

tate the microscopic examination of large machine parts in place, a portable microscopic mounting has been designed and built at the Station, and is so arranged that the microscope may be focused upon a surface at any angle.

Physical Tests of Metals.—The testing machines seen in Fig. 2 provide for tension, compression, shearing, transverse, single impact, alternating impact, fatigue and hardness tests of materials. These machines are employed to determine the suitability of new materials for specific purposes, to determine the defects, if any, in materials which have failed, and for research along various lines. An investigation is under way of the effect of alkaline solutions upon the strength of steel.

Chemical Tests.—The chemical tests include analyses of bearing metals, boiler-tube materials, valve materials, brasses and bronzes, cast irons and steels, alloys of steel with vanadium, chromium, nickel, etc., monel metal, boiler compounds, boiler deposits and scales, internal combustion engine deposits, lubricating and fuel oils, coal, furnace gas, various brines, etc.

Instruments.—All the instruments used in the test work at the Station must be calibrated and kept in good working order. Some instruments must be calibrated before, after, and even during each test. A number of instruments have been designed and built at the Station for special purposes or to facilitate the work. Tests to deter-

mine their suitability for naval use have also been made upon thermometers, pyrometers, pressure gages, speed indicators and tachometers, water and oil meters, torsion meter, etc. In the center of Fig. 2 is seen a displacement meter mounted for test upon an oscillating platform, to simulate the motion it would have on a rolling ship.

Miscellaneous Tests.—In addition to the tests coming under the preceding headings, a number of miscellaneous tests have been made, among which may be mentioned: Methods of galvanizing, methods of welding, ball and roller bearings, expansion sleeves, lock nuts and washers, whistles operated by air and steam, flexible couplings, grease cups, fire brick baffles, fire cement, boiler tube cleaners, water circulation in boilers, rotary engines, paraffin illuminants, gasoline drums, friction clutch, steam pipe insulations, bearings and bearing metals, refrigerating machines, smoke preventatives, steam hose, pipe wrenches, pipe unions, files, etc.

The above summary of the character of the tests completed and in hand will give some idea of the variety of work covered at the Naval Engineering Experiment Station or naval laboratory for the Bureau of Steam Engineering. With the help of the data obtained, reduction in weight and increased efficiency in operation of machinery on shipboard have resulted. The grades of materials purchased have been improved and better adapted to the services required, although their cost has decreased. For

example, the cost of packing has decreased during the past five years to one third of its former cost, and less of it is required. Although the cost of lubricating oil has decreased in like proportion, less lubrication troubles are experienced. Thus, not only has a basis been prepared for future development, but much valuable work has already been accomplished.

In spite of the increased efforts of the technical staff, as shown by the greater number of reports made per year, the tests in hand at the end of each fiscal year have also increased. Congress has shown its appreciation by increasing the appropriations from time to time. Neither the appropriations nor the staff, however, have increased commensurately with the work assigned for the Station to do. The photographs reveal the overcrowded condition of all the laboratories.

The tests are becoming more miscellaneous in character and longer investigations are being required. These investigations grow out of what is at first a short routine or miscellaneous test. Thus, there is a blending of routine and research work, which is beneficial to both. The routine tests in direct connection with actual conditions keep the investigator down to a practical basis in his research work, an essential at least in engineering research. On the other hand, his research investigations enable the test officer to deal better with routine work than he would otherwise be prepared to do.

The Improvement of the High-Boiling Petroleum Oils—II*

By the Action of Aluminum Chloride

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Oklahoma Crude Oil.—The residual oil from this crude (sp. gr. 34 deg. Bé.) by the usual process is a black, tarry mass, containing a large amount of asphaltic constituents and also paraffin. The amount of asphaltic constituents is so great, as a rule, that it is difficult to make paraffin and paraffin lubricating oils of the same grade as that obtained from Pennsylvania or Caddo residuums. By the aluminium chloride process (see Table III) this residual oil is cleaned of its asphaltic

TABLE III.—TESTS ON OKLAHOMA CRUDE OIL

(SP. GR. 34° BÉ.)

Distilled to Free It from Moisture and Natural Gasoline.

YIELD FROM CRUDE OIL.				
Primary distillate	Primary residual oil	Loss	Total Per cent	
20.83	78.31	0.86	100.00	
TESTS ON PRIMARY DISTILLATE.				
Sp. gr. 54.1° Bé.			Color W. W.	
Distillation over 152° F.				
Per cent.....	10	20	30	40 50
Up to.....	210°	226°	242°	252° 271°
Per cent..	60	80	90	95 (dry point)
Up to.....	290°	313° 345°	408°	455° F.

Fractional Distillation.		Per Cent	Per Cent
		Charge.	Crude.
Gasoline.....		70.00	14.58
Kerosene.....		20.00	4.17
Gas oil.....		7.50	1.56
Loss.....		2.50	0.52
Total.....		100.00	20.83

TESTS ON PRIMARY RESIDUAL OIL.				
Color	Sp. gr.	Flash test	Fire test	Pour test
Black	29.8° Bé.	170° F.	205° F.	20

Distillation over 330° F.				
Per cent.....	10	20	30	40
Up to.....	436°	484°	543°	590°

Mixture of primary residual oil and 5 per cent by weight of aluminium chloride was distilled during period of 48 hours. Temperature of the vapor line at the point of exit into final condenser was held around 350° F.

YIELD FROM $AlCl_3$ DISTILLATION OF PRIMARY DISTILLATE.

	Per Cent	Per Cent
	Charge.	Crude.
Secondary distillate.....	64.61	50.60
Secondary residual oil.....	17.97	14.07
Loss.....	17.42	13.64
Total.....	100.00	78.31

TESTS ON SECONDARY DISTILLATE.				
Sp. gr. 48.3° Bé.		Distillation over 140° F.		
Per cent..	10	20	30	40
Up to.....	225°	270°	294°	326°
Per cent..	70	80	90	95
Up to.....	413°	454°	503°	547°

FRACTIONAL DISTILLATION.		Per cent	Per cent
Fractions		Charge	Crude
Gasoline.....		40.00	20.24
Kerosene.....		50.00	25.30
Gas oil.....		7.50	3.80
Loss.....		2.50	1.26
Total.....		100.00	50.60

* Read before the Seventh Semi-Annual Meeting of the American Institute of Chemical Engineers, San Francisco, August 25th, 1915.

TESTS ON GASOLINE.

Color	W. W.
Odor	Sweet
Bromine No.	1.5
Dry test	O. K.
Heat test	2
Per cent S	0.027
Sp. gr.	64.5

Distillation of Gasoline Fraction—Over 130° F.

Per cent.....	10	20	30	40	50
Up to.....	160°	186°	200°	213°	222°
Sp. gr.....	83.8	76.2	70.1	66.6	62.8
Per cent..	60	70	80	90	Residue
Up to.....	238°	252°	270°	299°	8.3 per cent
Sp. gr.....	60.4	58.5	56.1	53.3	48.2

TESTS ON SECONDARY RESIDUAL OIL.

Color	Sp. gr.	Pour test	Flash test
Red-green bloom	28.2° Bé.	90° F.	230° F.

Secondary Residual Oil Distilled.

	Yield.	Per Cent	Per Cent
		Charge.	Crude.
Wax stock.....		60.00	8.44
Cylinder oil.....		40.00	5.63
Total.....		100.00	14.07

SUMMARY

Products from $AlCl_3$ Process (Per Cent Crude Oil)

	Gasoline	Kerosene	Gas oil	Residual	Total
Distillate					
Primary.....	14.58	4.17	83.72
Secondary.....	20.24	25.30	5.36	14.07
Loss Due to:					
Aluminium chloride distillation.....				13.64	16.28
Working distillate into standard products...				2.64
Total.....					100.00

COMPARISON OF $AlCl_3$ PROCESS WITH USUAL PROCESS.

Per Cent of Crude Oil.	$AlCl_3$ Process.	Usual Process.
Gasoline.....	34.82	12.50
Kerosene.....	29.47	41.00
Gas oil.....	5.36	35.00
Residual oil.....	14.07	9.00
Sum of Products.....	83.72	97.50
Loss.....	16.28	2.50
Total.....	100.00	100.00

constituents, and paraffin wax and paraffin lubricating oils of excellent quality are made therefrom. At the same time, the yield of gasoline from the crude is greatly increased, at the expense of the less valuable fractions of the crude.

Although the crude petroleum from the various oil-producing districts in this country differ greatly in quality and in chemical composition, yet they are generally divided into three types: asphaltic-base crude, paraffin-base crude, and paraffin-asphaltic-base crude. The oils I have spoken of in this paper are representative of each of these types: Texas, asphaltic-base crude; Caddo, paraffin-base crude; and Oklahoma, paraffin-asphaltic-base crude. To give figures on other crudes would be merely a repetition of the results obtained on one of these. I shall, therefore, not take the time to give

further examples. I might add that among the samples here are products made by the aluminium chloride process from 14 gravity California crude and 20 gravity Mexican crude.

RECOVERY OF ALUMINIUM CHLORIDE.

But all the good results of this process would be of no commercial value if the aluminium chloride could not be reclaimed. This chemical, when made on the ton scale, is not so expensive as it is when made on the pound scale, but nevertheless its cost is high, and from a dollars and cents view, it is necessary to recover it.

After a time, 48 hours or longer, aluminium chloride used in distilling oils, even the driest of oils, loses its catalytic activity and becomes converted into a coky mass. Analysis of the coky mass shows chlorine and aluminium present in the right proportions to form aluminium chloride, but the latter is, so to speak, masked. It does not display its ordinary reaction with petroleum hydrocarbons. The granular coky residue, after it comes from the oil-converting process, carries varying amounts of oils with it. If allowed to cool down in the presence of the body of oil, it may carry 40 to 50 per cent of its weight of oil. If the oil body has been separated while hot from the coky residue, the amount of oil will be reduced to 4 or 5 per cent.

After removing the oil, or the bulk of it, from the coky residue, the aluminium chloride can be extracted from the latter with water or steam to obtain a concentrated solution of hydrated aluminium chloride. Aluminium chloride in the hydrated state does not have the catalytic property of the anhydrous material, but the hydrated salt can be used as the raw material for making the anhydrous salt. To do this, advantage is taken of the property of hydrated aluminium chloride, breaking up when moderately heated to form aluminium oxide and hydrochloric acid gas. The alumina, when mixed with carbon and treated with hydrochloric acid vapors at a high temperature, reacts to form the anhydrous chloride, hydrogen and oxides of carbon. In utilizing this property, one portion of the hydrated chloride is heated to produce hydrochloric acid vapors and alumina, and these vapors on drying enter a further charge of alumina and carbon heated to redness. The hydrochloric acid vapors given off at a moderate temperature are thus utilized in further operations at high temperatures.

In another method of recovery, and the preferred one, the coky residue is heated to red heat in an atmosphere of chlorine which disengages the aluminium chloride from the carbon. Aluminium chloride volatilizes normally at a temperature around 365 deg. Fahr., but the coky residue may be heated to redness without much evolution of these vapors. If the heating is done in an atmosphere of chlorine, the aluminium chloride is unlocked, i. e., it vaporizes away from the carbon and is condensed in suitable receivers.

This account by no means covers the full scope of the aluminium chloride reaction with petroleum oils, yet to speak further would lead me outside of my subject.