Bradford District Trip - Saturday May 29, 1937

Leader: Chas. R. Fettke.

Bring a lunch.

Party will assemble at Foster Brook, two miles northeast at Johnston and Matthews Filling Station at 8:00 A.M., E.S.T.

Foster Brook can be reached by way of Jackson Avenue along northwest side of Tunungwant Valley or by way of East Main Street along southeast side of valley.

Cars can be parked along north side of road west of Filling Station.

Note the broad level floor of the Tunungwant Valley at this point. It is underlain by nearly 250 feet of alluvial deposits which accumulated in a long lake that occupied the valley during the Wisconsin stage of the Pleistocene. The Wisconsin ice sheet did not reach as far south as the Bradford district. Observe the relatively slight depth that Tunungwant Creek has incised its channel into this late Pleistocene surface.

The discovery well of the Bradford pool was drilled by the Foster Oil Company on the flat west of Foster Brook. It reached the Bradford Third sand, the productive horizon of the pool, at a depth of 1,110 feet in November, 1871. The daily production was about 10 barrels. Active development of the pool, however, did not start until about three years later. Eventually a continuous area of 84,000 acres proved to be productive in this sand. The peak of production was attained in September, 1880 when the average daily production reached 69,000 barrels, 1881 was the banner year with an average daily production of 62,863 barrels and a total of 22,945,000 barrels for the year.

After 1881 a decline set in which was comparatively rapid for the first six years and then became more gradual. In 1888 the annual production amounted to only 5,300,000 barrels and in 1906, 2,000,000 barrels. Beginning about 1907 the effects of water-flooding began to be noticeable in the total annual production which again commenced to rise at first slowly and then more rapidly as more and more operators adopted the water-drive and the methods of applying it underwent improvement. In 1936, the annual production amounted to 14,570,000 barrels. The field has already produced 352,700,000 barrels of oil during the period from 1871 to 1936, inclusive, a figure which will probably be raised to a total of 500,000,000 barrels in the future by the methods of production now in use.

Stratigraphy

In addition to the unconsolidated alluvial deposits of Quaternary age along the lower portions of the major valleys, somewhat more than one thousand feet of consolidated strata appear at the surface within the limits of the Bradford district, ranging in age from lower Pennsylvanian to upper Devonian. Nearly six thousand feet more have been explored with the drill. The deepest well in the district reached strata of upper Ordovician age.

Pennsylvanian System.

Pottsville Series.

The youngest of the bed-rock formations belong to the Pottsville series of the Pennsylvanian system. The principal area occurs in the southern portion of the district where the broad plateau between the headwaters of Tunungwant and Kinzua Creeks is immediately underlain by about 170 feet of strata of Pottsville age. Pottsville rocks also cap most of the high hills in the northwestern portion but are absent in the northeastern. Small patches have escaped erosion along the high ridge in the northern part of the field.

The following members in descending order are represented in the district:

Mercer shale and coal - will be seen at Stop No. 10.
Connoquenessing sandstone.
Sharon shale and coal.
Olean conglomerate - will be seen at Stops Nos. 1,2,and11.

Mississippian System

Knapp Formation

Whether or not there are any strata present in the Bradford district that belong to the Mississippian system has long been a mooted question. Caster, who has made the most recent faunal studies of the Knapp beds, has placed them in the Mississippian system.

(Kenneth E. Caster. Stratigraphic Relationships in Northwestern Pennsylvania (abstract). Bulletin of the Geological Society of America, Vol. 44, 1933, pages 202-203).

Glenn applied the term "Knapp" to the formation immediately underlying the Olean conglomerate at the village of Knapp Creek in southern Cattaraugus County, New York. Here it has a thickness of 65 feet and consists of two conglomeritic beds separated by a varying thickness of shale. The outcrop is not well exposed at present.

(L. C. Glenn. Devonic and Carbonic Formations of Southwestern New York State Museum Bulletin 69, 1903, pages 980-981.)

Over that portion of the Bradford district west of the East Branch of Tunungwant Creek, the lower of the two conglomerates is usually present. The pebbles of the conglomerate are predominatingly rounded. In contrast to the ovoid or ellipsoidal shape of the Olean conglomerate pebbles, however, they exhibit a pronounced tendency toward a flat or discoidal shape. Red jasper pebbles, which are absent from the Olean, occur sparingly distributed throughout the Knapp conglomerate.

East of the East Branch of Tunungwant Creek, the conglomerate is rarely seen, its place being taken by sandstones and sandy shales. It is, therefore, difficult to draw the line between the Knapp and the Oswayo in this area as the Knapp sandstones are very similar in appearance to some of the interbedded sandstones which occur associated with the underlying Oswayo shales. The sandstone phase of the Knapp will be seen at Stop No. 3, and the lower Knapp conglomerate at Stop No. 9.

In the northern part of the Bradford district at Knapp Creek village and in the northwestern part at the head of Hedgehog Hollow, the interval between the base of the lower Knapp conglomerate and the base of the Olean is 65 feet. In the southwestern portion in the vicinity of Guffey, this interval has increased to 190 feet, due to the beveling of the gently southerly dipping strata by the Mississippian-Pennsylvanian unconformity.

In the Warren quadrangle to the west, Butts found fragments of a fossilbearing sandstone which he considered to represent the feather edge of the Berea-Corry horizon, immediately overlying the upper member of the Knapp formation. In the Warren quadrangle, the Knapp has a maximum thickness of about 120 feet.

(Charles Butts, Warren Folio, No. 172, U. S. Geological Survey, 1910, page 5.

The relationship of the sandstones and sandy shales which come in above the type Knapp beds and the base of the Olean in southern part of the Bradford district to the Berea-Corry horizon has not yet been established. In mapping the Bradford quadrangle, the writer has tentatively included them with the Knapp beds. An exposure of a portion of these strata will be seen at Stop No. 11, north of Bingham in a cut along the B. and O. R. R.

Devonian System.

Upper Devonian.

Oswayo Formation.

The greenish-gray sandy shales with interbedded shaly and frequently fossiliferous sandstone layers, which lie beneath the Knapp and above the Cattaraugus red beds in the Bradford region,

comprise the Oswayo formation. The type locality for this formation is Oswayo Creek which empties into the Allehgeny River one mile above Portsville, southeast of Olean, New York.

The formation exhibits very little variation in thickness over the area covered by the Bradford district. At the head of Fourmile Creek, just north of Knapp Creek village in the northeastern part of the field, the thickness is 209 feet; at the head of Hedgehog Hollow in the northwestern part, 198 feet; and at Guffey in the southwestern part, 213 feet. About sixty feet above the base of the Oswayo, locally, there occurs a limestone from one to three feet thick which Ashburner called the Marvin Creek. It consists largely of innumerable fragments of broken brachiopod and other marine shells imbedded in a sandy matrix.

(C. A. Ashburner. The Geology of McKean County, Report R, Second Geological Survey of Pennsylvania, 1880, pp. 68-69, and 167.)

Cattaraugus Formation

The name "Cattaraugus" was given by Glenn to the three hundred to three hundred and fifty feet of red shales interbedded

(L. C. Glenn. Devonic and Carbonic Formations of Southwestern New York. New York State Museum Bulletin 69, 1903, page 973.)

with greenish-gray shales and fine-grained, greenish-gray, thin-bedded micaceous sandstones which occur between the Oswayo and the Chemung shales in Cattaraugus County, New York and extend southward into the Bradford district. Glenn recognized three rather well defined conglomerate horizons in the Cattaraugus formation in the Olean and Salamanca quadrangles, namely, the Tuna (Killbuck) at the top, the Salamanca near the middle, and the Wolf Creek at the base. All three of these conglomerates are characteruzed by flat or discoidal shaped quartz pebbles accompanied by occasional red jasper pebbles. In the Bralford district, a fine-grained, greenish-gray, micaceous and argillaceous sanlstone frequently occurs immediately above the top of the highest red shale, but a conglomerate was nowhere observed. The nearest outcrop of typical Wolf Creek conglomerate observed occurs east of the field along the state highway, one-half mile north of Coryville in Eldred Township. Red shale occurs a short distance above it, but none was observed below it.

Southwest of Bralford in the Venango district, the Venango Oil sand group, as originally defined by Carll, represents approximately the same stratigraphic interval as that occupied by the Cattaraugus formation. The Venango First Oil sand corresponds approximately to the Tuna conglomerate; the Venango Second Oil sand to the Salamanca; and the Venango Third Oil sand, to the Wolf Creek.

(John F. Carll. The Geology of the Oil Regions, Pennsylvania Second Geological Survey, Report 13, 1880, page 130.)

Chemung Group

It has been customary in northwestern Pennsylvania to include all of the strata from the top of the Portage group to the base of the Cattaraugus formation or its equivalent to the west, the Venango, in the Chemung group. Only the uppermost portion of this interval is exposed in the Bradford district. Luther, in 1902, on the evidence of the fossils, placed the bottom of the Chemung at the base of the Long Bearls Riffs sandstones which crop out along the Genesee River, half a mile south of Fillmore in northern Allegany County, New York. Chalwick has shown that the base of the Dunkirk black shale of the

(D. Dana Luther. Stratigraphy of Portage Formation between the Genesee Valley and Lake Erie. New York State Museum Bulletin 69, 1903, p. 1009.)

Lake Erie section corresponds in stratigraphic position to the base of the Long Bearls Riffs sandstone. Attention must be called to the fact that the upper beds thus included in the

(George H. Chalwick. The Stratigraphy of the Chemung Group in Western New York. New York State Museum Bulletin 251, 1924, pp. 149-150.)

Chemung are younger in age than the Chemung beds of the type locality around the sides of Narrow Hill, at Chemung Narrown, west of Chemung, in south-central New York. This necessarily follows since the Catskill type of sedimentation, of which the Cattaraugus represents only the last stage, began progressively earlier as one goes eastward and southeastward. Chalwick now thinks that outcrops of the highest true Chemung barely enter Chautauqua County, New York, the type area of the Chautauquan series of the Upper Devonian, and that, therefore, this series cannot be considered to contain any strata of true Chemung age and that all of the strata above the base of the Dunkirk black shale are post-Chemung in age.

(George H. Chalwick. Chemung is Portage. Bulletin of the Geological Society of America, Vol. 46, page 351, 1935.)

While the older grouping has been retained by the writer for the present, it is realized that a revision of the nomenclature now in use will have to be made after a thorough restudy of the Upper Devonian stratigraphy of New York and Pennsylvania has been completed.

The Chemung group in the Bradford district consists of interbedded greenish-gray and gray shales and sandy shales, fine-grained light gray sandstones, and fine-grained chocolate-brown sandstones. The total thickness is approximately 2100

feet. Sandstones occur more abundantly in the upper and middle portions than in the lower. In the basal portion, layers of grayish-black shale are present, which, it is thought, represent the Dunkirk shale horizon. Although marine fossils occur throughout the entire thickness, they are much more abundant in the upper one-half than in the lower.

The oil and gas bearing sands of the Bradford district occupy an interval of a little over one thousand feet in the middle portion of the group. The Bradford Third sand, the chief producing horizon, occurs about 1250 feet below the base of the Cattaraugus red beds.

0.0 miles Leave Foster Brook at 8:00 A.M., E.S.T.
Proceed east on Route 346.

2.7 miles Turn left onto Route 646 at sign "To Olean".

5.9 miles Cross Pennsylvania-New York line.

7.2 miles Knapp Creek Village. Fine view of Schooley (?) peneplane.

9.1 miles Rock City.

Stop No. 1. Arrive 8:20 A.M. Leave 9:00 A.M.

Park on vacant ground north of highway. Walk north to outcrop of Olean conglomerate. This is the type locality for the Olean. Observe weathering and erosion along joint planes forming the "rock city". The conglomerate has a thickness of 64 feet here and is predominatingly conglomeritic. Cross-bedding is a prominent feature. The pebbles consist mostly of vein quartz and, for the most part, are well rounded. In shape they are ovoid or ellipsoidal.

Return toward Bradford on Route 646.

11.4 miles. Stop No. 2. Arrive 9:05 A.M. Leave 9:10A.M.
Outcrop of Olean sandstone in cut on west side of road.

13.0 miles Stop No. 3. Arrive 9:15 A.M. Leave 9:25 A.M.
Outcrop of Knapp sandstone in cut on west side of road.

12.3 miles Cut in Oswayo shales.

12.8 miles Stop No. 4. Arrive 9:40 A.M. Leave 10:20 A.M.
Park cars on west side of road at small garage. Walk south along highway through two cuts. First cut shows typical development of Oswayo shales. In second cut there is a fine exposure of the contact between the Oswayo and Cattaraugus formations.

Continue southwest along Route 646.

15.5 miles. Junction of routes 646 and 346. Continue west on Route 346 toward Bradford.

18.2 miles. Junction of Routes 346 and 219 at Foster Brook. Turn left onto 219 and proceed toward Bradford.

20.3 miles. Turn right onto Main Street, Bradford, cross creek and railroad tracks and turn left onto Congress Street in city.

21.7 miles. Junction of Congress Street Extension and Route 219. Stop No. 5. Arrive 10:55 A.M. Leave 11:10 A.M. Examine outcrop of uppermost Chemung beds. Continue south on Route 219.

25.1 miles. Stop No. 6. Arrive 11:25 A.M. Leave 11:40 A.M. Contact of Cattaraugus red beds and Chemung shales exposed in quarry on west side of road. Lower-most red beds exposed in quarry represent base of Cattaraugus.

Continue south on Route 219.

25.4 miles. Junction of Routes 219 and 823. Turn left onto Route 823.

25.6 miles. Turn left at Lewis Run and proceed toward Hanley quarry on east side of valley.

26.4 miles. **Stop No. 7.** Arrive 11:45 A.M. Leave 12:35 P.M.

Quarry of the Hanley Company.

The lower portion of the Cattaraugus formation is well exposed in this quarry. The following section was measured here:

Top of Cattaraugus red shale,	
Covered,	45.0 feet
Greenish-gray medium-grained platy sandstone,	5.0
Covered,	113.5
Greenish-gray and reddish-gray fine-grained platy micaceous and argillaceous sandstone,	6.0
Greenish-gray medium-grained massive sandstone - contains numerous plant fragments, some fish remains, and fragments of small shells in certain layers - rill marks on bedding planes - Salamanca,	11.6
Greenish-gray shale with occasional thin sandstone lentils with a few small discoidal quartz pebbles,	45.3
Variegated red and yellowish-green shale,	15.3
Dark reddish to purplish-gray fine-grained sandstone - very fossiliferous - contains a few quartz pebbles in upper part,	14.0

in part ...dy

Greenish-gray shale, in part sandy,	5.5
Brick red shale containing several lenticular beds of greenish-gray fine-grained sandstone up to 10 inches thick,	21.5
Covered to base of Cattaraugus - estimated,	13.0
Total thickness of Cattaraugus,	295.7 feet.

The 11.6 feet of sandstone occurring 169.5 feet below the top of the Cattaraugus are thought to represent the Salamanca horizon in this section. This sandstone appears near the top of the cliff at the quarry. The more prominent sandstone, 14 feet thick, lying sixty feet below it and forming the floor of the quarry represents a local development. It should appear near the top of the section exposed in the quarry on the west side of the valley, visited during Stop No. 6. If present at all at the latter locality, its development is insignificant.

Observe the noticeable southeasterly dip of the strata in the quarry. This represents a relatively steep dip for the Bradford district. Over most of the area, the strata are more nearly horizontal.

The regional dip of the surface formations in the Bradford district is slightly west of south. If the correlation of the Bradford Third sand with the Laona sandstone on the outcrop to the north is correct, this horizon descends 1068 feet in a southerly direction in a distance of about 44 miles, or an average of 24 feet per mile. Due to the fact that most of the underlying formations thicken in a southeasterly direction, the regional dip of the deeper strata swings toward the southeast.

The major structural features developed on the Bradford Third sand in the Bradford district consists of two asymmetrical anticlines trending northeast and southwest, plunging southwest, and converging on the northeast in a broad dome. The anticlines are characterized by broad tops with gentle dips toward the northwest and considerably steeper dips toward the southeast. The Hanley quarry at Lewis Run lies on the southeastern flank of the Bradford anticline, the northwestern one of the two anticlines.

After leaving quarry, return to Lewis Run.

27.2 miles. Turn right on Route 823 at Lewis Run.

27.4 miles. Intersection Routes 823 and 219.
Turn left on 219 and proceed south.

30.9 miles. Kennedy Park.
Stop No. 8. Arrive 1:00 P.M. Leave 2:00 P.M.
One hour for lunch.
Park cars either on west side of road or enter park at south entrance.

Continue south on Route 219.

36.0 miles. Bridge across Kinzua Creek.
Stop No. 9. Arrive 2:15 P.M. Leave 3:05 P.M.
Park cars on north side of creek. Follow old logging road thru woods up east side of Winter-Green Run Valley to outcrop of lower Knapp conglomerate.

This is an unusually fine exposure of the lower Knapp conglomerate. The bed, which has a thickness of 14 feet, is conglomeritic throughout, shows pronounced cross-bedding, and contains occasional marine fossils. It will be observed that the bed consists of a number of alternating horizontal and cross-bedded layers, and that in the cross-bedded layers the cross-laminations are not all inclined in the same direction. The interval between the base of the Olean, whose outcrop can be seen near the top of the cliff on the opposite side of the run, and the base of this conglomerate is 200 feet.

The pebbles of the Knapp conglomerate are predominatingly rounded. In contrast to the ovoid or ellipsoidal shape of the Olean conglomerate pebbles, however, they exhibit a pronounced tendency toward a flat or discoidal shape. As in the case of the Olean, they consist mostly of milky vein quartz. A few rose colored ones are also present. In marked contrast to the Olean, red jasper pebbles occur sparingly distributed throughout the Knapp conglomerates.

On returning to cars, observe fine exposure of contact of Oswayo shales and Cattaraugus red beds in cut on east side of Wintergreen Run near mouth.

Return north on Route 219.

39.1 miles. Turn right at cross-road to east.

39.9 miles. Stop No. 10. Arrive 3:30 P.M. Leave 3:40 P.M.
Small stripping operation along outcrop of Mercer coal.

Continue east. Fine views of gently rolling upland surface obtained along this road.

43.5 miles. Turn left into improved road after passing through Mount Alton.

45.3 miles. Bingham Station on B. and O. R. R.
Stop NO. 11. Arrive 3:55 P.M. Leave 5:05 P.M. Park cars at station. Walk northwestward along railroad tracks.
The Olean loses its conglomeritic character in the southern portion of the Bradford quadrangle. Over much of this area, it consists of a medium to coarse-grained quartz sandstone very similar to the Connoquenessing in appearance. The following section was measured in the cut, 1600 feet north of Bingham Station:

Light gray coarse massive sandstone,	4.5 feet.
Coal (a local lens only)	1.0
Shale, black and carbonaceous at top,	2.0
Gray, medium-grained platy sandstone,	3.0
Gray, medium-grained massive cross-bedded sandstone,	24.0
Gray clay containing abundant plant remains - a thin seam of coal occurs at the top and a thin lens of flat pebble quartz conglomerate near the base,	13.0
Bottom of Olean,	
Light gray thin-bedded shale,	6.0

The 13 feet of gray clay with a thin seam at the top represent the Lower Marshburg coal horizon of Ashburner.

(C. A. Ashburner. The Geology of McKean County. Report R, Second Geological Survey of Pennsylvania, 1880, page 64.)

The strata occupying the interval represented by the Knapp formation are exposed in a number of cuts along the B. and O. R. R., starting at the base of the Olean, 1600 feet north of Bingham Station, and continuing northwestward to a point 3100 feet northwest of Taylor. A total of nearly 180 feet is represented in this interval. It was impossible to determine exactly the contact between the Knapp and the underlying Osway as the lower Knapp conglomerate was not recognized in the section exposed. Here, the upper portion, which has been included in the Knapp on the areal geologic map of the Bradford quadrangle, very likely is the equivalent of the Mayfield member of this formation or may even represent higher beds.

The following section, 3200 feet north of Bingham Station, will be visited:

Light gray coarse sandstone with sub-angular quartz pebbles, clean,	20.0 feet
Light gray shale with interbedded thin sandstone layers toward base, some of these contain marine fossils	15.0
Almost white, coarse-grained massive sandstone containing some marine fossils,	8.0
Light gray, finely laminated shale,	5.4

Continue northeastward to Simpson.

47. 0 miles Turn left at Simpson (Cyclone P. O.) onto Route 59.

Return to Bradford via Routes 59 and 219.

58. 5 miles Arrive at Bradford at 5:45 P.M.

LOG OF TRIP "A"

PENNSYLVANIA FIELD CONFERENCE, MAY 30, 1937

BRADFORD TO WOODWILL HILL

Leave Bradford at 7:30 A.M. sharp. Bring your lunch with you.

Odometer	
00.00	Leave Bradford Hotel Emery Hotel Holly 7:30 A.M. sharp. Bring lunch South on Route 219
3.7	Custer City. Turn right on Route 59 All cars will stop here for 10 minutes until group has assembled.
21.2	Cornplanter Station. Turn left on Route 59 down Allegheny River. River Valley to Kinzua principally carved by ancestral north flowing stream.
23.6	Kinzua village. Junction Route 68. Continue down river on Route 59.
24.0	Stop 1. Foot of hill out of Kinzua. Basal Conewago sandstone (Panama horizon which is the same as the Venango Third sand), and the top of the Chadakoin member ("Chemung" or "pink rock"). Fossils.
24.4	Stop 2. Park cars along road just beyond highest point in the hairpin curve on the down-hill straight stretch. Lower Salamanca sandstone (Venango salt sand), and Amity brick shale. Note Upper Salamanca (the Venango Second sand) on nose of hill above.
25.00	Narrowest and youngest part of the Upper Allegheny valley. Former divide.
33.4	Junction of Routes 59 and 6. Turn right (west) on Route 6.
34.2	Cross Allegheny River to Glade.
34.3	At end of bridge, Allegany Hotel, turn right on Hemlock Street.
34.4	Turn left on Bauer Street and continue up winding dirt road to old Cobham estate; to second gate.

Odometer

35.00 Turn into field on left at second gate. Park cars.

Stop 3. Walk up hill past "Brick castle" to "Stoney Lonesome" monument. Knapp stratigraphy and physiography of the Warren area. (See stratigraphic section at Warren on appended sheets). Corry horizon. Walk along edge of Knapp escarpment up river to Cobham Ledge. New River valley.

35.7 Retrace to cars, and down hill, to Route 6. West on Route 6.

36.00 Turn right on dirt road up west bank of Glade Run to join black top at village limits and continue up Glade Run.

40.00 Note on right flat-topped pyramidal shaped hill: Characteristic expression of the Corry cap rock overlying the Tidioute shale.

41.5 Stop 4. Park cars along road just beyond red brick (Smith's) school. Tidioute shale and Corry drift. On toward Scandia.

42.00 Pass slowly through a rock city in the Olean conglomerate on top of Quaker Ridge.

43.00 Turn right on dirt road toward Quaker Ridge coal mines.

45.00 Stop 5. Park cars at end of road. Examine one of the most northerly coal outliers and one of the oldest Bituminous coal seams in Pennsylvania. Examine workings and/or eat lunch. Retrace to Smith's school.

49.00 Bear right on black road just beyond Smith's school.

49.05 Stop 6. About 100 yards beyond road fork examine old quarry in the Tidioute shale ("ferruginous Knapp" of Mr. Butts). Fossils.

51.00 Turn left at first black top junction toward Warren.

52.5 At end of road in Warren, turn right on Conewango Avenue. Turn left two blocks north on Conewango Avenue at Coco-Cola sign. Pass school on left and cross bridge across Conewango Creek.

53.00 At first traffic light turn on Route 62. Across Conewango Creek note truncated high delta deposits.

53.7 In North Warren, just before crossing railroad, turn left on dirt road up Follett Run toward Knupp school.

Odometer

54.5 Stop 7. Park cars along road at first red brick house on right. Walk up hill to the old Asylum quarries in the Upper Salamanca sandstone, (Venango Second Sand). Fossils and stratigraphy. Return to cars and on up hill.

58.5 Junction of Follett Run and Yankee Bush road. Continue on latter toward Dalrymple school.
Stop 8. Just beyond junction stop at first house on right. Examine the Warren expression of the Marvin Creek limestone ("Spirifer band"). On North on Yankee Bush Road.

56.5 Stop 9. Cemetery Hill triangulation point. Top of a pyramidal hill. Corry grit and Tidioute shale. Physiography.

59.4 Dunhams Corners. Turn left on black top road.

61.2 Note pyramidal hill ahead. Corry cap rock.

62.5 Upper Salamanca bench and outcrop in ditch.

63.0 Stop 10. At foot of hill just after crossing creek. Examine Tanners Hill red band and sandstone in basal Conewango. (Panama?) Also examine the Chadakoin ("Chemung") shales. Comparisons with Kinzua section.

63.5 Join Route 6. Turn right (west) on Route 6.

64.5 On right note prominent escarpment of the Upper Salamanca sandstone (Venango Second oil sand).

66.0 Junction of Routes 6 and 62. Turn left on Route 62 and cross Allegheny River.

72.0 First roadside bedrock exposure. Lower Salamanca sandstone (Venango salt sand) just South of Slater's Run.

73.5 Stop 11. Park on macadam section of road. Examine Lower Salamanca (Salt sand) just south of Cobhams Run.

Note salt sand exposures for next five miles. Drive slowly past exposures.

80.00 First highway exposure of Upper Salamanca sandstone (Venango Second sand). Exposures continue for next two miles.

81.00 Stop 12. Examine the Upper Salamanca sandstone (Venango Second sand) and note great variation in the sand.

Odometer

82.6 Cross Allegheny River into Tidioute.

82.9 At end of street in Tidioute turn left on Route 127.

83.2 Cross Dennis Run. Exposure at bend is Upper Salamanca sandstone (Venango Second oil). This produces oil less than a quarter of a mile away in the hill ahead.

83.5 Stop 13. Middle of Dennis Run Hill. See section of rocks on Dennis Run appended to this itinerary. Examine Woodcock sandstone (Venango First oil) along road just above first white house in the run.

83.7 Stop 14. At first rod line crossing road stop to examine "Spirifer zone" of Carll (Marvin Creek limestone zone) and Corry sandstone in three-part development along roadside. Continue up hill on Route 127.

84.2 Bear right at fork in black top road toward Enterprise. Junction is at position of the Shenango sandstone in the Dennis Run Section.

85.1 Triumph Rocks. Olean conglomerate. Note interval here between the Olean and the Corry. Contrast with conditions at Warren.

86.00 Road cut through the Olean conglomerate.

88.5 Experiment in steam-heating the oil sands.

93.5 Junction of Route 127 and 27, at Enterprise. Stop 15. Examine exposure of Corry at the road junction. Continue up Goodwill Hill to right on Route 27.

94.0 Stop 16. At junction of dirt road on left, just below brow of hill, roadside exposure of Shenango sandstone. A few marine fossils.

97.5 Turn left on black top road and follow to Goodwill Hill representing plant of the National Petroleum Company.

Note: If the time element demands it, the party may split soon after noon. Those interested in seeing secondary recovery practice will head down Allegheny River in time to arrive at Good Will Hill by about four o'clock. Transportation should be arranged with this possibility in mind.

STRATIGRAPHIC MEMBERS OCCURRING IN NORTHWESTERN PENNSYLVANIA
Chiefly after Caster

		PARTIAL SYNONYMY	
PENNSYLVANIAN SYSTEM			
Olean conglomerate			
MISSISSIPPIAN SYSTEM			
Waverlyan subsystem			
Kinderhookian series			
(Crawford sub-series)			
Shenango stage			
(Shenango monothem)			
Hemphill shale member		Shenango shale	
Shenango sandstone member (Johnsonburg sandstone)		"Sub Olean conglomerate" (second mountain sand)	
Meadville stage			
(Meadville monothem)			
Custards shale member		Upper Meadville shale	Original - Meadville group.
Conneaut limestone member		Upper Meadville limestone	
Harvest Home shale member		Lower Meadville shale	
(Byham limestone member)		Middle Meadville limestone	
Sharpsville sandstone member	Sharpsville formational suite	"Sub-Olean conglomerate"	Original - Sharpsville format.
West Mead limestone member		Lower Meadville limestone	
Shaws sandstone member		Sharpsville sandstone	
Orangeville shale member (stage?)		"Cuyahoga" of Pennsylvania	
Oil Lake series			
Berea stage			
Corry sandstone member		3d. Mountain sand: Pit Hole Grit	
Cussewago stage			
(Cussewago monothem)			
Hayfield shale "formation"		Cussewago shale	
(Little's Corner limestone member)		Cussewago ls, Hayfield ls.	
Tidioute shale member			
Cobham conglomerate member	Knapp formational suite	Upper Knapp cong; Cussewago ss.	
East Kane shale member		Knapp shale (middle)	
Wetmore conglomerate member		Lower Knapp conglomerate	
Kushequa shale member		Knapp shale	
(Marvin Creek limestone zone)		Marvin Creek ls. (Meadville ls.)	
DEVONIAN SYSTEM			
Conewango series			
Riceville stage			
(Riceville monothem)			
Oswayo shale member		"Red Bradford" of the Oil Region	
Roystone coquinite member		Mistaken for the Marvin Creek ls. by some geologists.	
Venango stage			
(Venango monothem)			
Woodcock sandstone member		First Venango Oil sand	Cattaraugus
(Hosmer Run conglomerate)			
(Tuna-Kilbuck conglomerate lens)			
Saegerstown shale member			
Pope Hollow conglomerate	Salamanca formational suite	"A"	
North Warren shale member		Second Venango oil sand	
Bimber Run conglomerate member		"B"	
Amity shale			
(Dutchman's conglomerate lens)			

Panama conglomerate member- - - - - - - - - Third Venango oil sand,"Wolf Creek

Chautauquan series

Chadakoin stage - - - - - - - - - - - - - - - - - "Upper Chemung"

(Chadakoin monothem)

(Tanners Hill red band)

Ellicott shale member - - - - - - - - - - - - - "Pink Rock"

Dexterville shale member

Lillibridge sandstone member - - - - - - - -Quarry sandstone

Girard stage

Girard shale

Cuba sandstone

Canadaway series*

Northeast shale
Shumla sandstone
Westfield shale
Laona sandstone
Dunkirk black shale

] - I. C. White's "Portage"

Chemung

Falls Creek conglomerate

* After Chadwick

Erie Trip. To Study Pleistocene and Recent Shore Line Features

Leave Headquarters at 9 A.M. Sunday. Field Dress Not Needed.

Bradford to Corry. Group need not keep together in this stretch. Follow Rt. 219 to Custer City; Rt. 56 west to junction with Rt. 6; Rt. 6 west to junction with Rt. 189 in north of Corry. From Sugar Run through Kinzua we follow the Allegheny River, a composite stream formed by the union of many streams during Glacial times. This stretch formerly flowed north into New York State but later united with streams near Warren to take its present course. At junction with Rt. 6 we pass from non-glaciated country into an old fringe of glacial material probably of Kansan or Nebraskan age. These continue to junction with Rt. 62, west of Warren. From that point through Pittsfield to Freehold we cross Illinoisan gravel areas. Beyond that we see Wisconsin glacial materials all the way to Erie. From Irvine to Corry we follow old wide stream channels, the Brokenstraw Creek and its tributaries flowing east. At Corry we reach the divide and, to the west, the flow is west along branches of French Creek. The wide "through Valley" condition leads us to think that the Brokenstraw and this portion of French Creek may have at one time flowed west and north into Lake Erie.

Corry: Meet at junction of Rt. 6 and Rt. 189 where Rt. 6 turns sharply south into Corry. Meet at 11 A.M. This is 69 miles from Bradford.

Corry-Wattsburg. Rt. 189 north to Cutting N. Y. 6 miles. Left on Rt. 74 follow a branch of French Creek into Wattsburg.

Wattsburg-Northeast. Right at Wattsburg on Rt. 8, two miles to Lowville. Straight ahead on Rt. 89. From Lowville to Greenfield we cross the Cleveland Moraine. Note north-south drumlin-like hills of gravel and one at Greenfield worked for its gravel. Three miles beyond Greenfield reach the divide at about 1500 ft. above sea level. Pre-glacial divide was miles to the south. Note deep gullies beginning the swift descent to Lake Erie. They drop 900 ft. in six miles carving out deep gorges known locally as "gulfs". Strata here are of "Chemung" age and we are on the north edge of the Allegheny Plateau. Thence to Northeast we descend the Escarpment and as the road curves down it we will stop to get a view of it and of Lake Erie in the distance.

Northeast. Lies on the Lake Plains province. City on plain, representing the shore line and bottom of Glacial Lake Whittlesey. The shoreline stands at 800 ft. A.T. of 227 ft. above Lake Erie. Beach gravels and ridges should be seen at the railroad and along Rt. 20 in Northeast. Drive straight north through Northeast toward Lake. First mile and a half we are on the Whittlesey Plain to junction with Rt. 99. Between this point and the shore we leave the Whittlesey Plain and drop to the next old Glacial Lake level, Lake Warren.

Lake Warren beach ridges swing rather close to the modern bluff here and we see both in continuing down to the modern beach. Note the beach at this point then return to Rt. 99 and turn right or west on it.

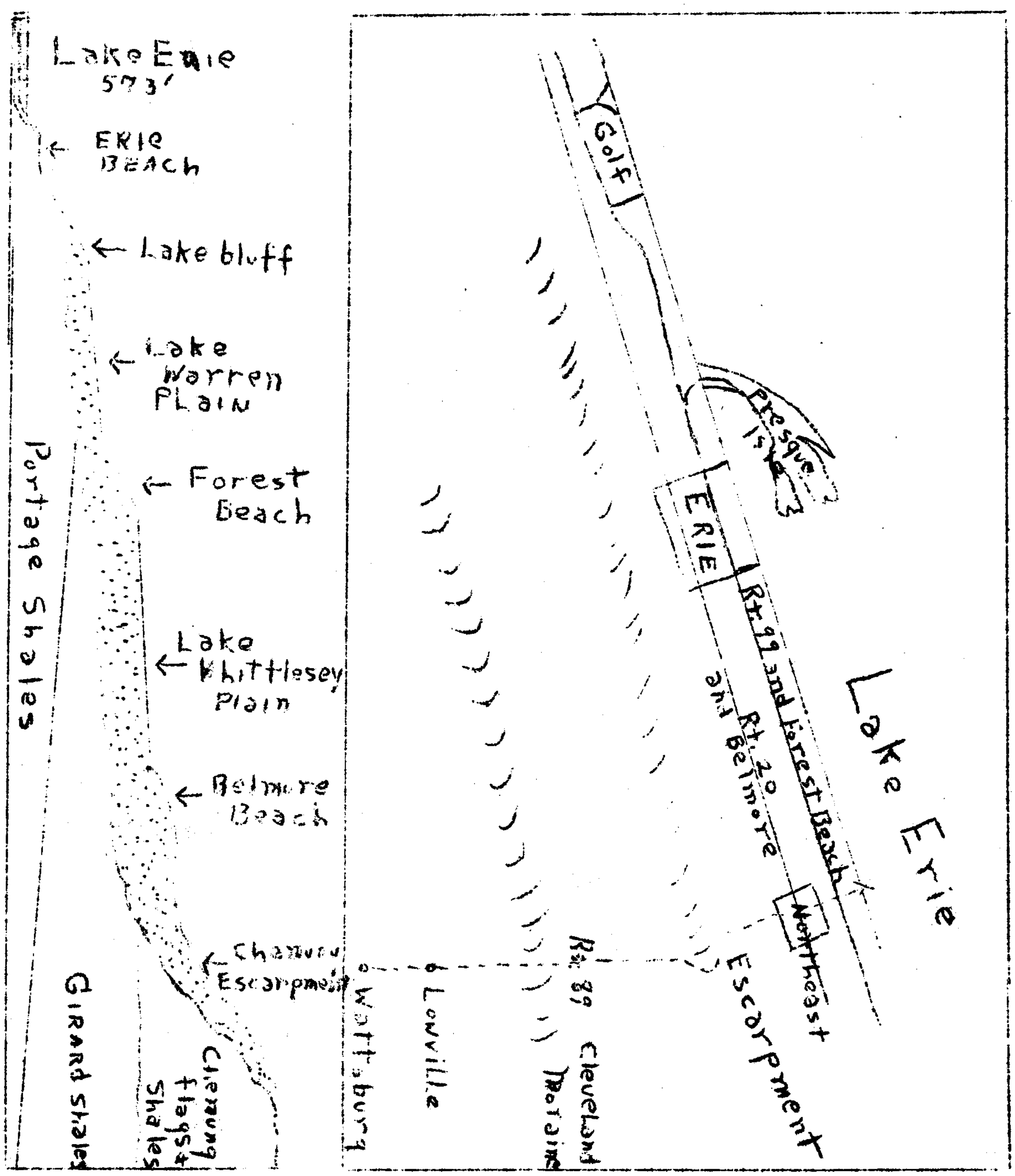
Northeast to Erie. On Rt. 99 for 3½ miles drive on fertile Whittlesey Plain, with Forest beach and the Warren Plain on our right. Then we descend to the Warren level and follow it to Erie entering along 6th Street. At Park and Ford Hotel, park and have lunch at Ford Hotel. After lunch drive down State Street to the wharf, dropping down from the Warren Plain at 2nd. Street to the Erie shore with the bluff very evident. Note the good harbor surrounded by the tree covered Presque Isle.

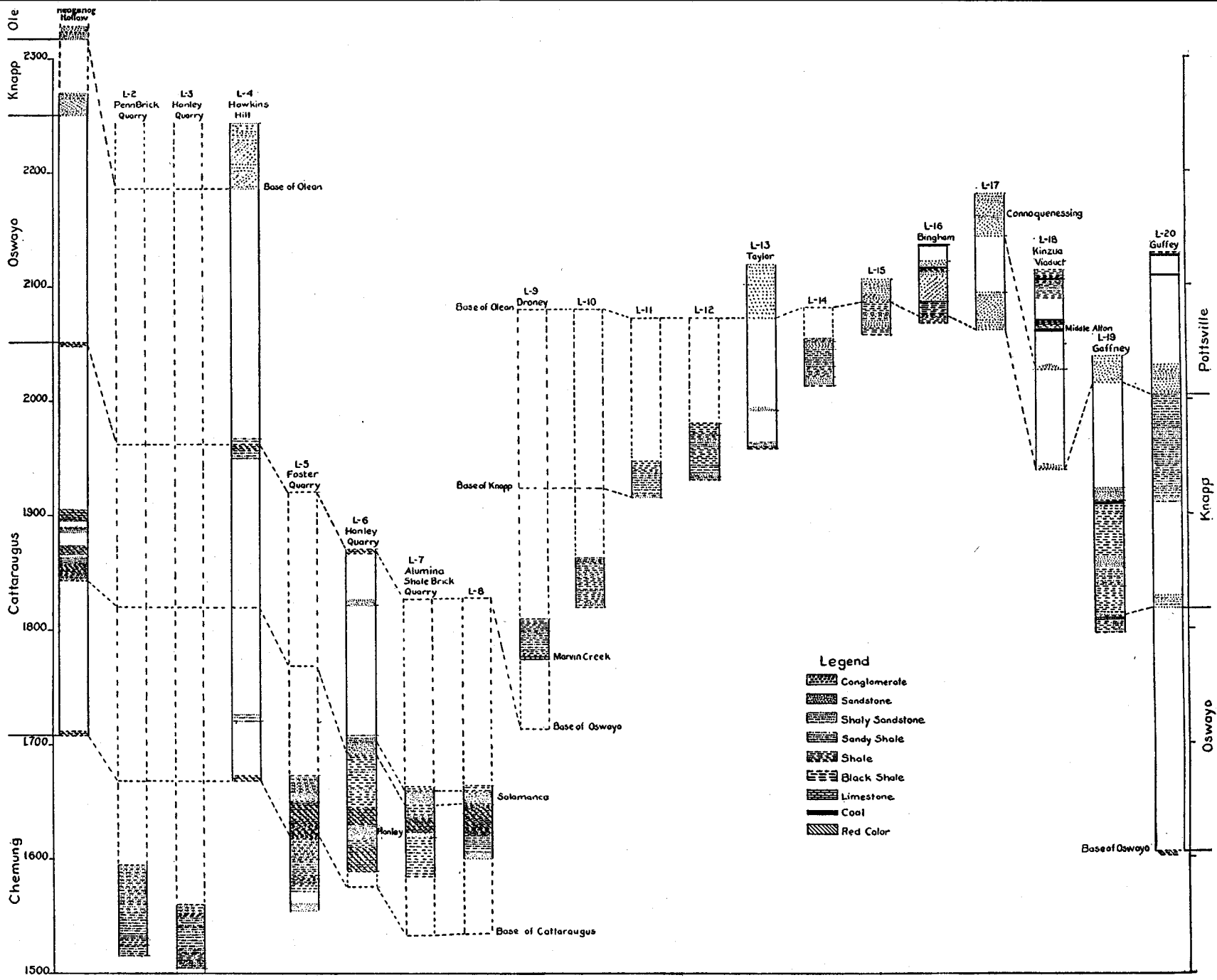
Erie-Presque Isle. Return to 6th. Street and Rt. 99. Right or west 4 miles then right on Rt. 832 into Presque Isle.

Presque Isle, a compound recurved spit of sand and shale fragments, curving around Erie Harbor for seven miles and almost touching the mainland east of Erie, a narrow ship channel being maintained at that point. The Isle is a well-governed State Park with 16 miles of concrete roadways. Note the narrow neck of land connecting it to the shore and the efforts to maintain this neck from erosion by means of steel piling and rip-rap. Keep to right road noting the Bay on the right. Note the large trees on the older part of the peninsula. Dr. Jennings says these indicate a peninsula at least 600 years old. Stop at Perry monument and old ship Wolverine for a historic moment. Next stop. See shore phenomena and note a new point, Long Point, now a bird sanctuary. Peninsula built of a succession of such bars and intervening lagoons. Shore currents move material eastward. Return along north shore of peninsula noting sand dunes and protective measures.

Back to Rt. 99 and west on it 4½ miles to Lake Shore Golf course. We are driving on the Whittlesey Plain with the drop to the Warren Plain on our right and the beach phenomena of Lake Whittlesey about a mile to our left, along Rt. 20. At golf course we drive down over the beach line of Lake Warren and get a fine view of such a beach and terrace. Proceed to far end of Golf grounds and walk down a small gully in the Lake bluff to the shore. In the gully we see very fine boulder clays carrying striated limestone pebbles and boulders. The clay also shows modern mud flows and land slides. At the base we see the bed rock shales of Portage age, the Northeast shales, non-fossiliferous. On the beach are many fine glacial boulders, and sands, wave-panned in places to show garnet and magnetite.

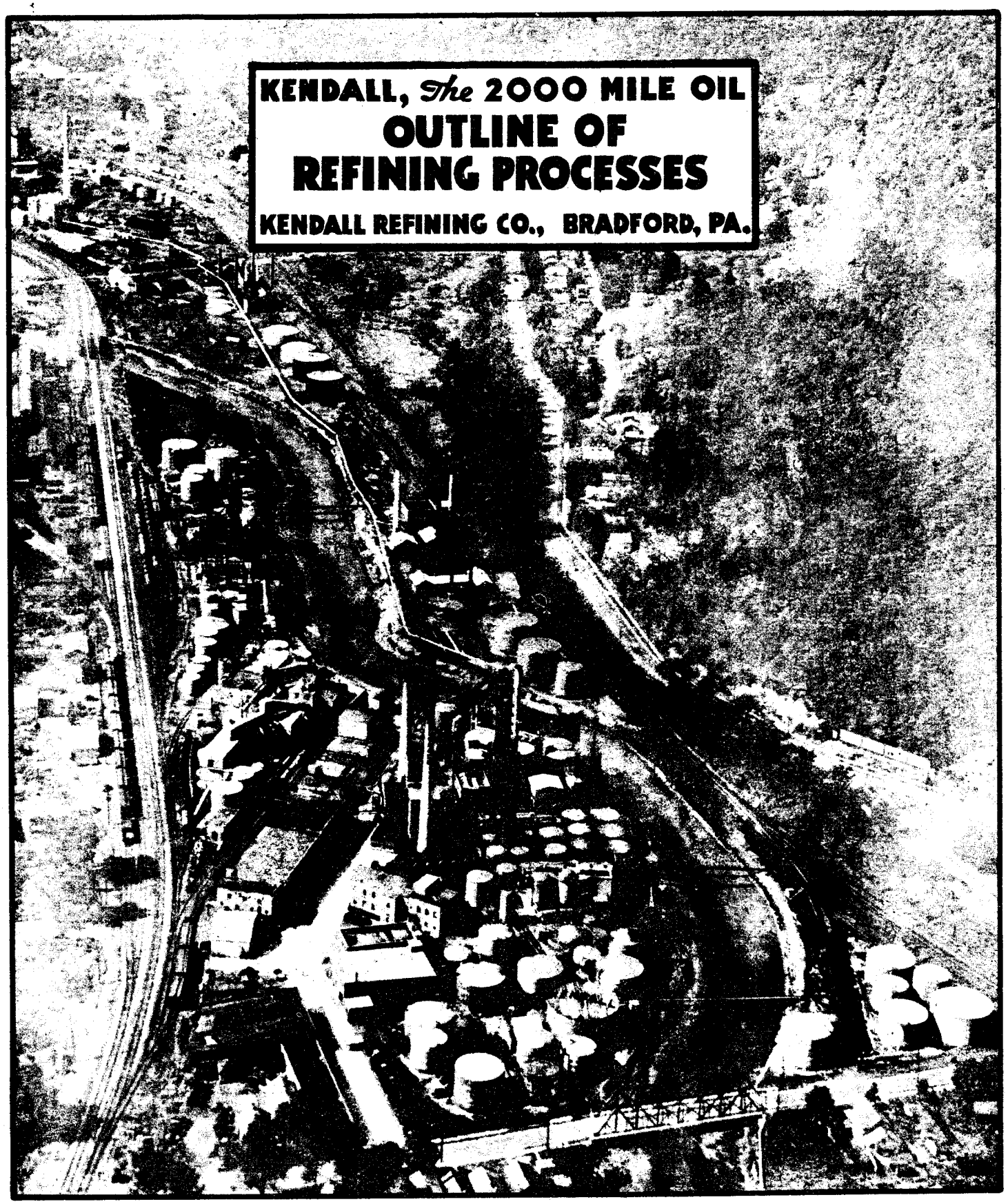
Party will disband at this point. Time should be 3 to 4 o'clock.


Lake Erie
573'
Erie Beach
Lake bluff
Lake Warren Plain
Forest Beach
Lake Whittlesey Plain
Belmore Beach
Escarpment
Portage Shales
Girard Shales
Shales
Golf
Presque Isle
ERIE
Rt. 20 and Belmore
Lake Erie
Northeast
Escarpment
Rt. 89
Cleveland Moraine
Lowville
Wattsburg



COLUMNAR SECTIONS MEASURED IN THE BRADFORD QUADRANGLE

By Charles R. Fettke, *Pennsylvania Geological Survey*


KENDALL, The 2000 MILE OIL
OUTLINE OF
REFINING PROCESSES
KENDALL REFINING CO., BRADFORD, PA.

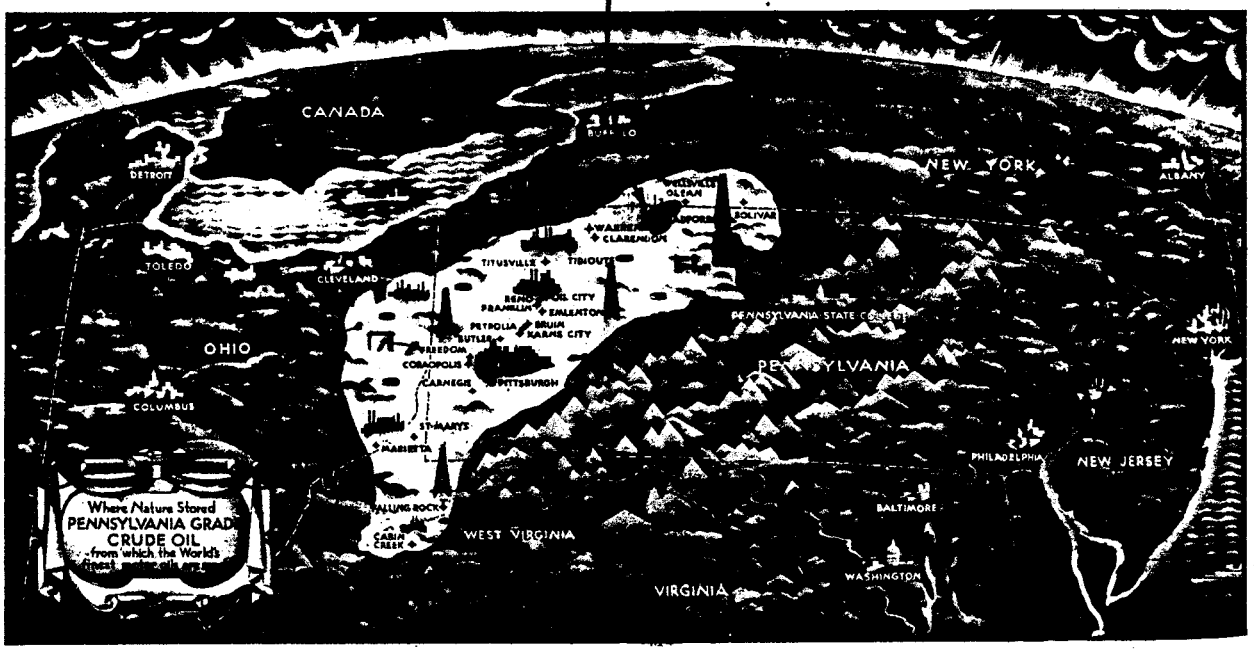
KENDALL, THE 2000 MILE OIL, 5/1/36
OUTLINE OF REFINING PROCESS

Kendall Refining Company Bradford, Pa.

Here in the hills of Northwestern Pennsylvania is an 85,000 acre area that has yielded more wealth to its various owners than most other areas of comparable size in the entire world. This is the Bradford oil field - source of the world's premium price, premium quality crude oil.

In the early 1870's, some twelve or fifteen years after Colonel Drake drilled the first oil well in America (1859), the Bradford oil field was discovered. Since its discovery only fifty years ago, nearly 350 million barrels of crude oil have been produced from the Bradford field.

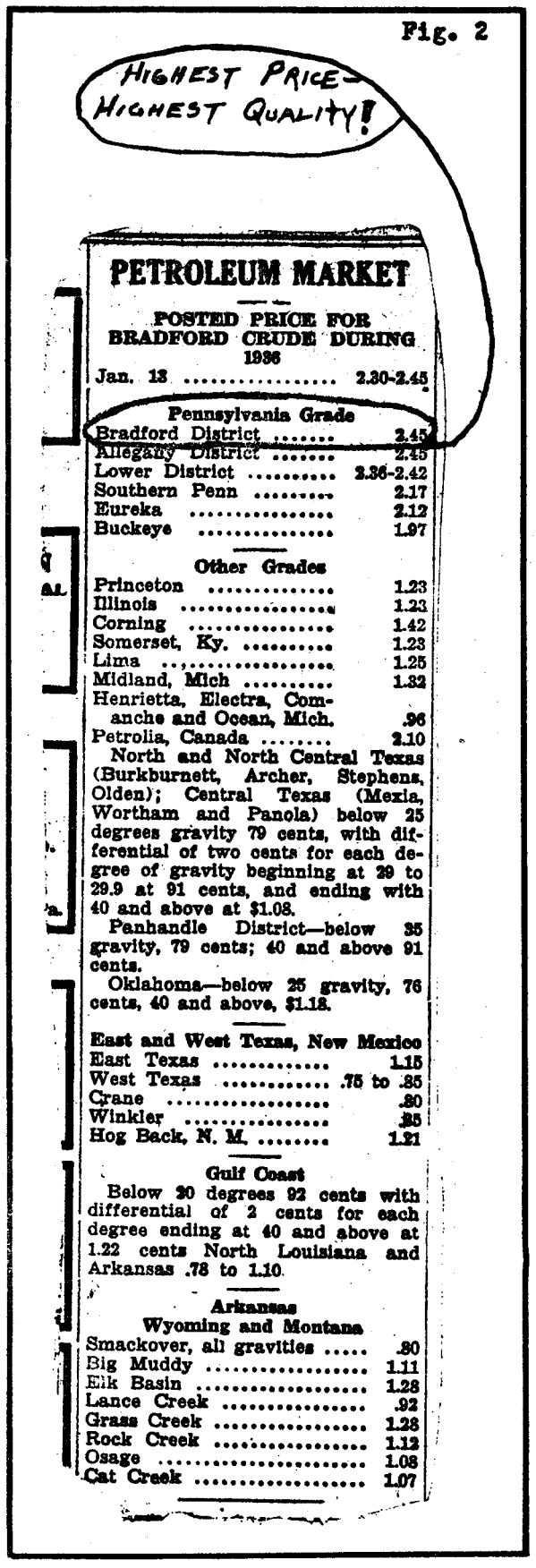
Fig. 1
THE BRADFORD OIL FIELD



Actually, the Bradford oil sand comprises only about 5% of the Pennsylvania Grade Oil producing territory. Yet, in 1935, the Bradford field was responsible for 52% of the total Pennsylvania grade crude oil production for the year.

To the casual observer, most of the Bradford territory is almost

Fig. 2



HIGHEST PRICE—
HIGHEST QUALITY!

PETROLEUM MARKET

POSTED PRICE FOR BRADFORD CRUDE DURING 1936

Jan. 13 ..... 2.30-2.45

Pennsylvania Grade	
Bradford District	2.45
Allegany District	2.45
Lower District	2.36-2.42
Southern Penn	2.17
Eureka	2.12
Buckeye	1.97

Other Grades	
Princeton	1.23
Illinois	1.23
Corning	1.42
Somerset, Ky.	1.23
Lima	1.25
Midland, Mich	1.32
Henrietta, Electra, Comanche and Ocean, Mich.	.96
Petrolia, Canada	2.10

North and North Central Texas (Burkburnett, Archer, Stephens, Olden); Central Texas (Mexia, Wortham and Panola) below 25 degrees gravity 79 cents, with differential of two cents for each degree of gravity beginning at 29 to 29.9 at 91 cents, and ending with 40 and above at $1.03.

Panhandle District—below 35 gravity, 79 cents; 40 and above 91 cents.

Oklahoma—below 25 gravity, 76 cents, 40 and above, $1.18.

East and West Texas, New Mexico	
East Texas	1.15
West Texas	.75 to .85
Crane	.80
Winkler	.85
Hog Back, N. M.	1.21

Gulf Coast

Below 30 degrees 92 cents with differential of 2 cents for each degree ending at 40 and above at 1.22 cents North Louisiana and Arkansas .78 to 1.10

Arkansas Wyoming and Montana	
Smackover, all gravities	.80
Big Muddy	1.11
Elk Basin	1.28
Lance Creek	.92
Grass Creek	1.28
Rock Creek	1.12
Osage	1.08
Cat Creek	1.07

primitive in appearance. The numerous hills, heavily wooded with timber, abound with game of all sorts. Hunters come many miles for the fine hunting in deer and bird seasons.

So securely nestled very nearly in the center of this hilly territory that it is invisible from an airplane five miles away, is the veteran oil town of Bradford. The most important industry in Bradford is the Kendall Refining Company, which has operated - on Bradford crude oil exclusively - since 1882. One of the proudest claims of the Kendall Refining Company is that its oils are refined from Bradford crude oil exclusively. The Kendall Refining Company owns its own pipe line facilities and most of its producing wells. All of these wells are within ten miles of the refinery. Wells not owned by the company are on adjacent properties, owned, in most cases, by company stockholders.

Operating on the same uniformly high quality crude oil for over fifty years, the Kendall Refining Company has been able to better adapt its refining processes to the production of the highest quality refined petroleum products than other refiners who are forced to secure their crude supply from more than one field in the Pennsylvania region. (There are more than 270 different "sands" in the region, each supplying a crude individual to itself but all of "Pennsylvania Grade.")

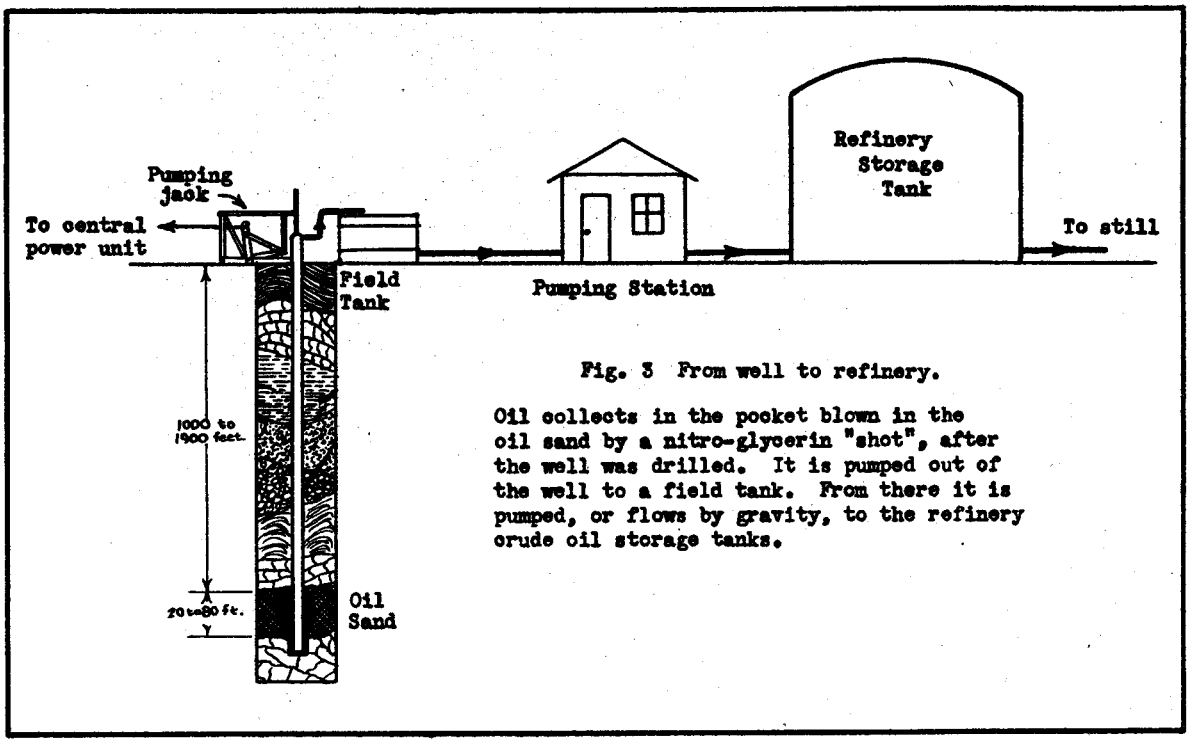


Fig. 3 From well to refinery.

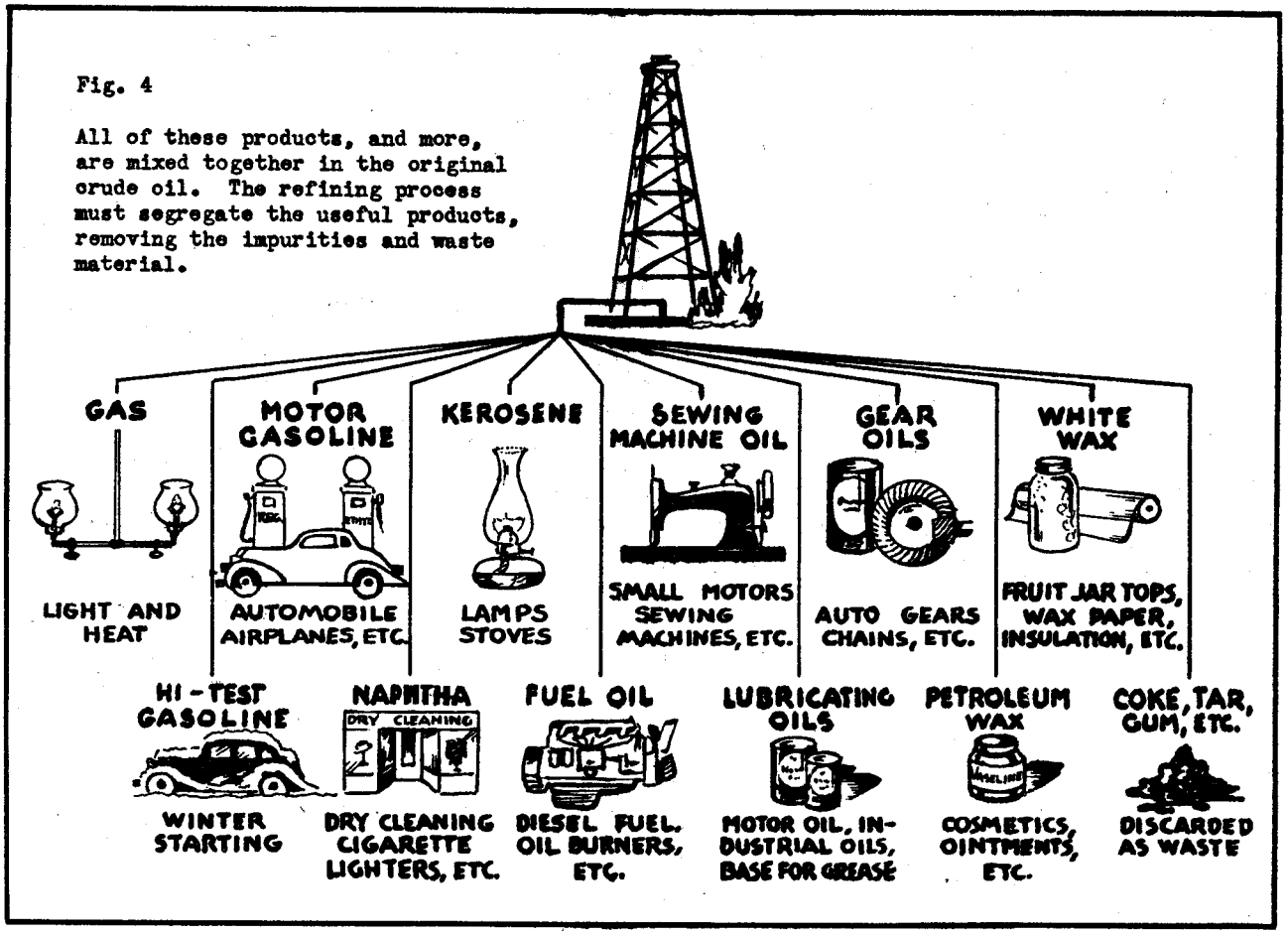
Oil collects in the pocket blown in the oil sand by a nitro-glycerin "shot", after the well was drilled. It is pumped out of the well to a field tank. From there it is pumped, or flows by gravity, to the refinery crude oil storage tanks.

The process of refining oil, like the refining of any other raw material, consists of removing impurities from the raw material, and separating the refined product into its marketable components. Briefly stated, the quality of the refined product depends on three factors: (1) the quality of the raw material (crude oil), (2) the extent to which the impurities are removed, and (3) control of the complete process to maintain uniform quality. The highest quality oil will, therefore, be obtained from the highest quality crude,

refined by a uniform process in which a maximum of impurities are removed.

Fig. 4

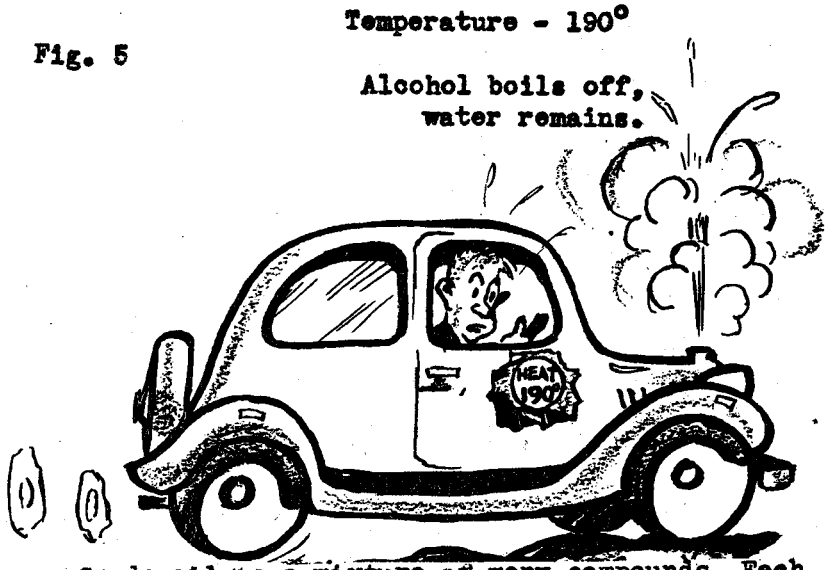
All of these products, and more, are mixed together in the original crude oil. The refining process must segregate the useful products, removing the impurities and waste material.



The original crude oil consists of all the products illustrated above - gasoline, naphtha, kerosene, fuel oil, lubricating oil, gear lubricants, wax, impurities, etcetera - mixed together.

The first step in refining is a rough separation of the crude oil by "distillation."

Fig. 5



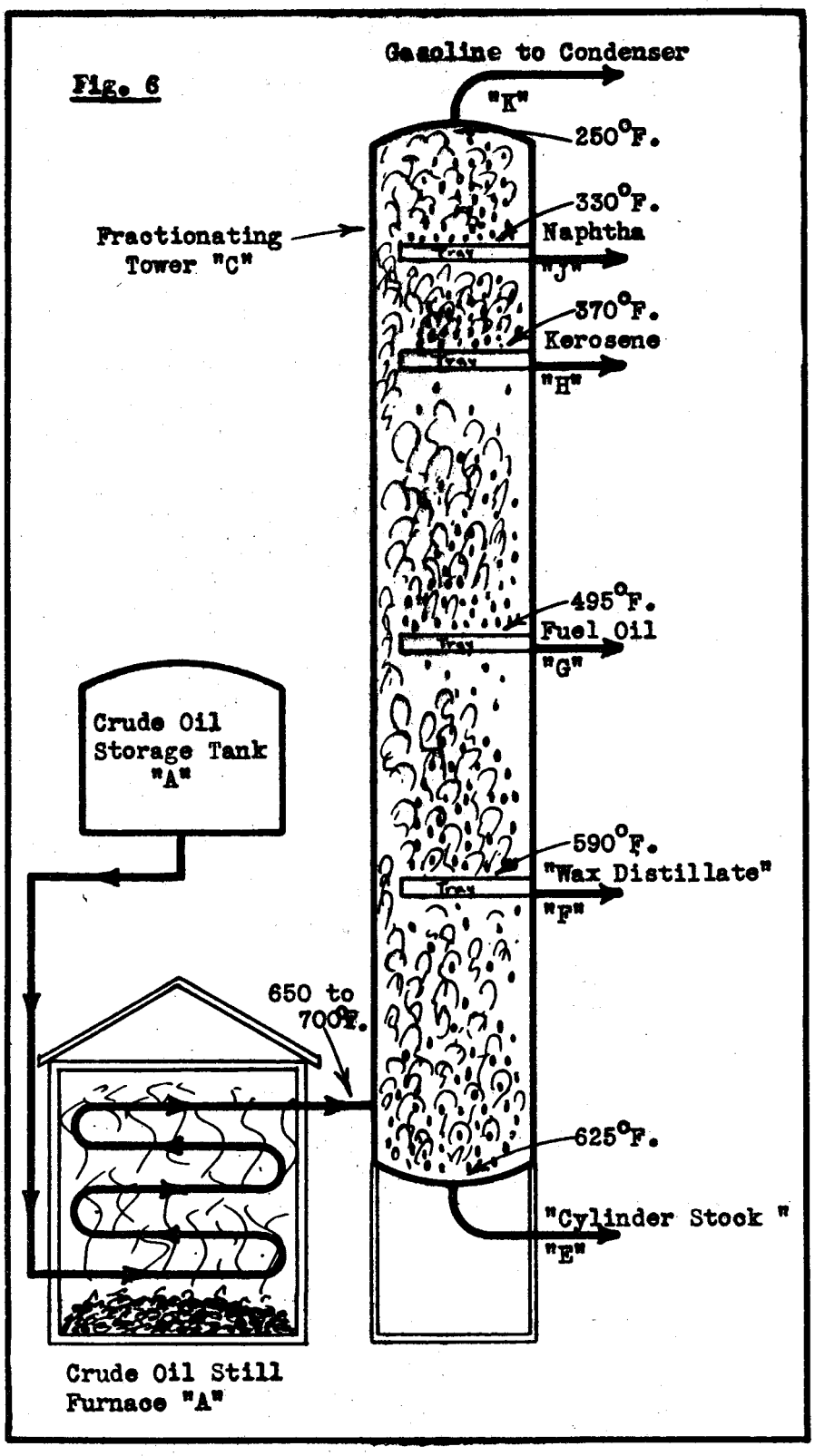
Crude oil is a mixture of many compounds. Each one has a definite "boiling point". As the crude is heated, these compounds boil off - are separated - as they reach their "boiling point", or temperature, just as alcohol boils away - separates - when the automobile is overheated in winter.

The various compounds in crude oil have different "boiling points." Thus, when crude oil is heated to, say, 100° F., a very volatile high test gasoline is "boiled off." When it is heated to higher temperatures, all of the gasoline is boiled or distilled off. Next, kerosene, fuel oil, etcetera, are distilled in the order of their boiling ranges.

Actually the distillation is accomplished as illustrated in Figure 6 (page 6). Crude oil is pumped from crude storage tanks (A) to furnace (B). In passing through the furnace coils it is heated and mostly vaporized at temperatures of 650 to 700° F. From the furnace it enters the bottom of fractionating tower (C). As the vapors rise in the fractionating tower, they pass through a series of baffles (not shown) and become cooler. Thus, the top of the tower is nearly 400° cooler than the bottom of the tower, which is at nearly the outlet temperature.

Vapors, rising through the tower baffles become cooler, condense,

and fall on trays (J, H, G, F), from which they are pumped to storage tanks. The gasoline vapors are so very volatile that they pass completely through the tower without condensing. These gasoline vapors are separately condensed after leaving the top through pipe (K).



The heavy, rich cylinder stock is much too heavy to be vaporized in the tower. Consequently, it drops to the bottom of the tower and is withdrawn through pipe (E).

In the fractionating tower the first rough separation into six basic products has been made. These products must now be further separated and refined before they are salable commodities.

The gasoline, naphtha, kerosene, and fuel oil will not be considered for the moment. "Wax Distillate" from pipe (F) near the bottom of the tower is the first "fraction" or distillate containing useful lubricating oil.

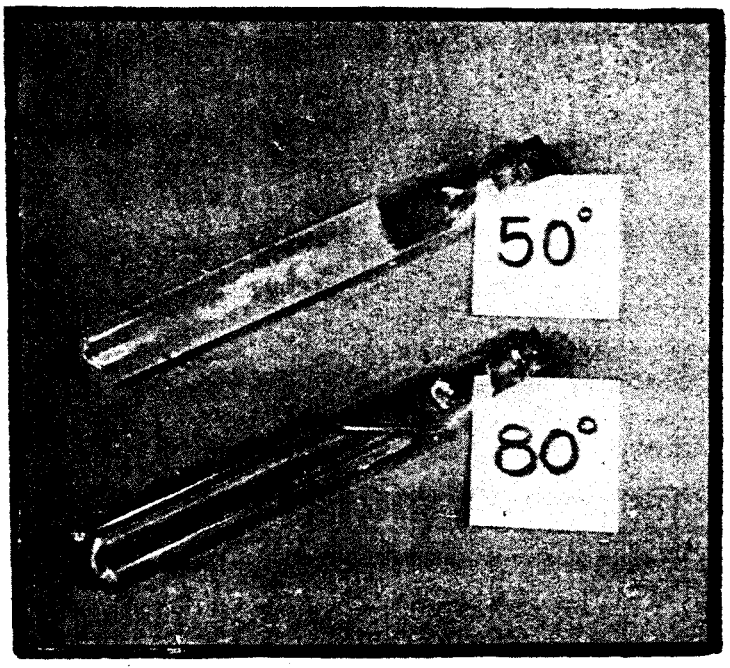


Fig. 7

At 50°F. the wax has congealed and the wax distillate is solid. At 80°F. the oil is clear and fluid. The wax distillate is dewaxed to pour freely at zero in the wax pressing plant.

Kendall wax distillate is a pale straw-colored oil of very light body. Below a temperature of about 75° F. it is cloudy and congealed by crystallized wax. Wax distillate actually contains:

1. Light (SAE 10) motor oil - (called "viscous neutral".)
2. Light (sewing) machine oil - (called "non-viscous neutral".)
3. Fuel oil
4. Wax (called "white scale wax" - such as used for fruit jar tops, wax paper, candles, etc.)
5. Impurities (small amounts of tars and gums.)

Kendall cylinder Stock is taken from the bottom of the fractionating tower (C), figure 6. It is a heavy, dark green oil, congealed at temperatures below 30 - 40° F. by the solidification of "petrolatum" or "amorphous wax." The cylinder stock actually contains:

1. Heavy (SAE 70) motor oil - (later known as "bright stock.)
2. "Petrolatum" or "petroleum jelly" - (this product refined is commercial vaseline.)
3. Impurities - (tars and gums.)

The products in which we are most interested are, of course, the finished dewaxed SAE 10 motor oil (viscous neutral), and the finished dewaxed SAE 70 motor oil (bright stock). When these oils are refined, by mixing them in the proper proportions a complete line of motor oils results, from SAE 10 through SAE 70.

REMOVAL OF WAX

First, however, wax must be removed from the wax distillate and cylinder stock. Wax in the light oil is called "white scale wax." At low temperatures it crystallizes into a matrix of solid crystals and flakes which may be removed by forcing (pressing) the oil through several layers of heavy canvas. The solid wax crystals are deposted on the canvas pads, and the oil passes through.

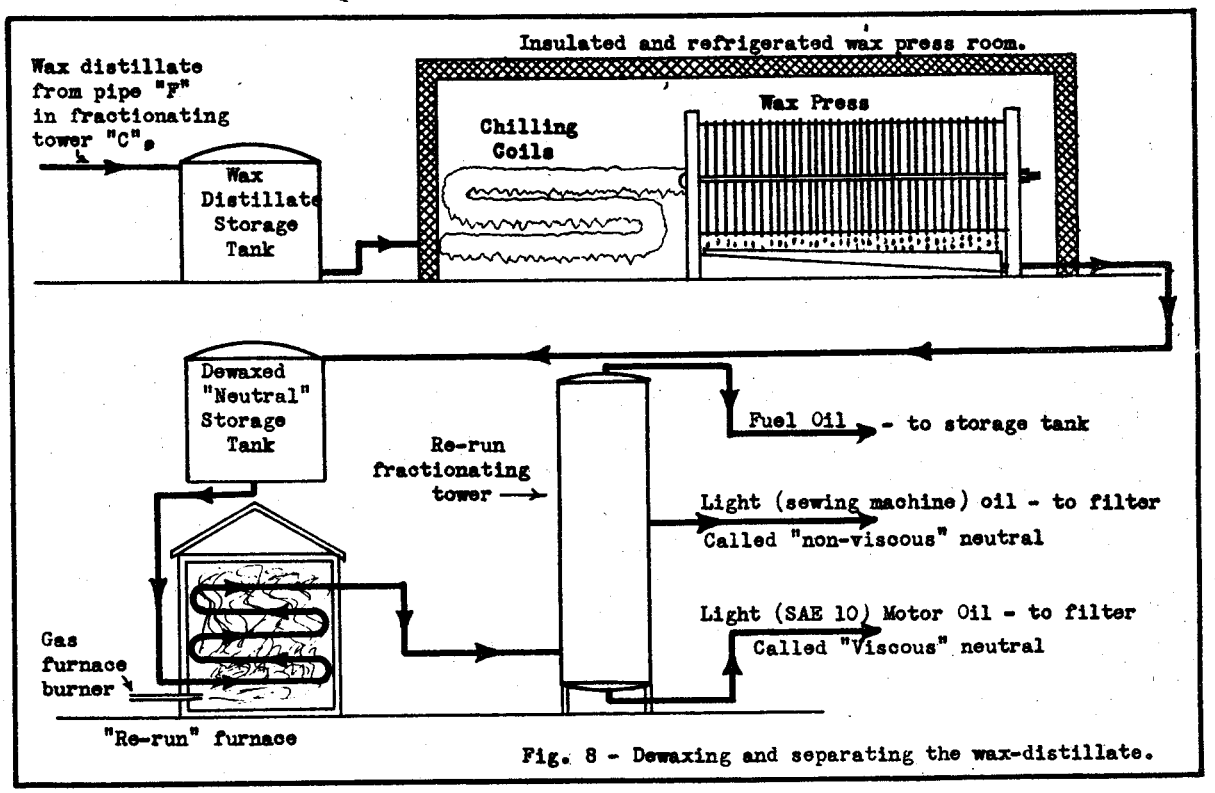


Fig. 8 - Dewaxing and separating the wax-distillate.

The accompanying diagram, figure 8, illustrates the wax press. The wax distillate passes from fractionating tower (C), figure 6, into the Wax Distillate Storage Tank. From here it is pumped into the heavily insulated, refrigerated wax press room. It is

first chilled to very low temperature in coils equipped with jackets through which refrigerant is circulated. Next it is pumped into the wax press, which consists of alternate sheets of heavy canvas and spacer discs. The wax is deposited on the canvas discs, and the dewaxed oil oozes out of the edges of the canvas into a tray at the bottom as illustrated in figure 8.

The dewaxed oil is then pumped to a storage tank, and eventually into the furnace coils of the "re-run fractionating" tower. The action of this tower is the same as the action of the crude oil

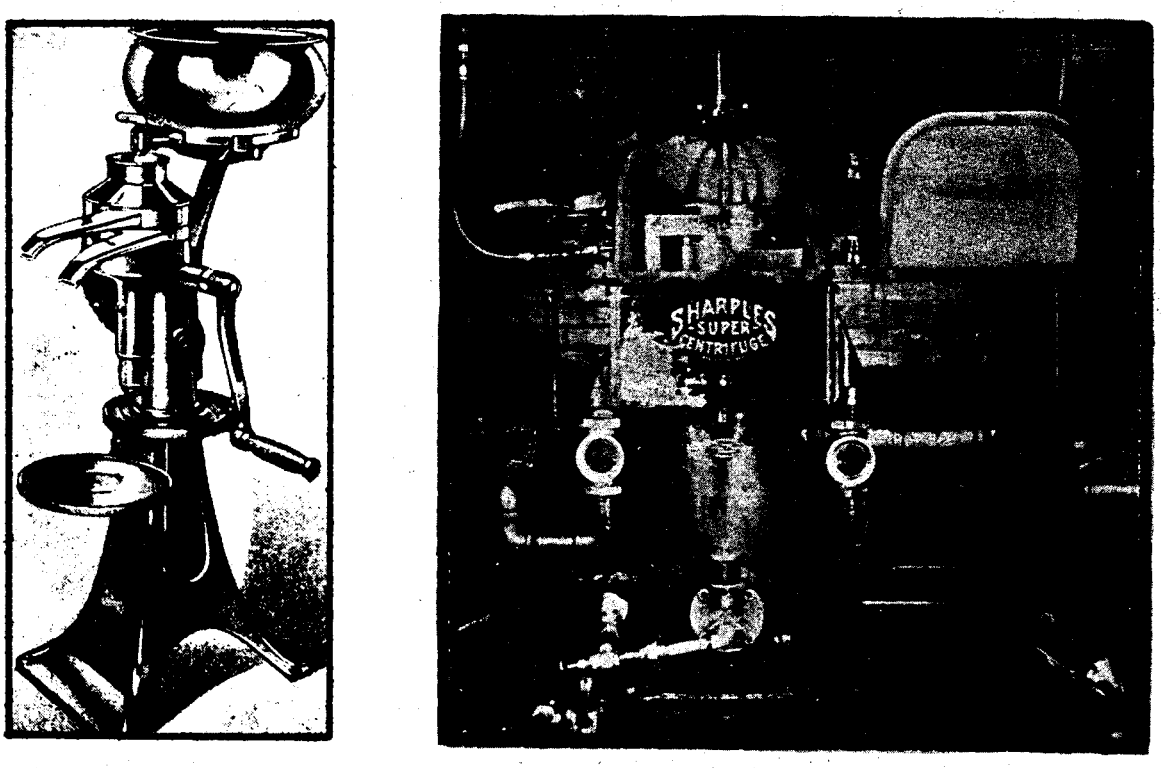


Fig. 9
Left picture shows the ordinary dairy cream separator. Note the similarity between this and the Sharples Super Centrifuge at the right. Both machines operate on the same principle. Centrifugal force is utilized to separate the cream and milk in the cream separator, and the petrolatum from the stock mixture in the centrifuge.

fractionating tower (C), figure 6, except that in this tower the dewaxed (cold test) neutral is separated into light fuel oil, the heavier "sewing machine oil" (non-viscous neutral), and a residue of SAE 10 oil (viscous neutral.)

The fuel oil is pumped directly to storage tanks. The non-viscous and viscous neutrals are pumped to filters where impurities such as tars and gums are removed. (Filters will be discussed later.)

The wax in the cylinder stock differs from "white scale wax" in that it only congeals at low temperature, and does not crystallize. It is called "petrolatum wax" or "petroleum jelly", and the refined product is marketed commercially as "vaseline.". Because of its jelly like consistency, this wax cannot be removed by filtration or "wax pressing" as the white wax is removed.

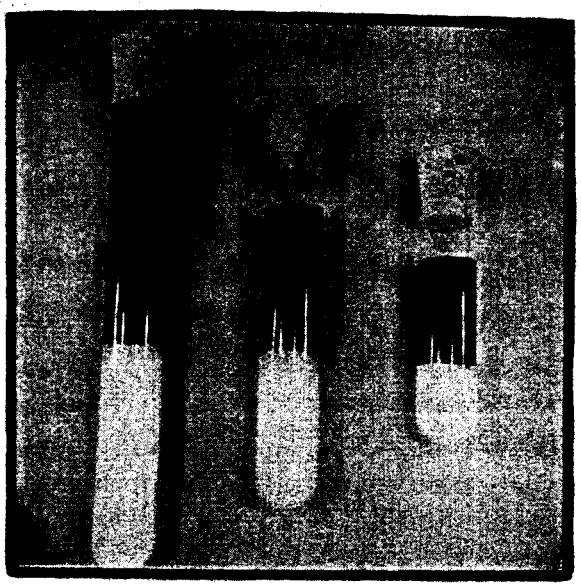


Fig. 10 The tube at the left indicates the amount of wax in the original crude oil. (The dark layer is petrolatum - vaseline - wax from the cylinder stock; the lower layer is white wax from the wax distillate.) The second tube from the left is the amount of wax usually removed to produce oils which the wax congeals and/or clouds at 25°F. Kendall removes the additional amount of wax in the tube at the right. All grades pour freely at zero as a result of this thorough de-waxing.

The Kendall Refining Company uses the Sharples Super Centrifuge for removal of petrolatum wax. The cylinder stock is first diluted with naphtha (later removed by distillation) to cause it to be pumped more easily. It is then chilled to about 60° below zero, and run through the centrifuge. This machine operates on

the principle of the old fashioned cream separator. The heavy congealed wax is thrown out of the cylinder stock solution by centrifugal force, and is carried away in heated pipes.

Kendall Motor Oils are more thoroughly dewaxed winter and summer - than any other Pennsylvania Oil. Every grade of Kendall motor oil from SAE 10 through SAE 70 is dewaxed to pour freely at zero temperature.

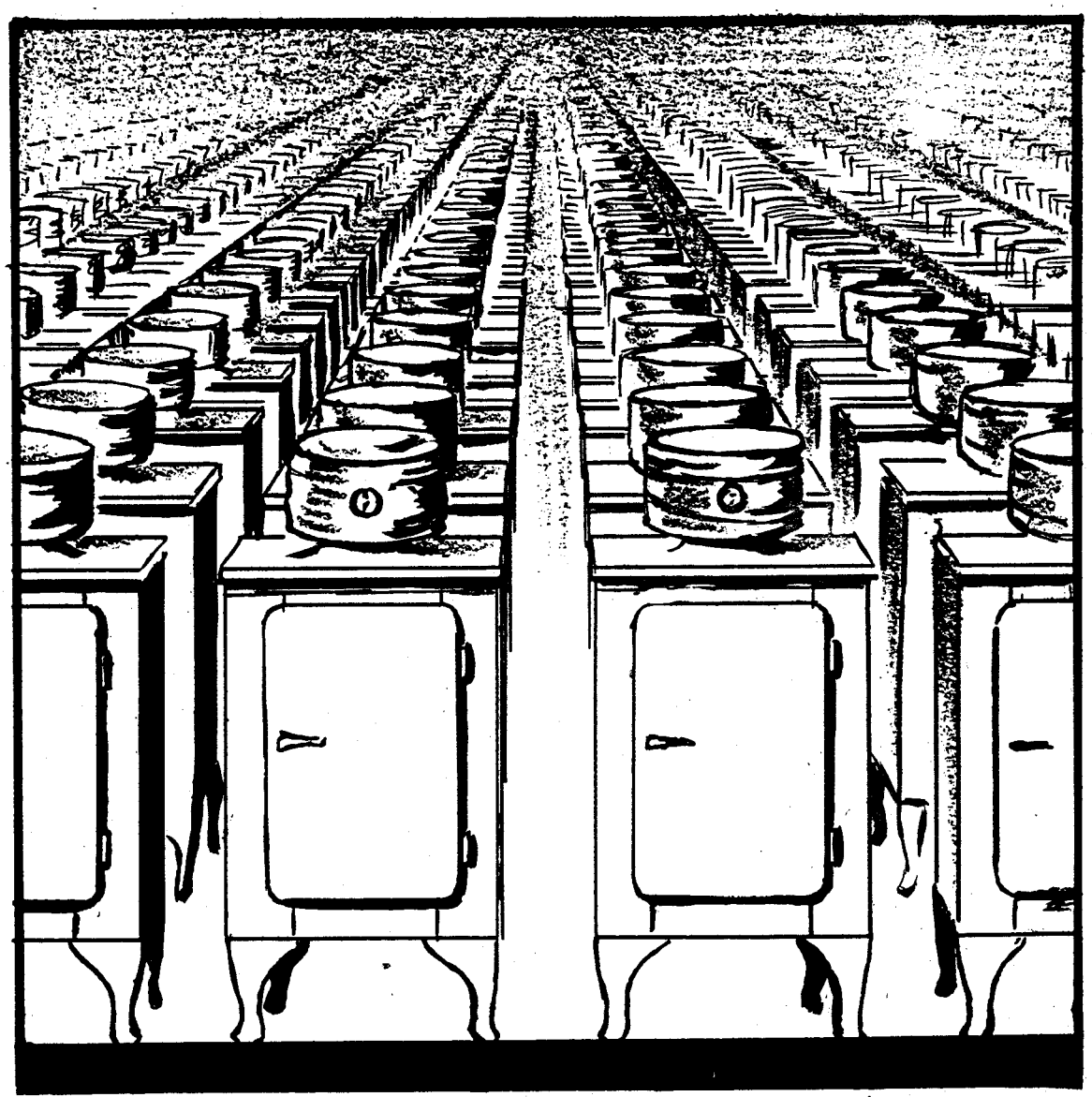


Fig. 11 50,000 ordinary electric home refrigerators would be required to dewax Kendall, the 2000 Mile Oil

Since oils must be chilled to remove wax, the Kendall Refining Company operates a most impressive refrigeration plant. This plant has a capacity of approximately 500 tons of ice per day. This is the equivalent of about 50,000 average size, electric home refrigerators operating twenty four hours a day.

REMOVAL OF TARS AND GUMS

Tars and gums are removed by filtration through Fuller's Earth. The dark colored tarry and gummy materials are left in the earth and the clean, purified oil passes through.

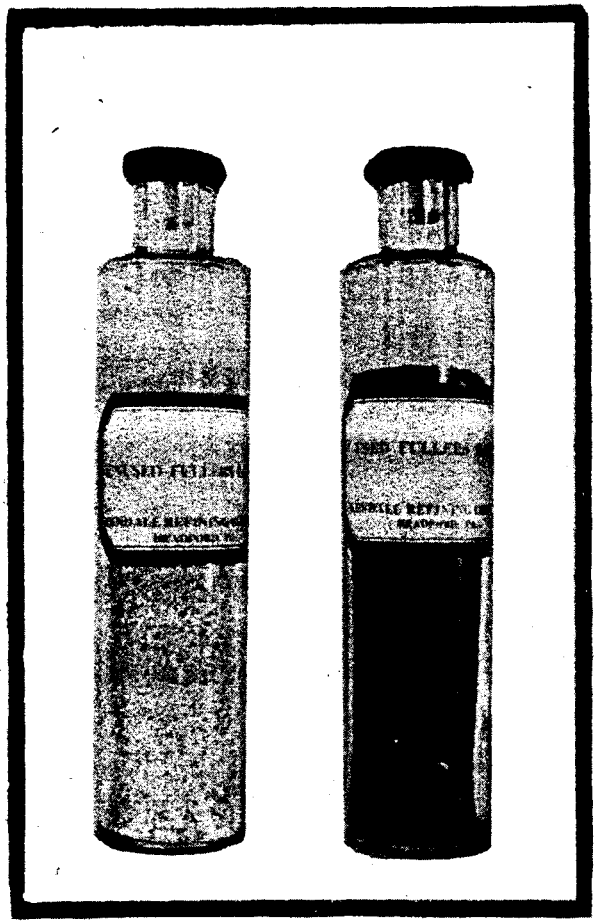


Fig. 12
Unused and used ("spent") Fullers Earth. Note the very dark color of the "spent" earth as a result of the impurities which it has "adsorbed".

(Fuller's earth is a porous mineral resembling sand in general appearance. The individual grains when magnified, appear porous or sponge-like. Fuller's earth is said to "adsorb" the tarry, gummy impurities and retain them in the pores. Used or "spent" earth may be rejuvenated many times by burning the impurities out of the porous earth. The action of earth in filtering or purifying oil is akin to the action of charcoal or similar materials in purifying the air passing through a gas mask.)

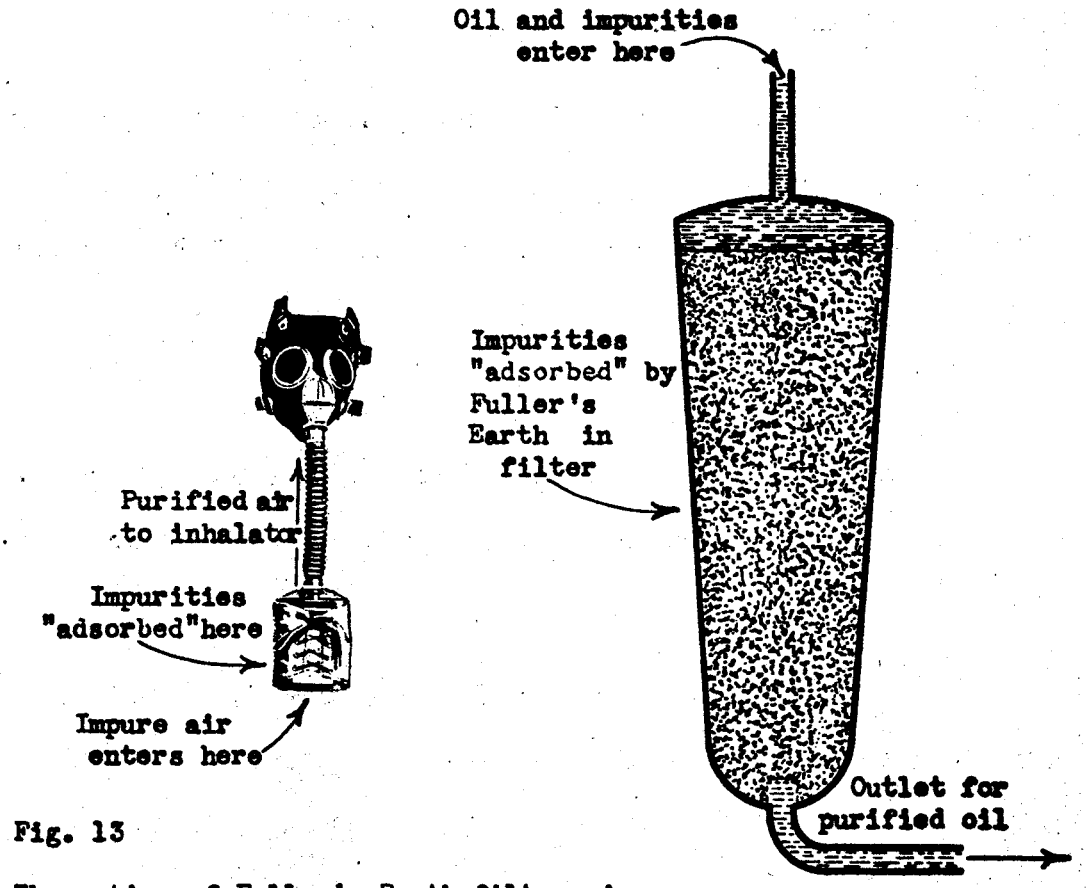


Fig. 13

The action of Fuller's Earth filters in purifying oil is similar to the action of a gas mask in purifying air.

The neutral (light bodied) oils are dewaxed and then filtered. The naphtha diluted cylinder stock mixture is first filtered, and then dewaxed in the Sharples centrifuge machines.

The dewaxed filtered neutral oils are now completely refined. The light (non-viscous) neutral oil is now Kendall 32 Lemon, used for light duty, high speed machinery, electrical transformers and switches, floor oil, etc. The heavier (viscous) neutral oil is now Kendall "B" (SAE 10 and 10W) Motor Oil, used for breaking in new cars, winter lubrication of automobile motors, electric motors, etc.

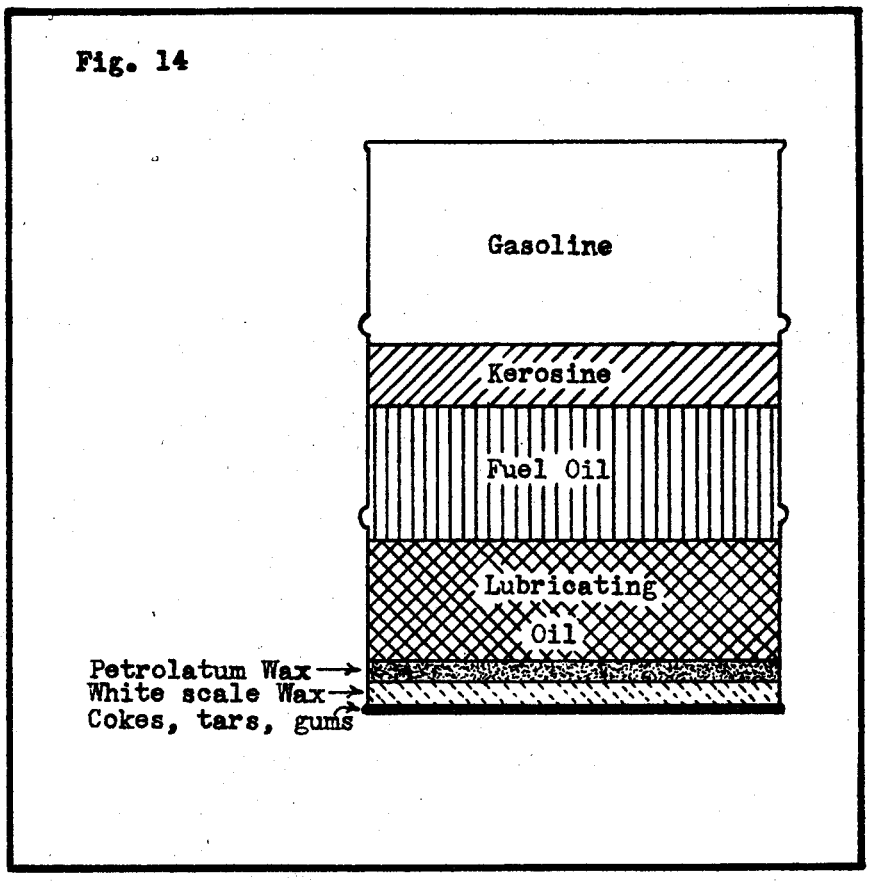
After the naphtha diluent has been distilled from the dewaxed filtered cylinder stock, the latter is called "Bright Stock", and is sold as Kendall "GG" Motor Oil, SAE 70.

By mixing Kendall Bright Stock and Viscous Neutral in the proper proportions all other grades of Kendall motor oil - "C" (SAE 20 and 20W), "E" (SAE 30), "EE" (SAE 40), "F" (SAE 50), "G" (SAE 60), and "J" (SAE 70) - are formed.

The gasoline and naphtha from fractionating tower (C), figure 6, are subjected to chemical treatment for improvement of odor, and are then ready for market.

The fuel oils from fractionating tower (C) and the "re-run" tower, figure 7, are ready for use. These oils make excellent Diesel fuels, and also are suitable for oil burning heating equipment.

Excess fuel oil, and wax removed from the lubricating oils are transported to a Dubbs "cracking unit", and "re-formed" into gasoline. The Dubbs unit converts waste products into high quality anti-knock gasoline by "destructive distillation" using extremely high temperatures and pressures. (Kendall's Dubbs Plant is one of the most modern plants in the country. Several world's records for efficient operation are held by this unit.) Each barrel of Bradford Crude Oil is separated and refined into the highest quality petroleum products, in the proportions illustrated in figure 14.



Kendall Gasolines are marketed within one hundred miles of the refinery. Kendall Purple and Kendall Ethyl gasolines are well known in this territory for their clean burning, powerful, quick-starting characteristics and their economical performance.

The refining process has been outlined in the most simple form. Those parts of the process which would tend to complicate the picture have been eliminated. Actually, volumes have been written on certain phases of refining such as the fractionating tower, the wax removal plant, the cracking process, etc.

The following table is presented to interpret the relative influence of crude oil properties and phases of the refining process in terms of performance.

VISCOSITY INDEX	
Viscosity index is a measure of the change in body of an oil with change in temperature. Pennsylvania oils have high viscosity index (show least tendency to thin out when heated, thicken when cooled.)	Kendall, the 2000 Mile Oil, and Kendall O.K. Gear Lube, refined from 100% Bradford Pennsylvania Crude Oil, naturally possess high viscosity index. This means easier cold weather starting, less wear, less consumption, and better piston seal.
WAX REMOVAL	
High quality crudes naturally contain wax, which must be removed to produce highest quality oils.	All grades of Kendall Motor Oil are thoroughly dewaxed to pour freely at zero temperature. The result is easier cold weather starting, and cleaner engine operation in summer.
LOW VOLATILITY	
Low volatility (minimum tendency to vaporize at engine temperature) is essential if crankcase oils are to show least consumption.	Kendall Motor Oils, refined from Bradford Pennsylvania Crude oil by special Kendall Processes, have such low volatility that oil vaporization does not take place under the most severe operating conditions.
GREATER STABILITY	
Motor oils must be "chemically stable" for clean operation, and resistance to deterioration.	The exclusive use of the world's premium crude oil contributes natural stability to the 2000 Mile Oil. In Kendall's special, modern refining processes the few impurities which might detract from greatest stability, are removed.
UNIFORM HIGH QUALITY	
Uniformity is an essential part of highest quality.	Kendall Motor Oils have been refined from the same premium crude oil for <u>over fifty years</u>. The refining process is controlled within the closest possible limits. The 2000 Mile Oil is retailed only in numbered, tamperproof, refinery sealed cans for your protection.