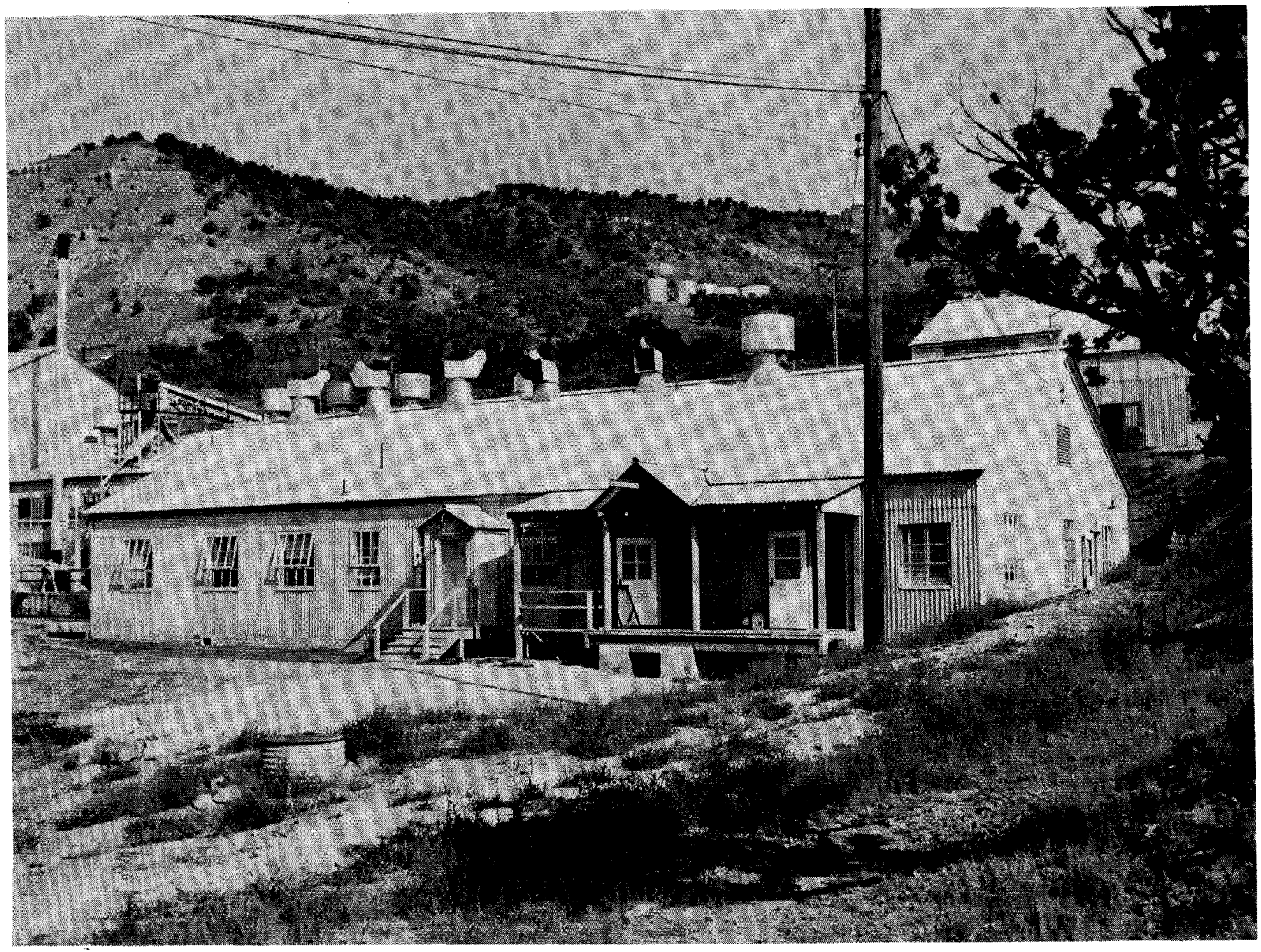

Figure 43. - Laboratory and instrument-shop building.

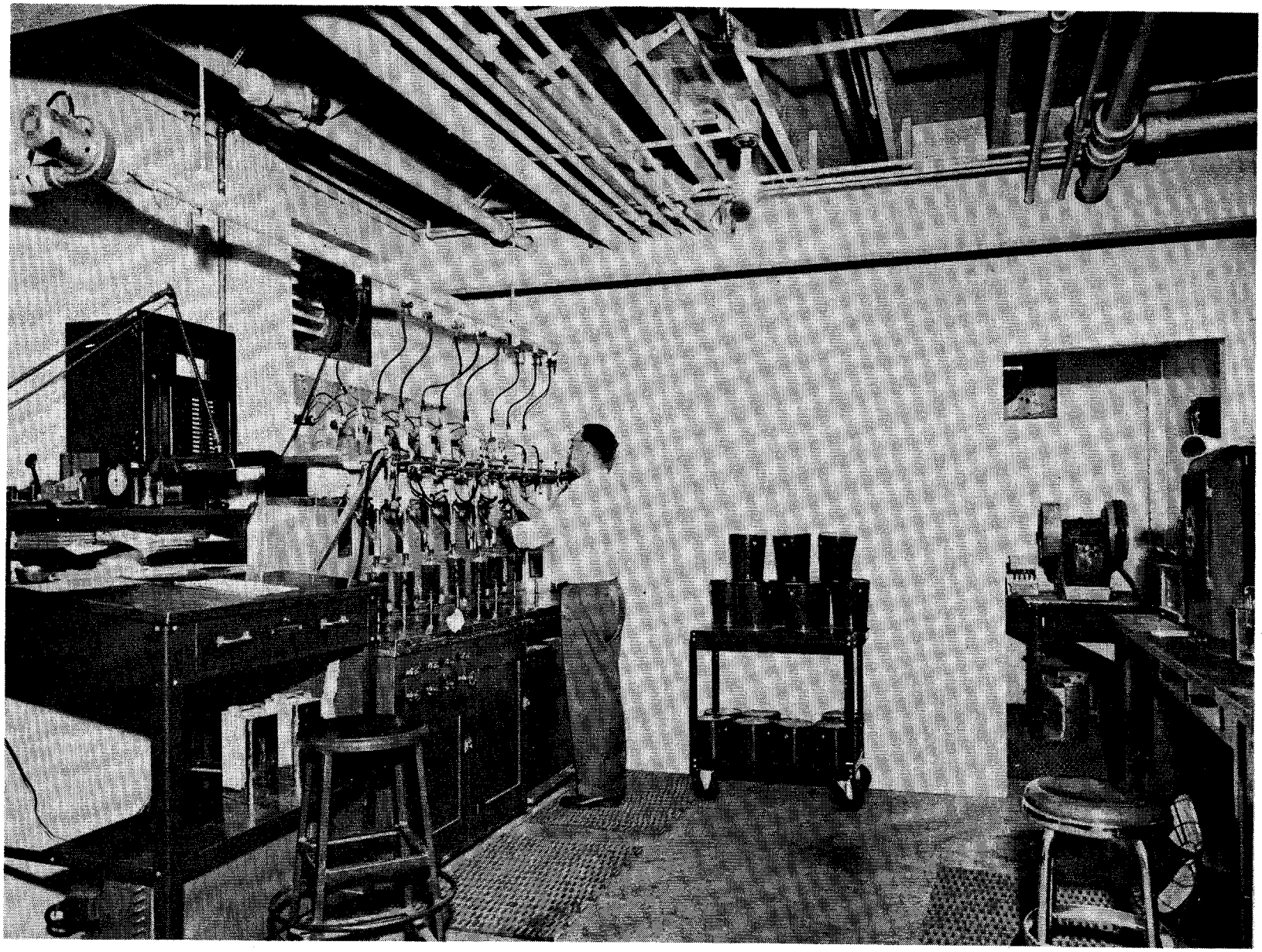

Figure 44. - Oil-shale laboratory.

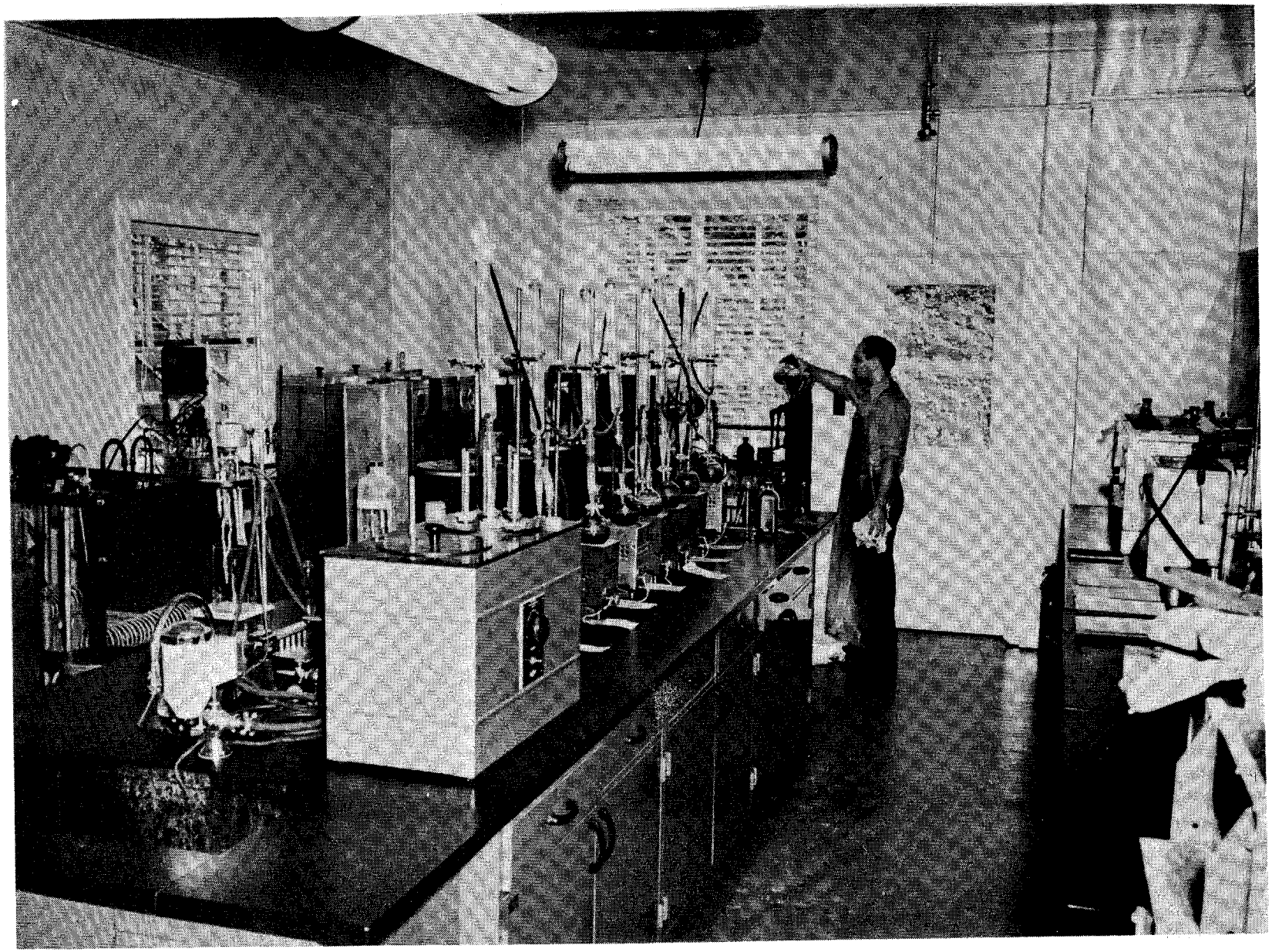

Figure 45. - Physical testing laboratory.

accountability records are maintained for approximately 4,000 pieces of non-expendable property valued at approximately $3,750,000.

Fiscal accounting records are maintained to account for yearly appropriations exceeding $1,800,000. Cost-accounting records show that approximately $960,000 was allocated to cost this year through the medium of 106 job authorities and 300 service orders. The cost-accounting system is designed to ascertain the cost of developing oil-shale deposits, producing oil shale, extracting the oil and refining it into finished products, as well as the cost of each structure, job, or operation, and of overhead and other indirect cost items. Where applicable, these data will be projected to determine the final cost of finished products. Since the beginning of the project, approximately $10,465,205 has been allocated to cost.

More than 420 applicants for employment were interviewed and 411 personnel actions processed. The plant and mine employ an average of 280 graded and ungraded employees yearly. The local Board of Civil Service examiners, composed of Bureau personnel of the Rifle Station, announced 30 examinations, processed 375 applications, established 30 registers, and placed 59 persons during the past year.

Owing to the remoteness of the project from any town and the desirability of having some of the technical, administrative, and other employees reside nearby, a 70-unit housing area is maintained. Also, a community hall is provided in the housing area for use by all employees. Social functions are scheduled in the hall, such as dances, card parties, moving pictures, little theater plays, and pot-luck suppers, usually sponsored by employee groups, such as the Anvil Points Recreation Association, the local chapter of the N.F.F.E., and the employees' Federal Credit Union. These groups also sponsor basketball, softball, and bowling leagues.

Approximately 3,000 visitors took the guided tour, which is conducted twice daily, 9:15 a.m. and 1:30 p.m., and a booklet containing general information pertaining to the Oil-Shale Demonstration Branch and Mine was presented to each.