Work in the Oil Industry

Work in the oil industry was the third most important human exertion in Veracruz by 1910. It mattered worldwide that year for its great discoveries and production. Nationally it was already significant for the fuel it provided railroads and the profits it promised enormous companies with formidable investments in oil lands, concessions, leases, and installations. Like work on the railroads or at the ports, it therefore seriously concerned the federal government. And as the boom carried from the fields to town, it interested the state government and some newly prominent municipalities.

Since the industry already embraced “production, transportation, manufacture and marketing,” it involved (like sugar) several quite different processes. In the few departments that the companies had as yet organized, “exploration,” “fields,” “engineering,” “sales,” the chiefs and superintendents each managed some similar but many different tasks and operations. Technically then the work happened through at least a dozen different divisions of labor. Production, for instance, which consisted of “exploration” and some of the “fields” and “engineering” work, included at least six divisions, four of them in different sorts of construction, building drilling rigs, roads, railroads, and pipelines. The subdivisions numbered in the scores.

The work also happened in many different kinds of places. The two “oil regions” where the companies had the grandest properties and privileges were expanses so vast that they “can only be estimated roughly....” The Tampico region, “the coastal plain between the Rio Soto La Narina and the vicinity of Jalapa....bounded on the East by the Gulf of Mexico and on the South-west and North-east[sic, for -west] by the front of the great central plateau....comprises, roughly, an area of about 1,700 square miles.” The Isthmus, “the basin of the San Juan, Coatzacoalcos, and Tancochapa Rivers,” amounted to some 6,000 square miles. Neither region contained many towns or villages. Both were largely wild country, savannah, swamp, jungle, famously but erratically marked by “numerous exudations of petroleum...from small seepages a few inches in diameter to asphalt lakes....” Exploration occurred in erratic movements through these wilds and indefinite tasks at locations in unpredictable places in them. The “oil fields,” here exploration had succeeded and the work was “development,” i.e., construction and indefinite extraction, were places only a few square miles in extent, far from any town, reachable only by wagon roads or company railroads, and as different from one another as battlefields. Transportation of oil occurred variously inside and outside the regions, at pumping stations for the pipelines from the fields to terminals near the coast, along right of ways between fields, pumping stations, and terminals, on launches and barges back and forth along rivers and across lagoons between the fields and towns and terminals, and on tank steamers and barges back and forth across the open sea of the Gulf. Manufacturing in Veracruz took place at two quite differently established refineries on the outskirts of two quite different towns, the port of Veracruz and the Coatzacoalcos River town of Minatitlán. The agencies for distribution in the state were in four other very different towns, near the coast 50-odd miles north of Veracruz in Gutiérrez Zamora and upcountry in Jalapa, Córdoba, and Orizaba.

In none of these places, except on wagon roads in the summer, did work vary by season. Through the rainy and the dry months, it continued as constantly as the surface of the earth indicated deposits of oil below, good luck led to discoveries, and workers could capture oil, render it useful, and deliver it. The days of work were ordinarily therefore six or seven a week; the hours, all the hours possible.

The work of exploration was expeditionary. From bases in Tampico, Tuxpan, and Minatitlán it occurred in successive, hopefully clandestine operations into the interior. And everywhere the first movement was prospecting. From 1900 to 1906 this usually meant only quiet reconnaissance of an hacienda conveniently named, for example, El Chapopote, "Tar," and maybe getting a local boy to "scout" or spy on other strangers in the area. By 1910 it was much more extensive and difficult. It most often meant a secret foray for several days or weeks off the roads and up uncharted trails into company-owned or leased but still trackless wastes of sand and bush, gnats and nettles, ticks, scorpions, and rattlesnakes, maybe farther, across marshes and lagoons, up rivers and creeks with canebrakes 20 feet high along the banks, up weeded gullies thick with chiggers, flies, mosquitoes, more ticks and snakes, across lonesome little burned clearings, maybe through scrub, rank, hardly penetrable underbrush, and on into swamps and forests where "no axe had rung...for generations," the "dark and menacing" primary jungle, "great hardwoods and tropical cedars, tall spindly fern palms, great vines looping down, bamboo in profusion," the ceiling of leaves 100 feet above dripping day and night, the floor below melted into "one to two feet of mud for nine months of the year, and for weeks at a time...one scarcely sees the sky," growing, rotting "labyrinths' of "immense solitudes," backwaters drifting in and out, slow streams, mosquitoes and ticks there too, and wasps, bats, ants, centipedes, tarantulas, boar, jaguars, boa constrictors, leeches, cottonmouths and crocodiles, absolutely natural and inhuman working conditions, but sooner or later entered and endured in searches for <u>ojos de chapopote</u>, oil springs. And once at an impressive seepage, it continued in a research of the area for indications of a "cap rock" or "trap" below, outcrops of rock at the surface that seemed to expose in the earth's stratified beds hundreds or thousands of feet down a layer of impervious rock over a layer of porous rock, which might have accumulated gas and oil.

This prospecting required two kinds of workers. One was the prospectors themselves. They were not many, for all the companies in Veracruz in 1910 maybe only 23. According to the company that employed them, they differed in training, duties, and practice, For any company one prospecting trip easy or difficult usually took one prospector, so that from company to company some of the work was virtually identical. But the differences were notorious.

For Huasteca Petroleum the prospectors were a few "practical oil operators," old hands from the California and Peruvian fields. Mingling easily in Tampico, shrewd judges of city and country oil tales, they were schooled from experience where around a seepage to look for the cap rock and where to envision roads, reservoirs, and pipelines, lucky at least by reputation, confident of their guesses, and contemptuous of geologists, who in response accused them of faith in "wiggle sticks" and an "oil sense." On their trips they did not reveal a single trick. Having studied the company's records on oil exudes in the locality in question, one of them would simply ride there, look on foot for the reported and unreported seepages, note where they were if and when he found any, memorize the outcrops and terrain around them and where the closest water ran, and ride back to base to tell his opinion.

For Southern Pacific the prospectors were an aged "professor" and his "assistant." Trained in the Texas Geological Survey, for several years a professional consultant, since 1907 the company's chief geologist in Mexico, scorned by old hands as a "rock hound" and "ridge runner," the old man figured by 1910 among the world's few experts on the nature of things thousands of feet underground in northern Veracruz. In his mind he saw Tampico as "almost the center of the great ampitheatre [sic] formed by the valley of the Panuco and Tamesi Rivers and their tributaries," its depths "recent deposits of Quaternary age" on "a thick series of sedimentary deposits including shales, marls, conglomerates, sandstone, and impure limestones of Tertiary age,...which rest upon a thick series of limestones of Cretaceous age," the "entire series...folded and faulted...and intruded by dykes, sills, laccoliths, and plugs of igneous rock...," a century of countless traps. But on his trips he acted as if dumb. He kept mostly to the San Luis Potosí escarpment and foothills above the Pánuco Valley, haunting the railroad down the Tamasopo

Canyon toward Tampico. Slowly riding and hiking along the canyon and cuts, silently studying enormous caverns and springs, rocks and trees, he would only now and then stare eastward over the meandering river, do "constructive geological reasoning" to himself, glance at his compass, and sketch and scribble notes for voluminous reports.

The Águila prospectors were numerous and high-powered, several British-, Dutch-, and Swiss-educated and widely experienced field geologists and five U.S.-trained youngsters, four of them on leave from the U.S. geological Survey, not yet "rock hounds," but eager "pebble pups." From 1906 to 1909 the proper geologists had generally surveyed Águila holdings from north of Tampico to Tuxpan, mapping seepages and outcropped "anticlines," or "structures," evidence of the folds in the strata below, whose "dip" and "strike," angle and direction, point to their crests, which were the traps. By 1910 nearly all of Águila's prospecting was by the pups, to study the structures' "formation," the sequence and classification of the rock, to guess which trap might contain oil. "...Entranced with the possibilities of interpreting the geological structure from physiography and landform," and specifically instructed on the stratigraphic and topographical information they should gather, these young men could hardly hide their enthusiasm or the company's interest in their mission. When one of them rode away in full gear from Tampico or Tuxpan, he brought not only a compass and clinometer, notebooks, black pencils, and a copy of the company's general map and reports on exudes and maybe wells in the locality in prospect, but also a change of shirts, socks, and underpants, a mosquito net, cot, tent, slicker, quinine pills, geologist's pick, collecting bag, aneroid barometer, watch, pocket lens, tally counter, tape, protractor, plane-table, paper, and alidade, stadia rod, sketching case, colored pencils, and eraser. And when he found a promising seepage, one near a "volcanic plug," he sooner or later put all the equipment to use--to keep a route map, chart the seepage on the general map, read and record elevations, dips, and strikes at several surrounding outcrops, run traverses from one primary exposure to the next, plot the primary stations as control, take a plane-table survey of the locale by stadia traversing or triangulation, sketch, diagram, and note theories, hypotheses, inferences, and facts, determine the attitude of the rocks below and if and where there was "a good structure," draft a formation map, and write up and classify his notes for his report to base.

The other kinds of workers in prospecting were the <u>mozos</u>, as prospectors called them, or <u>guías</u>, as they preferred to be called, actually both "servants" and "guides." Unlike prospectors, there workers were ordinarily casuals, hired individually by any company from trip to trip and supposed not to serve so often that they became insiders. One being about as capable as another, they typically differed only in person, some grown men, others boys, some grudging already on the second day, others loyal to the end. For any trip there would be one or two of them. However recommended to the prospector who chose him, every one was expected and claimed to know not only the local seepages and trails, creeks, and crossings but also the local people, mules, canoes, properties, topography, climate, vegetation, and shortcuts to pumping stations, railroads, and rivers. But as prospectors differed, so did the work of their servants. It was hardest and most complicated the Águila prospectors. On a trip with a pebble pup, the guide would serve from before dawn to after dusk usually six days a week as wrangler, cook, saddleboy, packer, blazer, paddler, bodyguard, axman, chainman, rodman, hunter, fisherman, and camper.

"The trap's the thing," all prospectors insisted. But no one not superhuman could know if or exactly how far down a trap had oil, or how much, until the trap had been opened. The best any prospector who thought he had found a trap could do was recommend in his report the precise location for drilling a hole to test it. "The drill," as even pups agreed, "is the final arbiter."

On a good prospect therefore the next exploratory movement was drilling a wildcat. This took several groups of men to accomplish: at least two crews and three gangs to bring from Tampico, Tuxpan, or Minatitlán to the location the material, equipment, and supplies for drilling, a crew to build the rig, and another crew and another gang to drill. The time from location to the moment of proof, dry hole or oil, a well, would be two or three months or more.

In June, 1909, for example, Águila managers were considering likely prospects in the Tampico-Tuxpan region. By then they had the experience of three failures in the "ampitheatre." The first, at San Diego, had resulted in one abandoned hole, a well at 2,007 feet, and at San Diego No. 3 the glorious catastrophe of Dos Bocas, which destroyed everything there. The second, 28 miles up the winding Tuxpan River, at a place on its left bank called Tumbadero, had ended in three dry holes nearly 3,000 feet deep. The third, north of Tampico, had just ended in its fourth dry hole. But the chances were always as high as ever that the next try might succeed. They seemed particularly good from 10 to 20 miles northwest of Tumbadero, up the valley of a little tributary of the Tuxpan, the Buenavista River, where Águila had three haciendas under lease, already surveyed and recommended for testing. The likeliest prospect, the managers decided, was the one closest to Tumbadero, Hacienda Potrero del Llano. Its eastern rises showed "a large active seepage of pure chapopote" near the base of "a low hill of volcanic origin." Its western boundary, down along the Buenavista, featured “a great number of chapopote seepages and...chapopote cemented gravels.”

One of the geologists who had earlier examined the place returned and read underneath it “the crest and east flank of a N.W.-S.E. trending anticline” probably faulted close to its axis, with a very low dip eastward. He made the location among the west-side seepages, about 280 yards up the slope from the river. On his work the superintendent ordered the drilling outfit. This would be for a standard, cable-tool, 74-foot California rig to drill to 3,000 feet.

Tuxpan then was Águila’s main northern depot. An old port town of suddenly 3,000 people on the left bank of the Tuxpan River seven miles up from the bar at the river’s mouth, it could not admit sea-going vessels, but in the last five years its inbound tonnage had more than tripled. There for the last year S. Pearson and Son had been importing the material, equipment, and supplies for construction of the pipeline and railroad between Cobos, across and four miles down the river, and the Furbero oil field, 30 miles southwest. From steamships anchored in the Gulf a mile or two beyond the bar lightermen removed the company’s cargo, loaded it in their boats, by sail or tug brought it over the bar and upriver, and delivered it on the Tuxpan wharf. From the wharf gangs of handlers removed the freight through checking and customs to the company’s yards east along the river. Among the thousands of tons of things carried to these yards that summer were the material, equipment, and supplies for drilling at Potrero del Llano: 30 tons of rough pine and hardwood lumber and timber, three tons of rig irons, nearly a ton of finished oak wood work, a 4-ton 25-horsepower oil-country boiler, steam pumps, a 2-ton 25-h.p. steam engine, 700 lbs. of nails, bolts, nuts, and washers, 20 tons of drilling and other tools, four tons of cordage, 72 tons of casing, etc.

On August 26 a hurricane from the lower Gulf blew inland north of Tuxpan. Bringing cyclonic winds and torrential rains for three days across northeastern Mexico, the storm downed telegraph lines, washed out railroads, and left 2,000 dead in a deluge in Monterrey. Floods coursed through the oil region too. And they continued as the water fallen in the mountains kept running down to the Gulf. Exploration and development stopped for a month.

In late September Pearson stevedoring gangs in Tuxpan began loading the lumber, irons, etc. on the river’s hacks, 100-ton bilanders. The boat crews sailed the loads up to a landing at Tumbadero. A private contractor’s gang removed the freight from the landing to wagons. The contractor’s teamsters drove the loads, a 20-mule team for the wagon with the boiler, up the old road along the Buenavista’s left bank 15 miles to the little town of

Temapache, (pop. 2,322), [Perez ?, 77] then west five miles down to the location. There an Águila pioneer gang unloaded the freight, arranged it on site in yards, and about 150 yards south built a few "boxes" for housing; wooden floors, canvas walls (except for a yard-wide stripe of screen around the middle), and palm-thatched roofs; one of the boxes, with a stove, would be the kitchen and "mess hall." And soon there came an Águila wagon with "groceries," soap, a cook, and a houseboy.

In mid-October an Águila rig-building crew arrived. A "pusher" (a foreman) and four builders accustomed to going from job to job, these fellows were multiply skilled equals on a specialized team. They brought tools they would all use: machetes, picks, shovels, saws, axes, adzes, sledge hammers, building ladders, rig hatchets, rope, pulleys, and block and tackle. Strong enough to hold up and ???study with one hand the end of a 2" x 12" foot long, they could swing a rig hatchet with either hand and by its hammer head sink a 60-penny spike in three blows. (Lynch, 10-) They all had both hands callused inside like horn, dead to the feel of splinters. From dawn to dusk day after day for a week they would work interchangeably.

First they cleared brush and leveled an area 25-30 feet around the location and some 60 feet in the direction that would be forward. Then in a 21-foot square around the location they dug six holes for the derrick's foundation, two holes for the back corners, two for the sides, two for the front corners, and in the middle of the square they dug a cellar about eight feet on a side and six feet deep. From midway between the ???by liners, rollers, and rope, they brought the things they needed. Then, perpendicular across the center line they laid level five mud sills, 14"x 14" timbers, four of them about 16 feet long, each weighing about 650 lbs. The first they centered 3-1/2 feet forward from the front two holes, the second about six feet farther forward, the third exactly 12-1/2 feet beyond the first, and the fourth 6-1/2 feet farther forward; the fifth, about 8 feet long, the "nose sill," they laid about 7 feet behind the first (inside the square, about two feet in front of the cellar). According to the center line they cut 18-20-inch-wide gains across the sills. And exactly on the line they laid level in the gains the main sill, a 16"x16" timber 28 feet long weighing some 1500 lbs., about 6 inches over the nose sill in back and 6 inches over the fourth mud sill in front. They drove hardwood keys into the gains to hold the mounts true and tight, and bolted the main sill on the third mud sill forward. Parallel 5 feet to the left in gains on the three forward mud sills they laid the sub sill, a 16"x16" 18 feet long. And parallel to the right in gains on the two forward mud sills they laid the tail sill, a 12'x12" 12 feet long, its front end about 4 feet beyond the front mud sill. These joints too they keyed. Then they set the derrick's six hardwood foundation posts, 18”x16”’s, exactly 9 feet... *Go back under this flap to resume “8 inches...”* front they measured 20 feet too (the front sill gained 2 inches to fit over the main sill), a third on 5 inches of plank in front of the cellar, a fourth on a 1-inch board about 2-1/2 foot behind the cellar, and the middle three about two feet apart across the cellar, the back one on a 2-inch plank, the middle one on 3 inches, the next on 4 inches, the front of the middle one and the back of the next one forward respectively a foot behind and a foot before a point on the center line exactly 12-1/2 feet back of the center of the intersection between the first mud sill and the main sill. All four corners they beveled inward about 6°.

Then they started “running the derrick,” erecting it. At the front and back corners they set 2”x8”’s 20 feet high on the ends of the side sills, one at each corner, spiked them to the beveled sides of the floor sills, spiked 2”x10”’s 18 feet high one at each corner to the beveled ends of the floor sills, and on the building ladders spiked the 2”x10”’s to the 2”x8”’s up to 18 feet, which made the four “starting legs.

Inside the legs’ corners at 10 feet up they nailed the first tier of 2”x12” girts, and at 18 feet the second tier. In the open panels between the girts on the sides and in back they nailed 2”x6” X-braces, and from the inside bottom corners up to the second tier in front an A-brace. And on the left side up to 18 feet they made the first two sections of the derrick ladder, its ides 2”x4”’s, its rungs 5 inches wide, 2 feet long. Then they divided: the pusher and two builders, the “groundmen,” stayed on the ground, to check the timbers going up, “lay out” the ones that needed sawing, set spikes and nails in them, and hoist them by hand, rope, and pulley; the other two fellows (with whom the groundmen would periodically trade places) were the “climbers,” to go on higher, handle the pulley and scaffold boards, take and position the hoisted timbers, and drive spikes and nails. The groundmen raised four 2”x12”’s some 24-25 feet long. The climbers on the building ladders took them, laid them across the second tier of girts for scaffolds, and climbed onto them. They took the next lengths for the legs’’ sides, four 2”x10”’s 16 feet long, spiked the lower 2 feet to the upper 2 feet of the front and back 20-footers, took the next lengths for the front and back, four 2”x8”’s 16 feet long, and spiked another 4 feet of the 2”x10”’s to them. Together groundmen and climbers positioned four 2”x10”’s 24 feet long from the bottom up the legs’ sides that high, spiked them onto the sides. And did likewise with four 2”x12”’s 24 feet long up the fronts and backs, which made the derrick’s “doublers.” Then the climbers nailed a scaffold board outside across either side at about 22 feet, climbed up, spiked the legs’ sides to the fronts and backs from 24 to 28 feet, nailed the third tier of girts at 226 feet and the second panel of braces inside both sides, back, and front, raised the free scaffolds to the third tier, undid the nailed scaffolds, renailed them outside at 30 feet, did the fourth tier at 34 feet and the third panel, and on the left side added two more sections to the derrick ladder. So (with eventually shortened scaffolds) they continued up two more 16-foot lengths, spiking 2"x10"'s on the sides to the 2"x8"'s on the back and front, making girts every eight feet, braces every panel on all four sides, and up the left side the derrick ladder. The top of the legs they finished on the sides with 8-footers, on the back and front with 6-footers. At the top, on scaffolds 70 feet up, they nailed the ninth and highest tier of girts at nearly 74 feet for a square about 4-1/2 feet on a side, and finished the derrick ladder. Then they took a couple of 2"x8" 6-footers, laid them on top for scaffolds, lowered the scaffolds they had been using, and started the crown block. Outside across all four sides, flush with the top, they spiked 2"x16"'s, onto them 2"x12"'s, and onto them 2"x6"'s, which made the block's water table, about 6 feet square outside. On the table flat down across the back they spiked a 2"x16" 6 feet long, across the front another, for the back and front "bumpers." From front to back on the bumpers they marked the center line, and front its back end dropped a plumb line to the men below. From them they soon took two 2"x16"'s 8 feet long with matched grooves across one edge back and front, laid them edgewise as beams, grooves up, one bean 2-1/2 inches on either side of the line, grooves even back and front, both beams about two feet beyond the table in front, and spiked them to the bumpers. Beside them on the outsides they spiked edgewise two more 2"x16" 8-footers flush with the first ones, and spiked each pair together. On their outsides and to them they spiked edgewise two more 2"x16"'s grooved back and front but 6 feet long, flush with the table back and front. And even with them 5 inches over on either side they spiked edgewise another 2"x16" equally grooved 6-footer, which, making three channels with six grooves across the table, completed the block. It also completed the derrick, la torre, as the Mexicans said, "the towers," or el faro, "the lighthouse."

Next the climbers took some 2"x8"'s and on the table erected a 6-foot gin pole. From it they took and mounted one after another the crown block's cast-iron pulleys. A 285-lb. 30-inch crown pulley went in the central channel's back grooves (its front exactly 12-1/2 feet back of the intersection of the main sill and the first mud sill), a 22-inch sand-line pulley in the same channel's front grooves, and four 22-inch casing-line pulleys in the grooves in the right and left channels.

All on the ground again, the builders became millwrights. They framed and set the jack posts. The "front" one (on the right side), a 16"x16" cut 5'7" high, they partly joined on the main sill over the third mud sill forward, mostly dovetailed (leftward) into the mud sill, keyed, and braced from its top down forward into the main sill. The "rear" one, a 16"x16"x4'9", they dovetailed and keyed into the subsill about 4 feet to the left, and braced front and back into the subsill. Then they opened boxes of rig irons and crates of woodwork and made the band wheel. They fitted the jack-post boxes on the posts; mounted from the right box, the crane, outside, to a jackboard midway to the left the 550-lb. Wrought-iron crankshaft, 4-1/2 inches in diameter, 6-1/2 feet long; slipped the 300-lb. 36-Inch right and left flanges on it, slide it onto the left box, removed the jackboard, slid the shaft so that the crank hung no closer than three inches to the main sill's center line; set-screwed one collar inside the right box, the other outside the left box; set the right flange 3 feet left of the main sill's center line, the left flange 8 inches farther left, and keyed them; closed,, capped, and eyebolted the boxes onto the posts; and fitted and bolted wooden cants between the flanges into a wheel 10 feet in diameter, " perfect circle," its face "carefully finished," flat, 10 inches wide (2 inches over the left flange). On its left side they then fitted cants into a tug wheel 7 feet in diameter, another "perfect" circle, bolted concentrically to the big wheel, its rim a 2-1/2-inch groove. Onto the left end of the shaft they slipped a 400-lb. 48-Inch iron tug wheel, and keyed it. And on the right side, at the crank, they slipped a 30-lb. 15-Inch-long wrist pin into one of the five wrist holes, and put on the rear nut.

Next they did the bull-wheel posts. They cut two 10"x12"'s from 12 to 11 feet long, halved them at the bottoms 8 inches up from the long bottom. They set them in the derrick's back, the short bottoms on the back floor sill, the long bottoms behind overlapping the sill, the tenons against the first girt, the right-side post not quite 2 feet left of the right rear corner, the other one about 4 feet right of the left rear corner. On short 2"x12"'s nailed outside and doubled on the girt beside and between the posts they spiked a 20-foot "x12" across the back to cover the tenons. Then they made the bull wheels. Off a 16"x16" timber 22 feet long they cut 9 feet; cut the 13-foot length to an octagonal shaft 16 inches in diameter; quartered it lengthwise; grooved beds in the eight interior faces for four 20-inch-long bowl-gudgeon bolts in either end; rejoined the quarters with the bolts buried head and body except for the ends where the nuts would go; put the clamps on both ends; put the iron bowl 16 inches in diameter with a gudgeon 4-1/2 inches in diameter protruding 6 inches on either end; screwed the nuts tight on the bolts; mounted the shaft in the posts; adjusted the posts and shaft exactly for level and so that the wheel on the left would be in line with the band wheel's wooden tug; bolted the posts at the top to the girt and at the bottom to the floor sill; braced the left-side post forward down into the floor sill across the back of the cellar; and fitted and bolted arms and cants into the left-side wheel, 7-1/2 feet in diameter, its rim a 2-1/2-inch groove,, and about 11 feet to the right a wheel also 7-1/2 feet in diameter, its rim flat, 9 inches wide, both wheels with 16 right-side handles.

In front of the derrick then they started on the rig's levering mechanism. For the fulcrum's base they cut into the main sill where it crossed over the first mud sill a 6-inch deep mortice and a bed for a 2-1/2"x4'6"x20" key. Through the mortice they bolted the main sill to the mud sill. And beside the main sill right they cut into the mud sill a bed for another such key. They framed the fulcrum, the samson post, a 16"x16" timber 14 feet long, a dovetail in the bottom back, two pairs of holes bored from side to side through its top. And with the rope still on the gin pole, one end tied through the post's top (lying forward), the other end tied under and around the bull wheels' shaft, they turned the wheels by hand, pulled the 750-lb. Timber upright into the mortice, and drove the keys to center it exactly on the main sill's center line and hold the joint solid. From near the top down into the main sill they braced it front and back with 4"x6"'s, with a chicken ladder up the front brace, and at 10 feet they fixed 2"x10" side braces back left and right into the derrick's front legs. On top of the post, through its holes, they bolted the center irons. For a block under the lever in back they cut another 6-inch mortice into the main sill three feet inside the derrick (over the nose sill), framed the headache post, a 6"x6" also 14 feet long and dovetailed, stood it in its mortice, keyed it, at 11 feet fixed a brace forward into the samson post, and at 5 feet doublebraced it forward on the samson post's back brace. By the gin-pole rope and the bull wheels they pulled back to the right front of the derrick the lever, the misnamed walking beam, a 26-foot-long timber 12"x24" at its middle, its bottom side beveled up to 12"x12" at its ends, weighing over a ton. They framed it, boring two pairs of holes down through it 24" middle and another pair about 15 inches from the front end, cutting a 3-inch wide slot 8 inches deep through the back end and a 2-inch groove across the top 6 inches from either end. Then they mounted it on its fulcrum. With the gin-pole rope retied from inside the derrick around the beam's middle, other ropes on both ends to control the swing, they turned the bull wheels and pulled the beam halfway into the derrick, dropped a bolt in one of the middle holes, hoisted the beam about 15 feet high, holding its front end down and forward, pulled its back end down to level it, and pulled it forward and lowered it level, slowly, and exactly so that its bottom's middle came down on the samson post, the bolt in its hole in the saddle, the beam's length in line with the main sill's center line, the front groove straight above the crankshaft's dead-centered wristpin, the back groove straight below the front of the crown pulley. They bolted and clamped the beam on the saddle, and tilted it back to rest on the headache post.

To finish the “front” jack post, they braced it back down into the samson post. To connect the waling beam to power, they framed, bored, and bolted together the piman, 5”x5” at the top, 5”x12” at the bottom, 12 feet long, bolted the iron stirrup on top, hung the stirrup in the groove across the beam’s front end, and bolted the adjuster board over it. As they had done the bull-wheel posts in back, they framed and set the calf-wheel posts in the derrick’s front, two 10”x12”x11’’s, one about 7 feet left of the right front corner,, the other about 3 feet right of the left front corner. And as they had made the bull wheels, they made a 9-foot octagonal shaft 16 inches in diameter with 6-inch gudgeons on the ends, mounted it in the posts, bolted them to the front gift and floor sill, braced the one on the left down forward into the second mud sill, and built arms, cants, and braces into the calf wheel, also 7-1/2 feet in diameter, but double-rimmed with the two rims bolted together, the left one a 2-1/2-inch groove in line with the band wheel’s iron tug, the right one flat and 6 inches wide.

Most carefully they made the setting for the sand reel. They cut mortices into the tail sill and the subsill where they crossed over the front mud sill, and bolted them to it. They framed the tail post, a 12”x12” about 4-1/2 feet high, at the middle of its inner side bored a 6-inch hole, dovetailed the post into the mortice in the tail sill, keyed it, and double-braced it in front on the sill. They framed and bored the knuckle post, a 16”x16” about 4-1/2 feet high, dovetailed it into the mortice in the subsill, keyed it, and bolted it to the sill. They framed and bored the sand-reel lever, like the piman 5”x5” at the top, 5”x12” at the bottom, 12 feet long, and set it on a low pivot in the knuckle post’s notch. Between the hole in the tail post and a matching hole in the lever they mounted an 8-foot-long iron shaft, with the sand reel just inside the tail post and a 32-inch friction pulley just inside the knuckle post, so that when levered back the pulley’s face, flat and 10 inches wide, would bear under and exactly against the band wheel’s face. And in front of the pulley they made more 12”x12”’s and 6”x6”’s into a back brake, so that when levered forward the pulley would bear exactly into its concave. The brake and its support they bolted at bottom across the tail and knuckle posts and at top left and right back to the jack-post boxes.

Then they laid a foundation for the engine. In line with the mail sill about 18 feet forward from its front end they set a 12”x12” engine mud sill 12 feet long, parallel and even four feet to the left another mud sill, in gains across them two 12”x12” pony sills 8 feet long, and in gains across them, its left side just right of line with the right side of the band wheel, the engine block, a 24”x24” timber 8 feet long. They keyed the joints, and joined a 6”x6” bunting post from the back of the engine block 20 feet back to the front of the front mud sill.

There remained the easy details. The builder spiked three 2"x12"'s on top of the front floor sill, and on a 6-inch slope from front down to back laid the derrick's floor, 2"x12"'s 20 feet long, cut for posts, the left bull wheel's brace, and between the fourth and fifth floor sills forward, centered under the walking beam's slot, a 2-foot square trap door into the cellar, and about 3 feet left of that an 19-inch square and lidded hole. Under the floor below this hole they made a dump box and trough away downhill. They fixed a pivot and throw-off block just inside the front of the left bull wheel. They strapped one 29-foot -long iron brake band on the right bull wheel, another one the right rim of the calf wheel, stapled the bands to the floor, fixed brake blocks and levers, and to lock the brakes bolted into the floor under the levers 8-foot lengths of cable chain. They fastened a 25-foot drawbar, the sand-reel reach, from the top of the sand-reel lever back to the bottom of a lever pivoted in the floor just inside the calf wheel. The fixed a crane post, an 8"x8" 14 feet high, on the floor near the right corner. They erected guides from about 9 inches on either side of the center of the trap door straight up to 34 feet, cut an hinged the lower 10-foot ???, and hung them back out of the way. They extended the floor six feet to the right, and walled and roofed the extension, the forge house. In back they put a roof over the bull wheels. Over the engine block they built an engine house, floored it, and from it built a belt house back over the band wheel to the front of the derrick. From the derrick floor forward, about six feel; wide along the right side of the main sill, they laid a walkway out to the engine house. From under the walkway between the samson post and the tail post they laid perpendicular out to the right a couple of 20-foot timbers, about 16 feet apart, for a casing rack. About 120 yards west they built a stand for a fuel tank. And about 50 yards further west, down toward the river, they built a water tank. In late October, alignments and joints checked, this job done, their hands so cramped that they could not close them, all but the pusher loaded tools and themselves into a wagon and departed.

By then the teamsters from El Tumbadero had delivered the drilling machinery and equipment to the yards. And promptly an Águila drilling crew arrived. This was also four multiply skilled fellows, but the tool dressers. And with them came a gang of roustabouts, common laborers. From dawn to dusk, except for Sunday, October 31, and Monday, the Day of the Dead, when the roustabouts would not work, the pusher pushed crew and gang through almost a week of preparation. He concentrated his powers in the yards and on the roustabouts. Typically, the laborers "didn't know a drill bit from a tamale shuck," but under orders and directions they did move indicated things weighing hundreds of pounds to indicated places. The drillers and toolies meanwhile were mostly on their own, rigging up.

Methodically they first installed the fuel tank, fuel line, and boiler west of the derrick, and a steam pump about 140 yards farther west down by the river. They then mounted the engine in engine house, its 28-inch belt pulley in line with the band wheel, and there stored mechanic's tools and supplies in the ???cleaner an oil can, machine wrenches, a few files, a small vise and pipes- and thread-cutters, grease, cylinder and engine oil. They connected the water pipes from the riverside pump up to the water tank, from the tank to the engine's boiler-feed pump, and from the engine's feed-water heater to the boiler, and laid steam pipes from the boiler down to the riverside pump and back to the engine. And from between the engine's pump and its heater they connected a pipe through the belt house back to the headache post and there with a valve and hose into a barrel. Next they connected the transmission. They put a 10-inch belt on the engine's pulley and the bank wheel, tightened it, and clamped it. They attached a 12-inch "telegraph wheel" shoulder high on the headache post, and strung an endless cord forward from the wheel through the belt house for "telegraph line" to the engine's throttle. Likewise they hung forward from the headache post beneath the wheel a 3/8-inch pipe to the engine's reversing link. They passed the bull rope, 2-1/2-inch soft-laid manila, over the band wheel's wooden tug and in a cross back over the left bull wheel's rum, and the calf rope (of the same construction) over the band wheel's iron tug and straight back over the calf wheel's tug rim. In an arc about 3 feet right and back over the calf wheel's tug rim. In an arc about 3 feet right and back of the center of the trap door they bolted the jack circle to the floor. Right above the trap door, in the derrick fro a girt the right side they hung two foot poles, the short inner, with ?? on them that would reach down to the floor, the /// outer ends, outside the //, past the //of the forge house, with // on them down to the // and // to 230-lb //weights. In the forge house they installed a smithy, with slake tub, anvil, forge, and bellows. On the derrick-crane post in the right front corner they fixed a 10-foot crane with a 1-ton chain hoist and swivel wrench. Under the crane's farthest reach toward the center of the derrick they nailed a block on the floor for a "button." They hung the 3-foot-long 3000-lb temper screw from the groove across the slot in the walking beam's back end, attached two hay-fork pulleys to the beam's underside, one near the back, the other near the sampson post, and strung a rope from the screw's elevator through the pulleys to a counterweight. They attached three more such pulleys in their respective places, one from the second girt over the bull wheels, one from the first girt near the right front corner, and one to the right side of the headache post down near the floor. And they strung their ropes, the first's, with the slack hook on the inner end, from the trap door up to the pulley and down to a counterweight on the outer end over the bull wheels, the second's with the bod hook on one end, so that both ends would reach to the trap door, and the third's from a lever on the bellows, down to the floor, through the pulley, and forward out to lie by the crank.

By the next to last day of rigging up, roustabouts had rolled numerous barrels of water up from the river, emptied several into the water tank, and emptied several more, some 300 gallons, into the boiler, enough to fill it above the first gauge cock. They had also filled the fuel tank with fuel oil. The pusher saw that there were no water or fuel leaks, checked fittings, lines, pipes, and pumps, and ordered power. The toolies rechecked the boiler's safety valve, water gauge, and burner and the pumps' and engine's cylinders, valves, levers, and packing, lit a slow wood fir into he boiler's firebox, primed the pumps, oiled them and the engine, and greased the bearings of the shafts and gudgeons. In a few hours they had a little steam up, and turned on the burner. They adjusted the atomization until they could see in the box a nice yellow-white flame and over the stack a bluish smoke. Soon they had more steam, and started the boiler-feed pump. Soon they had much more steam, and started the riverside pump. Soon they had working pressure, 100 lbs., and slowly started the engine, in the instant bringing the band wheel, the bull wheels, and the calf wheel into very slow revolutions. In the engine house and at the telegraph wheel they learned the feel of the engine up to 150 rpm, its stops, and its reverse, particularly how often it stuck on dead center. (To restart it from dead center, a toolie would have to "kick it off," step down a flywheel spoke, and step aside nimbly enough not to lose his life in the wheel.) After about an hour one of them walked out to the boiler and blew it down. Meanwhile, the band wheel turning at times up to 35 rpm, with it at that speed the bull wheels at 32-2/3 rpm, the calf wheel at 18-2/3, the drillers checked the belt, bull and calf ropes, sand-reel friction, post joints and braces, throw-off, and brakes. Then they took due charge at the headache post, got the feel of the engine, and between them made the adjustments for tight drive and safe sudden stops. Sure of the rig's power and transmission, running the wheels at a fair speed, they threw off the ropes onto their respective shafts, braked and stopped the engine, had the toolies connect the walking beam's pitman to the crank's wristpin, restarted the engine, and most carefully tested the beam's balance and strokes at the pin's different positions. Satisfied, they stopped the engine, and the toolies disconnected the pitman and tilted the beam down in front, up in back, the temper-screw hanging forward away from over the trap door.

As the pusher directed, roustabout rolled the cable onto the floor. While the drillers checked for wear and brittleness, the toolies climbed the ladder to the crown block and gin pole. Then altogether, drillers and roustabouts below, toolies above, they wound one cable after another on. For the spudding rope, a coil of hemp cable some 250 feet long, they hitched one end under and around the bull wheels' shaft toward its right side, pulled the other end by the gin pole up to the crown block, carried it forward over the crown pulley, pulled it down to the floor, and laid it forward out of the way. For the sand line, a 1400-lb. Spool of 1/2-inch steel-wire rope 3,500 feet long, they put a spindle through the spool, set the spindle on blocks so that the spool would turn, pulled the line's outside end up to the crown block, carried it forward over the sand pulley, pulled it down forward to the sand reel, hitched it over and around the reel, shifted the reel's friction wheel against the band wheel, gave the engine a little steam, and watched and guided the line as it respooled evenly onto the reel, until the last 160 feet; having stopped the engine, they clipped the line's loose end on the bail of a 500-lb. 9-Inch x 19-foot dart-bottom bailer; and this, having lifted it upright by power on the lien, they stood off to the left out of the way. For the casing line, a 750-lb. Spool of 11/3-inch steel-wire rope 600 feet long, they likewise pulled the outside end up to the crown block, carried it forward over the front casing pulley on the left side, pulled it down to the floor, hitched it under and around the calf-wheel shaft, dogged the calf rope onto the calf-wheel tug rim, gave the engine a little steam again, and watched and guided the line as it respooled smoothly and solidly on the shaft, until the last 80 feet; having thrown off the calf rope, braked the wheel, and stopped the engine, they pulled up and temporarily hung a few feet under the crown block a 1,050-lb. 28-Inch three-sheave casing pulley block, threaded the line's loose end through the three other casing pulleys and the three sheaves, and hitched the deadline to the block's upper becket; in the lower becket they C-strapped a 240-lb. 4-1/2-inch double-swivel casing hook. Finally, drillers and toolies (back down on the floor) fastened the wristpin in the crank's fifth (outside) hole, slipped a spudding ring on it, and from the ring strung a jerk line to a spudding shoe on the spudding rope about 6 feet above the bull wheels' shaft.

By then the pusher had divided the crew into two "opposing" pairs. Usually thenceforth one driller and one toolie would work the "graveyard" or "morning tour" ("tower," they called it), from midnight to noon; the other pair, the "gravy" or "afternoon tour," from noon to midnight. Each pair would have its roustabouts. Shift after shift the drilling would ordinarily go around the clock (except from midnight Saturdays to midnight Sundays), until an accident stopped it, or the pusher declared a dry hole, or a driller struck oil.

But one preliminary operation by the full crew remained, "sinking the conductor." Already, as rigging up had ended, the pusher had had the roustabouts grunt from the yards to the casing rack the supplies for driving pipe: an 18" x 12' wooden maul, weighing about 700 lbs.; two 20-foot lengths of 16-inch, lap-welded, wrought-iron, collared, casing pipe, each about 1,050 lbs.; a 16-inch drive head and a 16-inch casing shoe; "Maude," the so called No. 16 chain tongs, 75 lbs.; a pipe grip, rope sling, and pole; a pair of 16-inch elevators, "the greatest breaker and crusher of fingers ever used," each about 400 lbs.; a "calfhead," or 16-lb. sledge hammer; and a "stabbing board," a 2"x12" 24 feet long.

At dawn on November 4 the pusher was on the floor to supervise the drive. Steam at working pressure in the boiler, a toolie oiling the engine, warming its cylinder, roustabouts grunted the maul onto a dolly on the walkway, and rolled it back to the right front corner. Together drillers and toolies opened the trap door into the cellar, hitched the spudding rope on the maul's staple, turned the bull wheels, and hoisted the maul up between the guide's upper sections; a driller put on the brake. They let the guide's lower sections down, released the brake to let the maul down slowly to floor level, on down between the floor sills, saw that it would fall true, rehoisted it high, braked the wheels again, and hung the lower guides back up. Meanwhile roustabouts dollied one of the pipes to the right front corner, collar end back, and in about 25 turns at either end unscrewed its thread protector and its collar, this accessory 17-1/4 inches in diameter, 6-1/8 inches long, 56 lbs. Drillers and toolies lowered the casing pulley block and hook, brushed and doped the pipe's threads at both ends, by hand screwed the shoe on the front end and the head on the back, with Maude counterclockwise around the shoe as back-up and the grip, sling, and pole clockwise on the pipe to lead bucked up the front a 26th turn and tight, with Maude countered around the head bucked up the back connection a 26th turn and tight, took off the tongs, pole, sling, and grip, latched ("like a horse collar") one of the elevators below the head, raised the elevator's 4-foot-long links, put the casing hook on them, turned the calf wheel to lift the pipe vertically over the hole in the floor, let the pipe down slowly between the floor sills into the cellar floor, plumbed it for exactly vertical, let the guides' lower sections down again, fastened them, unlatched the elevator, and let it down to the right front corner. They let the maul down slowly onto the head. A driller put on the brake. At his signal the other driller gradually wheeled the engine's throttle wide open. Gradually up to 35 times a minute in 3-foot strokes the maul banged on the head, driving the pipe down inch by inch as the driller at the brake jacked it off. Every foot or two down the drillers stopped the motion, and plumbed the pipe again for vertical. In several minutes the head was down almost to floor level. The driller at the engine stopped it. Drillers and toolies together turned the bull wheels, hoisting the maul high again; a driller put on the brake. They raised the lower guides. One of them lightly uphanded the head with the calfhead. The other three put the tongs again counterclockwise around the head, by grunting, pushing, and tugging the tongs' handle broke the head loose, took off the tongs, unscrewed the head, set it aside, rescrewed the collar on the pipe, and with the tongs clockwise on the collar bucked it up, the fellow with the calfhead bumped the handle around another half a turn. While some roustabouts dollied back the second pipe and unscrewed its protector and collar, others put the stabbing board up across the second tier of girts,, and one of the toolies climbed onto it. Below, the drillers and the other toolie brushed and doped the second pipe's threads, screwed the head on top, with the tongs, grip, sling, and pole bucked it up, latched the elevator under it, put the hook on the links, turned the calf wheel, hoisted the pipe over the hole, and let it delicately down, the toolie above "stabbing" it, aligning it for the free end to "drop" nicely into the first pipe's collar. They screwed the pipe around a few turns by hand, put the grip, sling, and pole on it, took equidistant positions around it, and passed the pole clockwise from fellow to fellow for some 20 more turns. The toolie above unlatched the elevator, climbed back down, and tapped the calfhead on the collar a few times, and the other fellows bucked the connection up. While roustabouts took down the stabbing board and took off the elevator, drillers and toolies together let the lower guides back down and refastened them. And the drillers restarted the driving. Shortly they had the head almost to floor level again, then almost down to the cellar floor. They stopped. The crew took down the guides, hoisted the maul onto the floor, undid the rope from it, and in the cellar took off the pipe's head and replaced its collar. The afternoon men left. The morning toolie went out and blew down the boiler. The roustabouts grunted the loose timbers away.

It was time to commence drilling, "spudding in." The pusher brought the "knowledge box," with the logbook inside, and stowed it in front of the headache post. The driller brought the "knowledge stick," 5-ft. measure, and the "knowledge bench," a three-stepped stool, and stood them in back of the post. At the crank the toolie moved the wristpin and the spudding ring to the third hole. A roustabout grunted up to the floor a steel rope socket, about 3 feet long, 80 lbs. Several roustabouts grunted up in the "specs" (a bit-holder) 6 ft-long 1,000-lb. 13" steel bit (actually 14-1/2" wide at its cutting end), laid it on the floor under the derrick crane, and shortly grunted up another, for the set of two. Others grunted up two 350-lb. tool wrenches. The driller and toolie tied to them the loose ends of the ropes hanging from the poles high above, pulling the counterweights into the air. Then they fixed the loose end of the spudding rope in the socket's woodpecker hole, put the swivel wrench square on one of the bits, stood it upright on the button, brushed clean and doped the socket's tapered box and the bit's tapered pin, screwed the socket onto the bit, by the crane moved the bit from the button to over the open hole in the floor, turned the bull wheels forward to tighten the rope, took off the swivel wrench, pulled the crane and wrench aside, and let the bit slowly down into the conductor, so that the joint of the socket and the bit was just above the floor. The driller braked. The toolie lifted and fixed the tool wrenches in the wrench circle, the left-hand wrench below, on the bit's square, the right-hand wrench above, on the socket's, put the wrench bar into the jack, levered the right-hand wrench around about a third of a turn, setting the joint up, took off the wrenches, and laid them aside. The driller released the brake, let the bit just touch bottom, chained the brake down, and tied a twister shoulder-high on the rope. The toolie turned the crank straight up, and pulled spudding shoe down to pull the bit up a few inches. The driller started the engine. Suddenly the crank jerked the rope and released it, rhythmically soon, as the driller wheeled the throttle wide open, lifting and dropping the bit to pound 35 times a minute in 2-ft strokes into the clay below. Above, the rope slapped 30-35 times a minute against the panel braces. From the crown block down the derrick trembled and squeaked. With one hand on the rope as the bit hit and lifted, the driller felt the strength of its impact and the nature of the ground it opened. Walking round and round the hole, one way, then the other, he turned the bobby twister to revolve the bit so that it made a round role. In about an hour, oblivious to the slapping and squeaking above, he began to feel the bottom of the hole fading, and released the brake just enough to keep the rope taut and the bit pounding with full force. The toolie ran out and blew down the boiler.

At noon as ordered the tours changed. The morning driller entered the first notes in the log, recording "surface clay" seven feet down (a foot below the cellar floor), and he and the morning toolie left. The afternoon men took over. And hour after hour these two continued spudding, the driller constantly on the floor, mostly at the rope, twisting it, feeling the rhythms of its tension and release and the bit's jarring, the toolie most of the time beside him, watching, but every hour or two running out to check the fuel, water, and steam and blow down the boiler.

As the November afternoon waned, the driller began hearing from the engine and feeling through the rope that the bit was sticking in the cuttings. The hole was about 9 feet down. It was time to bail. The driller stopped engine. The silence was vast. Together the two men turned the bull wheels forward to hoist the tools just above the floor, braked the wheels, put the tool hook on the tools, pulled them into the right front corner, stood them on the floor, and hitched them to the derrick leg. The toolie took the spudding ring off the wristpin and the lid off the damp hole. The driller hosed water into the conductor until he figured he had the cuttings slushy. Then he pulled the sand-reel reach's lever back, started the engine again, watched the sand line hoist the bailer into the air, pushed the lever forward to brake the lift, watched the toolie steady the bailer over the conductor, pulled the lever nearly upright, let the bailer down to bottom, shifted the lever back and forth to churn the bailer in the hole, pulled the lever back again, watched the bailer come dripping up, braked it, and stopped the engine. The toolie pulled the bailer left over the dump hole, and the driller let it down to empty the slush into the box and out the trough below. The toolie caught some of the mud in a bucket. The driller looked at it, felt it between his fingers, and the toolie dumped it. They ran the bailer down the conductor again, churned it, and dumped it. The hole cleaned out, they hosed off the bailer, replaced the lid on the dump hole, swung the bailer over to the left, and set it down.

Free to drill ahead, they put the spudding ring back on the wristpin, hooked the tools, ran them down the conductor to bottom, raised them a little, ______for a marker on the rope 5 feet above the floor, retied the twister shoulder-high, started the engine, and despite the renewed slapping and squeaking reset their sense to spudding. At dark the toolie hung and lit yellow-dog lamps, and by the light of "smoking, sickly yellow flame" the driller and he bailed again and retied the twister before the end of their tour. The driller noted "surface clay" to 12 feet for the second entry in the log. And so the morning driller and toolie continued, spudding a few feet, taking off the marker when it moved down to floor level, tying a second one 5 feet high, bailing, moving the twister, spudding a few more feet, bailing again.

Early on the second afternoon the bit hit something rebellious. By the marker it was 19 feet down. Drawing the tools out of the hole, the driller examined the cutting end and saw a black concrete of chapopote and gravel. This was worrisome" he could not drill or bail tar. He saved some asphaltic pebble for a sample, to put later in the engine house. Luckily, spudding only went slower. At the next bailing, late that night, the driller saw no black ooze in the slush bucket. He filled a bottle with the mud for more of a sample. Coming off his tour he noted "gravel" in the log.

As the morning driller found, the hard rock proved to be only 4 feet thick. Below it the bit went down easy, into a formation he would later log s "clay and shales." But when he and the toolie pulled the tools for the next bailing and checked the bit, they saw (as they expected) the cutting end worn out of gauge and scored. Unluckily they had the first dressing to do. After bailing, they lowered the joint just above the floor, braked it, put the wrenches on it backwards (left-hand above, right-hand below), broke it, took the wrenches off, drew the tools all out, put the swivel wrench on the bit, stood it on the button, unscrewed the socket, swung the worn bit aside to the forger, took the wrench off it, put it on the fresh bit, stood this tool on the button, screwed the socket on it, let it into the hole, and set the joint up with the tool wrenches. While the driller ran the tools down the hole, the toolie hitched to the wristpin the cored that led back to the bellows. The driller restarted the engine, and drilled ahead. But while he reconcentrated on the rope, he kept an eye on the toolie firing up the forge, cleaning the bit, examine it for cracks, by the crane and swivel wrench hoisting the 1,000-lb. Thing flat onto the forge's apron, waiting for it to reach a blue heat, removing it for the cutting end to go flat 4 or 5 inches into the fire, heating it there slowly up to red, by the swivel turning it over and heating it on the other side slowly up to red, likewise heating first one side and then the other up to cherry red, removing the thing flat onto the anvil, stoving it with the 16-lb. sledge "in rapid successive blows" from the center out to the wearing edges, driving down hardest the water channel, but lightly the edges and corners, turning it over and likewise stoving and driving down the other side, turning it on one edge, then the other, driving down the wearing edges and corners, slapping the gauge on it, seeing that the width was back to gauge and that the cutting edge was straight, turning it flat again on one side, then the other, reshaping the wearing edges and corners, resharpening the cutting edge's faces to a good angle (about 145°), trimming fringes, refinishing with a small hammer the wearing edges, corners, and faces, regadging the width and rechecking the cutting edge for straight, removing the thing into the fire, reheating it as before slowly and evenly to dark red, quenching it in the slake tub, unhitching the cord to the bellows to kill the fire, and cleaning the forge.

That afternoon the driller and toolie had it easier spudding in "clay and shales." They bailed for the last time that week near midnight, then, it being Saturday, capped the conductor. The driller logged his tour. The toolie shut down the engine and the boiler, hosed off the floor, and snuffed the yellow dogs. Together they quit for Sunday.

Drilling again on Monday and Tuesday as before, spudding, the crew by daylight Wednesday morning had deepened the hole to 60 feet. This was enough, as the pusher ordered, to string the drilling cable, hitch on a string of tools, and drill off the walking beam. Roustabouts refilled the fuel tank. The driller and toolie bailed, then hoisted the tools back over the hole, unscrewed the socket from the bit, stood the bit aside, cut the spudding rope out of the socket, laid it aside, and took off the jerk line, which a roustabout took away. Other roustabouts rolled onto the walkway and floor 2-1/2 standard coils of prespliced drilling cable, i.e., 2,00 feet of 2-1/2-inch manila hawser, water-soaked (to prevent kinking), weighing altogether a good 3 tons. And they dollied back a third steel drilling tool, the stem, 32 feet long, 2,120 lbs. The driller rechecked the bank wheel and crank, their alignment, and the brake. The toolie rechecked the water tank and the boiler, oiled the pumps and the engine, and regreased bearings, then tied the spudding rope's loose end to the free end in the center of the first coil of cable, and dogged the bull rope onto the left bull wheel's rim. The driller started the engine, watched the cable to up, back over the crown pulley, down under and around the bull wheels' shaft, and braked the bull wheels. At once the toolie stopped the engine, then undid the spudding rope for a roustabout to grunt away, and restarted the engine, slow. At once the driller released the brake. And together he and the toolie watched and guided the cable as it spooled smoothly and solidly in wraps and layers onto the shaft. The last 150-odd feet, having stopped the engine, they left hanging up forward over the crown pulley and down to the floor. The end there they fixed solidly in the socket. Under the crane, by the forge they recleaned and doped the socket's box, put the swivel wrench on the stem's square, hoisted it waist-high, cleaned and doped the stem's pin, screwed the socket on the stem, turned the bull wheels to take up the slack in the cable, set the brake, and took off the wrench. The toolie started the engine, slow. The driller released the brake. And slowly, guided by the toolie, the socket and stem swung up in the derrick over the hole. The driller threw the bull rope off onto the cable on shaft and braked. The toolie stopped the engine, put the swivel wrench on the bit, moved it under the stem, over the hole, recleaned and doped the bit's pin, and cleaned and doped the stem's box. The driller let the upper tools down gently to the bit, moved the wrench away, and left a string of tools about 40 feet long, 3,200 lbs., hanging from the crown pulley. He fixed the tool wrenches in the wrench circle, and as the driller let the string down gently, each joint just above the floor, made each joint up. The toolie then dogged the bull rope on, and started the engine, very slow, and the driller released the brake At the instant the cutting edge of the bit came up even with the floor, the driller threw off the bull rope and braked, the toolie stopped the engine. The driller set the brake, and where the cable came off the bull-wheel shaft 5 feet up from the floor he tied another marker the derrick string. Then between the cable and the brake he let the string of tools down the hole in jerks, springing the cable, until he felt the bit just hit bottom on a full stretch; in the rebound he braked. He reset the brake.

The derrick string was up just below the eight girt. At the bank wheel the toolie pushed the beam's front end up, moving the temper screw back down by the cable, turned the crank straight up, and attached the pitman to the wristpin (still in the third hole). The driller stood the knowledge bench between the headache post and the cable, climbed the stool, rubbed forge dust on the cable where the temper screw's clamps would grip, wrapped the cable there with a soft dry twine, put the clamps on the cable, screwed them tight, and just below them retied the twister. He released the brake. From the walking beam then hung the 3,200-lb. String of tools. The toolie pulled 20-30 feet of slack from the relieved crown pulley onto the floor, put the slack-hook roped around and hooked it, out of the way to the left side.

The driller started the engine. The crank drew the front end of the walking beam down two feet, raising the back end with the tools two feet, then raised the front end two feet so that the tools dropped and the bit hit bottom, and so on, the beam see-sawing up and down, the bit pounding into the bottom, clank-CLUNK. Gradually the driller wheeled the throttle open for about 25 2-foot strokes and clank-CLUNK's a minute, listened to the engine faintly slow on the upstroke, faintly race on the downstroke, and "talked to the rope," felt the cable under the screw for "motion" and the jar of the bit on the bottom. The rhythm of tension and release was steady, the jar solid; the bit was making hole. Twister in hand, the driller slowly circled the hole, turning the drilling cable round and round, one way, then the other, rotating back and forth the bit's line of perforation on the bottom. In about 10 minutes he felt from the cable's lift that the jar was working off, the bottom fading. Up on the stool with the "knockstick," he waited for the right upstroke, whacked the temper screw's yoke to loosen it, on the next upstroke gave the screw's crossbar a few spins, and on the next whacked the yoke back to tighten it. So after more circling some 10 minutes later he let out the screw a few more inches, and so periodically again and again, turning the rope, keeping a tight hitch on the tools, but feeding them deeper for the same rhythmic force to continue cutting.

In two hours he had deepened the hole three feet, with another three on the screw to go. But talking to the rope, he felt it was time to bail. Unlike in spudding, this meant first unhitching the tools. The driller slowed the engine, felt the tools begin to pegleg on the bottom, took off the twister, watched the cable below the screw unwind. The toolie let down the cable slack, untwisted it, and stepped to the telegraph wheel. The driller dogged the bull rope on and stepped to the brake. For about 20 seconds walking beam and bull wheels were both in motion. At the instant the last slack flew up and went taut, the toolie stopped the engine and the driller braked. The driller set the brake, then undid the screw's clamps, the string's load passing to the crown pulley. At the bank wheel the toolie removed the pitman from the wristpin and lowered the walking beam's front end, lifting the temper screw forward out of the way. Back on the floor he started the engine, pulled the string until the bit emerged from the hole. At once the driller threw off the bull rope and braked, and the toolie stopped the engine. The brake set, they checked the bit, saw it did not want dressing, and hooked the string into the right front corner. Then they ran water and bailed. The hole cleaned out and the bailer stood aside to the left, they ran the tools back in the hole, raised the beam's front end, reconnected the pitman to the crank, hitched the screw's clamps back tight on the cable's wrapper, retied the twister, started the engine, clank-CLLUNK, clank-CLUNK, and drilled ahead.

Two hours later, the hole another three feet deeper, the afternoon driller ran the screw's last threads out down near the floor. When shortly the jar worked off, he and the toolie as before unhitched the tools, disconnected the pitman, pulled out, and bailed again. Then as before they ran the tools back in the hole (until the old wrapper came down near the floor), and reconnected the pitman. But to "hitch over," reset the screw to the top for a new grip on the cable, the driller loosened the yoke, shoved (thanks to its counter-weight) the screw back up in the reins, and yoked it tight again. Then at the clamps' height he put another wrapper on the cable, hitched on, and drilled ahead.

So by around nine that night the driller and toolie had run two more screws and deepened the hole to 78 feet. Toward the end of the last screw the drilling had gone rough. On every revolution of the engine the driller felt the tools definitely sticking before lifting, and the motion on the downstroke was jerking in a false jar before the real one, which was moreover too heavy. He opened the throttle wider, turned the cable tighter. When he and the toolie pulled the string to bail, they found as they expected the pit loaded up with mud. Bailing, they had thicker slush than the last cuttings could have made. Evidently, since below the conductor the hole stood open, underground water was infiltrating, and the "clay and shale" walls caving down. They hung the tools on a wrench, did the log, put sample in the he engine house, and left to rest for special duty in the morning.

At daylight the pusher ordered the first string of casing run. The morning men hooked the tools into the corner and bailed again. The toolie checked the water tank and the boiler and oiled the engine. The afternoon men came to make the necessary full crew. From the casing rack two roustabouts rolled four 18- to 20-foot joints of 13-inch casing pipe onto the walkway, each (lap-welded wrought iron like the conductor) about 700 lbs. Others grunted up to the floor a 13-inch shoe, a set of two 13-inch, 375-lb. elevators, a pair of supporting blocks, a set of two 5-1/2-foot long, 380-lb. Drilling jars, and in the specs one and then another 10-inch (actually about 11-1/2-inches at the cutting edge), 750-lb. bit. They also helped put the stabbing board back up on the second girts. On the walkway the pusher checked the pipe and collars, measured lengths and diameters, logged the measurements. The two roustabouts there dollied the first joint back onto the floor. The drillers and toolies took off its protector, brushed and doped both ends, screwed the shoe on the free end, bucked it up, latched an elevator under the collar, raised the elevator's links, put the casing hook on them, and dogged the calf rope onto its rim. The pusher watching closely, one driller at the telegraph wheel, the other at the calf-wheel brake, one toolie up on the stabbing board, the other with a roustabout at the hole setting the blocks, the crew then got the pipe up, still, down into the conductor's mouth, and down until the elevator rested on the blocks on the floor; the toolie there laid down the links. Likewise the second pipe, the other elevator latched under its collar, they raised, freed from its protector, brushed, doped, and lowered into the first's collar. The toolie and the roustabouts on the floor screwed a few threads by hand, put Maude with one of the drillers for a third on the collar and the grip, sling, and pole on the pipe, with one of the drillers for a third took positions around it, and screwed the joint home, 20 turns. The other driller tapping the collar with the sledge as they bucked it up___. Tongs, pole, sling, and grip aside, the toolie and the roustabout took off the first elevator, and the driller again at the brake lowered the string until the second elevator rested on the blocks. In the same way the crew and the roustabout added the third and fourth lengths. The driller at the brake lowered the string. The toolie above climbed down. When the elevator on the fourth joint's collar was just above the blocks, the first's shoe landed, cutting into a tight seat on the bottom, and the casing line went slack. The toolies took off the elevator.

As the pusher ordered, the crew then pulled the conductor. While roustabouts took down the stabbing board, the toolies crawled into the cellar with a 16-inch elevator, latched it under the conductor's collar, raised the links, ran a wire-rope loop through them, and hung it on the casing hook over the 13-inch string's mouth. The engine going again, at half speed pulling the load about 12 feet a minute, up came over 20 clay-caked feet of pipe. At once the driller at the telegraph wheel stopped the engine, and the other braked. The toolies with hose and hammer found the second collar and under it latched the other 16-inch elevator. The driller at the brake let the load down on the blocks. While he held the brake tight there, the other driller put the slightest stretch on the line. The toolies broke the coupling with tongs, grip, sling, and pole, and unscrewed the upper joint. Together drillers and toolies raised it a few inches, pulled it rightward, screwed its protector back on, and lowered the length onto the floor. Likewise they removed the other joint. The afternoon men left. Roustabouts rolled the loose pipe back to the yards.

On the floor the morning men took the 13-inch bit off the stem and the stem off the socket, remade the string with the socket on the jars (a precaution against stickier clay), the jars on the stem, and the stem on a 10-inch bit, and hooked the 3,300-lb. String aside. Then they bailed the cased hole clean, capped it, and left. Roustabouts grunted away the big bits and elevators.

That evening the pusher stood with the afternoon men as they uncapped the hole, ran the bailer, and reeled it up dry: the casing was tight, the hole ready to pound. By yellow-dog light driller and toolie ran the tools, reconnected the pitman, hitched on, and to the again pounding rhythm of clank-CLUNK, clank-CLUNK, drilled a screw and more by the end of their tour, duly logged and sampled. So the morning men continued, drilling, bailing, hitching over for three more screws by the end of their tour, another note in the log, another sample. The work was becoming routine.

Friday night the driller suddenly felt that the bit was going into a new formation, easier to cut. As at the next unhitching he figured from the derrick strong down near the third girt and the last two feet of screw drilled more easily, as in bailing he saw in the slush, and as he later logged the sample, at 115 feet he had drilled into "blue and white marls and shales." At the next bailing the morning men took off the jars. For as deep as this formation went, it promised no more worry about sticking the tools, bailing but about every six feet, every hitch-over, and faster drilling.

By late Saturday morning the derrick string was moving down even with the floor. The driller and toolie then pulled the tools anyway to bail and hitch over again. But it was also time to "string over,' measure the "distance over" that the derrick string had gone from its starting point up over the crown pulley and down to the floor. After bailing, the toolie moved the string of tools over the hole, and the driller let it down until the cutting edge of the bit was at floor level. The toolie put the knowledge stick against the bit, flush with its bottom, and marked 5 feet at the stick's top. The driller slowly lowered the tools until the mark was at floor level. The toolie measured another 5 feet. So counting sticks they continued until the derrick string was to the floor again, about 29 sticks, a "distance over" of about 145 feet. The toolie took the string off. The driller kept it to save as a record with the samples, and 5 feet up from the floor in front of the bull wheels tied another one on the cable. Then the toolie reconnected the pitman, the driller hitched over and on, and they drilled ahead till noon.

Through Saturday afternoon and into the next week the clank-CLUNKing and the driller's routine became both monotonous and engrossing. On through the month and into December the only change in the hole was the hourly gain in its depth, the only drilling changes a few, small, gradual adjustments for the motion. The hole being 45-50 feet deeper every day, the longer cable stretched a little farther, and the bit hit the bottom a littler harder. Talking to the rope, turning it, talking to it again, the driller every tour let out the screw a little less often to cut as much hole as before. Every two or three days one or the other driller slowed the engine a few rpm., to keep the motion right. Eventually one had the toolie move the wristpin to the crank's fourth hole, then eventually to the fifth, to lengthen the stroke from 2 to 2-1/2 to 3 feet, and eventually slowed the engine to around 85 rpm. By 500 feet down, with the cable's stretch, this had the tools springing every three seconds five feet to pound the bit into the bottom, 1,200 nearly 15,000-foot-lb. Punches an hour, screwed down a few inches several times in the hour to keep the pounding clank-CLUNK solid, a regularity in force that would craze a weaker mind, but fed the driller's concentration. It took a little longer every time to pull the string, bail, and run the tools. But the ever increasing force and its continual application made a steadily deeper hole. Every third day, another 145 feet down, the morning driller took off another derrick string to save and tied another one on.

During these weeks the toolie's routines remained intermittent. Every tour about every three hours he took the wheel to take up the slack, disconnected the pitman, handled the bailer, bucketed someslush, reconnected the pitman. Every two or three hours between bailings he ran off to check the riverside pump, the water tank, and the boiler's water gauge, blow down the boiler, check the engine, and maybe grease a squeaky bearing in a post or the crown block. And every tour or two, because of the marl's grit and the wear on the bit, he fired up the forge and did a dressing. But as the weeks passed he accumulated many hours on the floor in study, despite the clank-CLUNK's concentrating like the driller on the motion, watching the details, learning.

Meanwhile at the pusher's command the roustabouts daily labored in monotonies of bother, such as wetting the cable on the bull-wheel shaft, and monotonies of exhaustion, such as rolling 10-inch casing pipe, each 20-foot length about 600 lbs., from the yards up to the casing rack, and racking it. Their only change was another exhaustion, weekly refilling the fuel tank.

Continuity ended on December 9. That morning a cave from somewhere along the hole's open walls between 78 feet and the bottom that the derrick string showed at about 1,200 feet so shook the cable that the driller and toolie quickly unhitched, disconnected, and pulled the tools. If the caving had broken the cable or buried the tools, the crew would have had a fishing job to retrieve them. The pusher ordered the 13-inch casing shortened and the 10-inch casing run--not to be set, since God only knew what lay below 1,200 feet, but to be carried deeper as the drilling deepened. Driller and toolie took off the 10-inch bit. And at the pusher's directions roustabouts grunted up to the floor the casing cutter, a piece of 2-inch tubing, a little tubing elevator, a mandrel, two 1-inch sucker rods, a 1-inch eye-box, a 10-inch shoe, and two 10-inch, 280-lb. elevators.

In a few minutes the driller and toolie had the casing line tight on an elevator on the 13-inch casing. They pulled the string of pipe about a foot, set blocks, let the load down on them, took off the hook, laid down the links, screwed the tube on the cutter, tight, put a little elevator on the tube, put the hook on the elevator, ran the tube about six feet down the casing (so that the cut would be just above the cellar floor), and set the brake. They took the sand line off the bailer, screwed a rod on the mandrel, screwed the rods together, screwed the eye-box on top, hitched the sand line on it, reeled up the rods and mandrel, lowered the mandrel past the hook and through the elevator, and ran it down the tube into the cutter (which forced the cutter's knives out against the casing's inner circumference). With grip, sling, and pole on the tube they turned it around and around. In about half an hour the turning went suddenly easy: the casing was cut. Grip, sling, and pole off, the driller and toolie pulled the rods and mandrel, laid them aside, took off the sand line, pulled the tube and cutter, stood them aside, took off the casing hook, raised the 13-inch elevator's links, put the hook on them, pulled the cut piece, laid it on the floor, hoisted the casing hook high out of the way, hitched the sand line back on the bailer, cleaned out the hole, and took off the boiler. Roustabouts took away the cut piece and all the no longer useful tools and equipment.

By then, mid-morning, the afternoon driller and toolie were on the floor too. The pusher directing, some roustabouts went to roll more 10-inch pipe up to the casing rack, two others dollied a joint from the walkway back to the floor, while another helped a toolie put the stabbing board up again. The pusher measured the pipe's length and diameters for the log. And under his close watch, as on the 13-inch casing four weeks before, the crew and three roustabouts proceeded with brush, dope, elevators, hook, engine, calf-wheel brake, tongs, grip, sling, pole, and dolly to make up the shoe on the joint, lower the shod end down through the floor, down the mouth of the casing in the cellar, rest the load on the blocks, bring the second joint onto the floor, add it to the first, lower them for a third, and so one, until they had run a string 60 lengths long, almost 13-1/2 tons of iron, hanging from the elevator (links down on the blocks) down to 1,183 feet. This took them until nearly dark.

In yellow-dog light the afternoon men stayed to drill ahead to the end of their tour. Roustabouts grunted up the indicated tools, two 8-inch, 550-lb. Bits (actually to cut about 9 inches wide), a 10-inch, 700-lb. underreamer to widen the bit's hole (to 11-1/2 inches) for the casing to follow down, and a 7"x19', 300-lb. bailer. Driller and toolie remade the socket up on the jars and the jars up on the stem, made the stem up on an 8-inch bit, ran the tools, reconnected the pitman, hitched one, and started clank-CLUNK pounding the bottom again. In about half an hour, to make sure they did not freeze the casing, they set up to "work the pipe." They unhitched, disconnected, pulled the tools, stood them in the corner, raised the elevator's links, lowered the casing hook, and hooked on to raise the string several feet and lower it back on the blocks, where it would stay presumably free while they drilled ahead another half hour.

But the driller was "somewhat unfortunate." When he and the toolie put the power to the calf wheel, the calf rope tugged, the casing line went out, the block and hook trembled, the elevator under the collar squeaked, but nothing of the almost 13-1/2 tons below budged. The driller throttled down, then socked more steam to the engine, to try to yank the string free. The derrick creaked and groaned, but still nothing below budged. The pusher returned to the floor. More yanks caused only more creaking and groaning. This was a bind. More powerful yanking might only pull the top off the string, or pull the derrick in. But on a wildcat no pusher or driller worth his salt would leave a heavy 10-inch string frozen that high without a battle. To reduce the hole there to 8 inches would distinctly increase the changes of running out of hole, after only one more reduction farther down having the hole too small under another cave to case yet again and deepen maybe into pay dirt--a shamefully shallow probe of the unknown. The pusher ordered a long pull on the string. The toolie ran to check fuel and water and blow down the boiler, ran back to stand ready at the calf wheel, to throw off the transmission and put on the brake if the driller cried "calf rope." The driller slowly increased the power on the line until he heard the groans in the derrick again, waited until they ceased, slowly increased the power again until he heard groans again, and so again, until he felt the derrick could bear no more. There he waited, watched, and listened as the tension gradually spread down the string. The rule was, pipe would stretch an inch every 100 feet. If the string did not come free, at least the inches eventually above the blocks might tell how far down it was frozen. But not only did the string not come free. In several hours, on through the night as the morning men maintained the pull, it stretched but a few inches, which told only how badly it was frozen.

Toward daylight the pusher ordered the pipe driven from the floor. The spring and vibration might loosen the cavings; an inch or two driven firmly down would promise that much and more up on a second long pull, enough then to begin working the string loose. Roustabouts grunted up a 10-inch drive cap, drive clamps, the jerk line, and the spudding shoe. The full crew reassembled, took off the casing hook and hoisted it high, took off the elevator, let the stretch go, screwed the cap into the collar, ran the tools nearly to the top of the stem, bolted the drive clamps on the stem's square, let the drive clamps down on the cap, restrung the jerkline from the wristpin to the spudding shoe on the drilling cable's slack, turned the bull wheels by hand to take up the slack, set the bull-wheel brake, marked the pipe even with the floor, and wheeled the throttle wide open. There was plenty of spring and vibration, but not an inch driven. More driving made no more difference. Mid-morning, to save the string's couplings and in hope that the vibration had helped, the pusher ordered another long pull. The afternoon driller and toolie left. Their opposites took off (?) roustabouts to grunt away the drive clamps, cap, jerk line, and spudding shoe, and pulled the tools. They hooked on and reapplied the tension to the string. They drew the stretch again, but still no movement. After several hours of frustration, the afternoon men getting no movement either, the pusher ordered them to drive the pipe with a jar-down spear. Roustabouts grunted up two subs, the long-stroke, 450-lb. fishing jars, and the spear. The driller and toolie took off the hook and elevator, took apart the drilling string, screwed the socket on the stem, the stem on the big-small sub, the sub on the jars, the jars on the small-big sub, and the sub on the spear, made up all the joints, ran the spear to where the derrick string showed about 1,173 feet, tripped its slips to take hold, felt where the jars hit going down, tied a "flag" (for a marker) on the cable even with the top of the casing, moved the wristpin to the crank's second hole, reconnected the piman, unhitched the temper screw (partly run out onto the cable, rocked the engine and adjusted the screw to see that just when the jar from below hit the cable the flag reached the end of the downstroke, and started a slow motion. Talking to the rope, the driller felt the rhythmic slamming on the spear in the pipe so far below. But the casing did not move. In a few minutes, to avoid bulging the pipe where the spear held, the driller and toolie changed holds, running up the screw so that the jars hit on the upstroke (which retracted the spear's slips), unhitching, disconnecting, pulling the tools 20 feet higher, tying another flag, reconnecting, hitching on again, and jarring down from that depth. So they passed the evening, changing holds and jarring down from higher and higher, making continual motion, but still getting no movement.

That night the pusher ordered jarring up. This required first finding “the friction,” the place (assuming only one) where the string was frozen, in order to start the jarring there. Accordingly the driller and toolie unhitched, disconnected, moved the wristpin back out to the fifth hole, reconnected, hitched on, and went to the end of their tour jarring down but once and then changing holds every few feet higher, watching the pipe, listening for it to ring, a sign that from the jar to the surface the string was free, in vain. Continuing the search, the morning men a few hours later got a ring at about 600 feet. Probably after the first cave-in toward the bottom, the marl’s clay had crawled around the pipe just below 600 feet, or all the driving and jarring had caused other cave-ins, this being only the highest. Anyway, no wonder neither pulling nor jarring down along had not moved the string; jarring up would do no better. The pusher ordered a combined pull and jar up. Roustabouts grunted up the drive-up spear, engine balances, several short, heavy timbers, and the 10-inch, 600-lb. ring and wedges. Driller and toolie pulled the tools, changed spears, made up all the joints again, and stood the tools in the corner. Meanwhile in the cellar, where yellow-dogs gave the sickliest light, the pusher and roustabouts laid a timber for a sill on either side of the casing, cut gains, laid two beams, leveled them, and keyed them tight. On a wire rope from the casing hook driller and toolie lowered the ring around the casing down to the beams, rehooked on the elevator, and started the tension through the string again. Several hours later they had the same few inches of stretch as before, slipped the wedges into the ring (to keep the stretch), took off the hook and elevator, hoisted the hook high, ran the tools to about 630 feet, took hold, felt where the jars hit going up, tied a flag, lowered the tools a few feet, pulled them again until the flag appeared, let them down a few inches, reconnected the pitman, hitched on, bolted the balances on the flywheel, rocked the engine and adjusted the screw to prevent too much strain, and started the motion. The driller felt the jar of the rhythmic slamming upward, but heard no ringing. Soon he changed holds, to jar up from a few feet farther down, and soon he changed again, and again. The afternoon driller and toolie tried to get more stretch, failed, and resumed jarring up, from farther and farther down. That night, Saturday, ending the fourth consecutive tour without a foot drilled, they pulled the tools, capped the hole, and left the string on the wedges to continue the battle next week.

On Monday the morning men tried another pull and jar up, again in vain. Considering the drilling time already lost and the various other ways out of his bind, the pusher decided to jack the string and jar it up. He sent to Tuxpan for the jacks, hydraulics that would lift 100 tons 18 inches. For the drillers this meant welcome downtime: after helping hoist the ring from the cellar and off the casing, the morning driller joined his opposite in rest. For the toolies it meant doing only maintenance, and not on the run, in relief blowing off and cleaning the boiler, oiling the pumps and engine, greasing bearings in the posts and the crown block. For the roustabouts, however, the pusher had the same labor as before, mainly racking more 10-inch casing, to follow down when the crew got the string loose.

Wednesday evening a teamster from Tumbadero delivered the jacks on the walkway, each about 600 lbs. Roustabouts dollied them back to the floor. The afternoon driller and toolie lowered them on the casing hook into the cellar and onto the beams, where the pusher evened and leveled them. They lowered the ring over the casing again and down onto the jacks. The pusher slipped in the wedges. And as he directed, the roustabouts started jacking. Slowly they raised the pipe, the same old stretch, then jacked again, much grunting, no movement. Not yet wanting to pull the top half of the string off the bottom, the pusher stopped them. The driller and toolie ran the tools, took hold, reconnected, hitched one, and jarred up again, to no effect, lower and lower, still in vain. The roustabouts jacked again, a little, and the driller and toolie jarred again, ever lower, ever in vain. The morning men tried too, failed too, and pulled the tools.

There followed a day of downtime for all--except the pusher, who reviewed his remaining prospects and pondered their possible consequences. The next morning, December 17, having lost a week of drilling time, he decided to damn the string and take the reduction. As he ordered, roustabouts and the crew released the jacks, slipped out the wedges, hoisted the ring and the jacks from the cellar, cut the casing short, took the jarring tools off the stem, made up the 9-inch drilling string again, and bailed. Roustabouts began rolling the forsaken 10-inch casing away to the yard, rolling back 8-inch pipe, each 20-foot joint about 400 lbs., tacking it. And at noon the afternoon driller and toolie ran the tools, reconnected, hitched on, and drilled ahead.

The clank-CLUNK and the work became routine again. And through the week following, down more slowly through more marls and shales, 40 feet on a good day, around 35 most days, the routines became monotonous again. After a long weekend because of Christmas on Saturday, bailing to start Monday was normal, no caving. Later that morning the hole gave its first promising sign, “shows of gas,” stinking and blowing strong enough for the driller to feel on his hand. By the derrick string and the motion he figured the depth at 1,445 feet. But the gas quickly faded, and bailing brought up no show of oil, no rainbow in the slush. Drilling deeper told of a change in formations, which the driller duly sampled and at noon logged as "hard light blue marl." But the monotonies of before then resumed, except significantly for the toolies: the bits wanted dressing a little more often, usually every three screws, ordinarily every tour.

Between clank-CLUNK's early Friday morning, December 31, the cable sent a new and more interesting message, figured as from 1,567 feet, prompting a pull-out and a bailing, and ???read in the slush as very hard light blue marl." This called for another serious decision by the pusher. Considering three risks, a cave below 1,183 feet burying the tools, striking oil through a trap at maybe 1,600 feet and losing it in over 400 feet of open hole, and casing only to run out of hole at maybe 2,000 feet, he chose to have the 8-inch casing run and carried (if possible and necessary to 2,400 feet). The driller and toolie took off the 8-inch bit, its stem, jars, and socket, and the tool wrenches for roustabouts to grunt away. Roustabouts grunted an 8-inch shoe and two 8-inch, 425-lb. elevators back up to the floor. At mid-morning the afternoon men arrived. And as on the 10-inch casing three weeks before, the pusher measuring and watching, the crew and three roustabouts ran the 8-inch string. The only difference from before was that 8-inch pipe had a shorter collar, 5-1/8 inches long, and three fewer threads to screw, so that they did each joint some seconds faster. They had about 1,180 feet in the hole by late afternoon, and for the pipe's safety stopped. At dawn on New Year's Day, 1910, they bailed, took off the bailer for roustabouts to grunt away too, picked up on the casing where they had left off, and by mid-morning finished it--a string of 78 lengths, almost 15-1/2 tons of iron hanging to 1,547 feet. The morning driller and toolie worked it several times to make sure it was free.

They then reconcentrated on drilling. Roustabouts grunted up a pair of 275-lb. tool wrenches, the next-size-smaller socket, jars, and stem, the 6-inch, 400-lb. bits (to cut 7 inches), the 8-inch, 550-lb. underreamer (to cut 9 inches), and a 3"x25', 265-lb. bailer. Driller and toolie reduced the wrench counterweights, tied the pole roped to the wrenches, fixed the socket on the cable, made up the jars, stem, and a bit, put the bailer on the sand line, ran the tools down the 8-inch casing, reconnected, hitched on, and as before, clank-CLUNK, clank-CLUNK, drilled ahead. But as ordered only about 20 minutes later and only some inches deeper, barely reaccustomed to the pounding, they pulled the tools (which from that deep took 5 or 6 minutes), stood them in the corner, hooked onto the casing, and worked it. Then they unhooked, ran the tools, reconnected, hitched on, and drilled for another 20 minutes, pulled out again, worked the casing again, and so on. At that rate, with such cautious and frustrating interruptions, they made less than a foot of hole an hour, the afternoon men the same. So Sunday too they drilled. Early in the morning, after only two screws on the bit, the driller and toolie had to put on the fresh one, and the toolie do a dressing, also interrupted to work the pipe. It took until early that afternoon to deepen the hole to 1,587 feet.

Then the driller and toolie pulled the tools, took off the bit, made the underreamer up on the stem, ran this tool down through the casing shoe at 1,547 feet, where its legs thrust out, on down springing into the shoulder at 1,567 feet, reconnected, hitched on, and began underreaming the hole below to 9 inches, clank-THUNK, clank-THUNK. This was worse than drilling. The driller tended constantly and precisely to the motion and twisting, for the hole's narrow walls strongly resisted the pounding and rotation, wanting to hold the lugs as if in key seats, threatening against the turning to break a leg off, which would entail an intricate and protracted fishing job. And as before, every 20 minutes, he and the toolie pulled the tools and worked the pipe, so that the rate down was as before frustratingly slow. For the toolie too the lugs were the main worry, not that they might break, but how fast they wore. Early Monday morning, after only two screws on the???, it befell his opposite to replace and dress them. Between interruptions the toolie had the devil of a time heating one lug slowly and evenly to orange (400° hotter than he did bits), hammering it straight and refinishing it before it cooled below red, letting it cool to hand warm, reheating it slowly and evenly to cherry red, not quenching it (like a bit) but carefully drawing its temper, and repeating the operation on the other lug. It took until mid-afternoon Monday to widen the hole to 1,537 feet.

Then the driller and toolie pulled the tools, and the crew and a roustabout added another joint, so that the string hung to 1,567 feet. Roustabouts grunted up a 16-ft.-long, 765-lb. sinker, for more weight on the bit. The driller and toolie took off the underreamer, made up the stem on the sinker and the sinker on the fresh 6-inch bit, ran the tools, reconnected, hitched on, and drilled ahead. On the next screw, at 1,590 feet, the hole showed gas again. The tools pulled, the hole bailed, the slush for the first time showed some oil. But drilling and working the pipe continued as before all day Tuesday, through the night, down to 1,617 feet on Wednesday morning. There the driller felt a new, less promising formation, later logged as plain "blue marl." Besides drilling more than 50 feet below the casing was a bad idea. Underreaming resumed. It took until the wee hours of Friday morning to widen the hole to 1,617 feet. Simply working the pipe would continue for the rest of the night. At daylight the crew would add another joint to the string, and drilling resume.

But while the yellow dogs smoked and flickered, in the first quiet night in nearly two weeks, the "somewhat unfortunate" (or sleepy) morning driller and toolie somehow got the string frozen. At daylight, as between expletives the pusher ordered, they tried to yank it free, but failed. There ensued practically a repetition of the battle a month before at 1,200 feet, except that the pusher already had the jacks for the last resort. And as before, despite long pulls, driving down, jarring up, and jacking as much as it seemed the string could bear, Friday, Saturday, and Sunday, the casing stayed frozen. Monday morning the pusher damned this string too. Its top cut off and the 6-inch drilling tools remade, the morning driller and toolie drilled ahead. From 1,617 feet down the bit's hole would remain but 7 inches. Roustabouts rolled away the forsaken 8-inch casing, and began rolling back and racking 20-foot joints of 6-inch pipe, each about 280 lbs.

Without casing to carry, drilling and bailing even so deep and in marl went fairly fast. The old monotonies again resumed. Tour after tour the clank-CLUNK, clank-CLUNK was the same, only about 12 feet deeper, the driller making but the slightest adjustments for the motion, the toolie every tour dressing a grit-worn bit, roustabouts rolling up and racking more pipe--until January 20. That Thursday night, talking to the rope, the driller felt the bit suddenly pounding hard and clean into the bottom. After bailing and reading the slush, he figured that at 1,846 feet he had drilled into "blue shales and limestones," the best promise so far of oil below. This meant a critical choice for the pusher. If he did not have the 6-inch casing run at least that deep, any oil discovered would probably go to waste. If he did have it run, but a driller got it frozen there or not much farther down, the chance of losing a discovery would be less, but the chance of running out of hole would be more: the bits to run inside a 6-inch string were the smallest useful in hard rock: he could not have their hole cased and expect a little bit to prove anything. At best, if he had the casing run, he could have it carried only another 100 or 200 feet, keeping open the possibility of striking oil only as far down as maybe 2,200 feet before the hole pointed out. The next morning the pusher went to Tuxpan to consult with the superintendent. The crew and roustabouts got two days of downtime, plus Sunday.

Sunday night the pusher returned and ordered the casing run. With him came the geologist who several months before had made the location. And from Hacienda Tierra Amarilla, an Águila lease a few miles northeast, came one of the company's pebble pups. While drilling below the casing proceeded, the pup would make another survey of the area, so that if this hole proved nothing, the pusher could reasonably consider whether and where to recommend a second.

Monday at dawn the crew and three roustabouts began running the 6-inch casing. Taking the joints in collars only 4-1/8 inches long, screening each only about 17-1/2 turns, they got down about eight lengths an hour. For the string's safety they stopped at about 1,560 feet, but still in good light. Tuesday morning they finished, 92 lengths hanging to about 1,830 feet. This being "the long string," the one to hold the pressure of any strike, the pusher had roustabouts grunt up a 6-inch casing clamp, its long anchor bolts, and a 6-inch casing head. The toolies bored two holes through the floor, in front and in back of the trap door, laid the anchors, and poked the long bolts through the holes down into the cellar. There the pusher and roustabouts fitted the clamp around the casing and at both ends around the long bolts, high, up against the sills ran the long bolts' nuts up to hold the clamp, and tightened the clamp's connecting bolts to hold it fast around the casing and its ears on the anchors. Other roustabouts grunted up two 100-lb. tool wrenches, the smallest socket, jars, stem, and sinker, two 4-inch, 250-lb. bits (to cut around 5 inches), a 30"x30', 150-lb. bailer, and the 6-inch, 350-lb. underreamer (to cut 7 inches). The morning driller and toolie took off the 6-inch tools, the 175-lb. wrenches, and the 5-inch bailer for the roustabouts to grunt away, reduced the wrench counterweights again, tied on the smaller wrench, made up the 4-inch drilling string, put on the little bailer, ran the tools, reconnected, hitched on, and drilled ahead.

The tours passed ever more grimly--drilling slowly down through "alternating" shales and limestone, loosening the clamp, working the pipe, retightening the clamp, bailing, sampling, so again and again to about 1,866 feet, underreaming the hole likewise to that depth, adding a joint to the string, loosening the clamp, carrying the casing down to about 1,850 feet, retightening the clamp, drilling ahead, and between the interruptions dressing bits and lugs. Late Saturday morning at the 13th derrick string, from 1,885 feet below, the rope gave the driller more good news. A foot deeper the afternoon driller and toolie bailed and read the news. As sampled and later logged, it was "blue limestone (Tamasopo)." It had all the feel and look of a trap. But there was no telling how thick it was. Drilling stopped for underreaming. Bound to plan for success, the pusher had the roustabouts begin digging an earthen tank about 100 yards southeast.

Sunday the morning and afternoon men kept working the pipe and widening the hole, by dark to bottom. Through the night they continued to work the pipe. The next morning the crew and a roustabout added another joint to the string, and carried the casing to about 1,870 feet. The morning men drilled ahead. Early Tuesday afternoon the bit made the hole to about 1,906 feet. Underreaming resumed. It was after dark Wednesday when the driller and toolie had the hole again widened to bottom. Again through the night they and their opposites worked the pipe. Thursday at daylight the crew and a roustabout added yet another joint to the string, and carried the casing to 1,889 feet. The morning men drilled ahead.

Very early Friday morning at a depth he figured as 1,918 feet the driller felt another change in formations. Bailing, he and the toolie found two compelling signs in the slush, "hard white vitreous limestone" and oil. This appeared "in some quantity," which between interruptions to work the pipe, they took the rest of the night to measure, "a bailer and a half [about 13 gallons] an hours." At daylight the pusher had them clamp the casing for good and screw on the casing head, and roustabouts lag a lead line from the derrick to the earthen tank. In deliberately very slow motion and frequent bailing the morning men continued drilling to noon. So their opposites continued, but as ordered, for the safety of the hole and the tools, only till evening. So Saturday at daylight, February 5, 1910, the morning men drilled ahead, and so after them the afternoon men, down that evening the driller figured to 1,933 feet.

There was still light. The walking beam disconnected and down in front, the tools standing in the corner, the pusher, geologist, crew, and pebble pup in the mess hall eating dinner, Potrero del Llano No. 1 "drilled itself in." As the pebble pup later recalled, the bit must have earlier deepened the hole "so close to the rock holding oil that the oil just broke through and finished the job." Driven by "enormous gas pressure," the oil rushed up the hole and with "a terrific roar, like the blowing off of a boiler," streamed hot and black up out of the open head and straight up through the derrick, "hitting the crown block and making two great ears of oil on each side." The mess hall emptied. The pusher in memory of Dos Bocas ran to the boiler and shut it down. "...The gas was very objectionable and the black viscous oil difficult to cleanse from body and clothes," but everyone on location was out to watch. On the pusher's orders the crew let the oil gush, to see if they were really in the pay. The gushing soon subsided. The crew closed the casing head. The pusher had roustabouts clean the derrick floor. On Sunday the crew connected the lead line up to the casing head and opened the outlet. The oil gushed through the line into the earthen tank, in a while slowed, ceased. But all day the flow continued to well up by heads, 30 or 40 barrels a head every hour and a half or two hours, "a 500-barrel well." This was enough to prove discovery, a producer. And the oil was "of very good quality, (about 19-1/2 to 20° Beaumé)." On Monday the crew and roustabouts began a partial stripping of the rig, removing the tools, cordage, engine, forge, and appliances to the yards. As soon as the drillers and toolies had the rigging down, they left for another job.

One discovery, however, did not complete an exploration. At least two were necessary to prove a field. It was anybody's guess how many more wildcats Águila managers would need to have drilled where on Potrero del Llano to get a second producer, or, if the holes were dry, order the place abandoned. The only good guesses were that after a discovery on the first probe the pusher and most of the roustabouts would stay, the second wildcat would be a better bet than the first, and the work would happen in essentially the same way.

At the company's call in February its principal geological consultant, the chief geologist of the U.S. Geological Survey, came "on furlough" to Potrero del Llano. He reviewed the records, conferred with the pebble pup (one of his protégés), and decided on a plan for four new locations: a system of rectangular coordinates, centered on No. 1, tilted NW-SE and NE-SW, "the direction...being determined generally by the dip and strike of the rocks and by the general surface trend of the seepages, both active and extinct"; rectangles to measure NW-SE 430 meters, NE-SW 300 meters' locations to be in their center, the distance between locations "such that intermediate wells can be located in case a commercial pool is developed....

Then he gave the "policy" to the pebble pup, and left. Accordingly by mid-March the youngster had chosen three locations and a sequence. Always from No. 1, 300 meters N. 75° E. He had No. 2; 420 meters N. 15° W., No 3; and 300 meters S. 75° W., No. 4. By then also Tumbadero teamsters had delivered the requisite supplies and equipment, less than before, because the pumps, boiler, engine, cordage, tools, and appliances used at No. 1 would serve for No. 2, and the oil from No. 1 would fuel the boiler.

Soon another of the company's rig-building crews arrived, erected a derrick practically identical to No. 1 at No. 2, and left. And another cable-drilling crew promptly arrived, rigged up as at No. 1, and on April 3 commenced drilling No. 2. Working like the drillers and toolies at No. 1 (except for starting on a Sunday), these men went down through practically the same series of deposits and rocks--31 feet of "alluvial clay," a foot of "chapopote-cemented river gravels," 1,368 feet of "shales and marls," 121 feet of "slatey marls" (in which they opened a "light show of gas" at 1,430 feet), 359 feet of "blue and light marls," 10 feet of "alternating limestone and marls," and at 1,840 ft into "blue limestone (Tamasopo)...." The only considerable difference in their work from that at No. 1 was in casing. Luckily they sank a 13-inch conductor true to 91-1/2 feet, ran a 10-inch string to 1,521 feet, set it, ran an 8-inch string to 1,390 feet, and set it in the blue limestone, getting nothing frozen. Without a fishing job or the interruptions and delays involved in carrying casing, they made the hole much faster. Meanwhile Tumbadero teamsters were delivering more supplies and equipment, including a second boiler. In late April yet another rig-building crew came, built another identical derrick at No. 3, and left, and on May 7 yet another cable-drilling crew commenced drilling the third wildcat.

On May 12 at 1,940 feet the driller at No. 2 felt gas from the hole, and the slush showed "hard white, vitreous limestone" and oil. The men drilled ahead. At 1,943 feet the cable suddenly slackened, a spray of oil sizzled up around it, and the casing head began to vibrate. Quickly the driller and toolie opened the outlets, to turn most of the flow into the reservoir, and pulled the tools. They had hit the same pay as at No. 1, another 500-600 barrel well, "quite as good or a better well than No. 1." Potrero del Llano was a field to develop.

This was not the only way to wildcat. Sometimes a superintendent ordered a test by the new "hydraulic rotary method' of drilling, which "consists in rapidly turning a column of pipe, the lower end of which is armed with a steel shoe having a serrated edge or a bit for cutting," and simultaneously and continuously forcing a "flow of water" or mud "under constant high pressure" down through the pipe and up the annulus around it. Faster than standard outfits in unconsolidated formations, capable of 140 feet a day in soft rock, but making holes hard to log and often crooked, rotary outfits were not yet common on wildcats or in proven fields. But if the company wanted to hurry a test and the superintendent expected much clay or shale, he might decide on a rotary. That had been the Pearson choice at Dos Bocas in 1908. In 1909-10, while Águila cable-tool crews were wildcatting at Potrero del Llano, other Águila crews were running rotaries not 15 miles away in virgin territory some 10 miles west of Tuxpan. At the same time East Coast Oil crews were on rotary wildcats five miles north of the town.

At a far distance a rotary outfit drilling looked like a standard outfit--a tall four-legged derrick and an oil-country boiler. But the closer the view, the more obvious were the differences. The derrick was bigger, typically 84 feet to the top of the crown block, on a 2-foot square foundation, and had an inverted V open in the back up to the third girt. The boiler was bigger too, probably 40 h.p. (by oil-country ratings), with a 6x4x6 feed-pump. Beside them stood a tool house. Behind the derrick lay stacks of maybe only 8-inch casing but much 6- and 4-inch line pipe, collar ends forward, a few protruding through the V. The ladder went up the derrick's left side to the crown block and gin pole, yellow dogs hung around the first girts, and the stabbing board lay across the second side girts. But most yellow dogs hung from the third girts, another platform lay across the seventh girts, 53 feet up, and still more yellow dogs hung from the girts over it. The ditch away from under the derrick floor on the left side did not dwindle away to waste, but had a specific shape and course, maybe 2 feet wide, a foot deep, 10 feet out to the left, 30 feet forward, 50 feet to the right across in front of the derrick, and 20-odd feet back to the derrick's right side into a big "slush-pit," also built to some specifications, 10 or 15 feet wide by the derrick, 3 or 4 feet deep, and from 20 to 50 feet long out to the right, the ditch and the pit full of a gray, slowly moving, slimy mud. There was no engine house, belt house, bandwheel, sand reel or sand line, no walking beam, samson post, or main sill. The engine, single-cylinder but probably 30 h.p., sat chugging on its sills immediately in front of the derrick. Its throttle cord and reverse rod reached back out about 11 feet into the derrick. Its drive shaft carried not a pulley and belt but a cast-iron sprocket and short, heavy, link chain, the links as big as a fist. That close to the floor, "the noise was incredible...." Inside there were no bull wheels or calf wheel, none of their posts or ropes, no headache post, temper screw, or drilling cable, no wrench circle or tool wrenches, no bailer or dumphole, no crane, swivel wrench, or forge. Instead there were four machines: at the front, like a calf wheel, a drawworks; in the center, with "a column of pipe" down through it, a "rotary table"; and on the right two steam "slush pumps." Everything looked gray and slick with mud.

Abstractly stopped, a rotary outfit's mechanism showed the principles of its radically different operation The drawworks, fixed and moving parts weighing maybe 2-1/2 tons, served both for hoisting and lowering. From the engine's drive sprocket it could take power by the short chain connected back and up to a driven sprocket set about the middle of its tell main line-shaft, probably 3 inches thick and 11/1/2 feet long. Borne in three babbitted journals bolted to the front side of three oak posts, these standing bolted at the bottom to the derrick's front floor sill and at the top to an oak headboard braced front and back under the first girt and bolted at either end to the derrick's front legs. Keyed on the line-shaft's ends, a foot long outside the left and right posts, were cast-iron catheads. Inside the right post the shaft carried a drive sprocket and another heavy chain, connected back and down to a sprocket on a steel, probably 4-inch thick and 7-ft.-long shaft borne in babbitted journals bolted to the back side of the middle and right posts. This driven shaft carried a cast-iron, probably 15"x34" flanged drum, with a jaw clutch (disengaged) at the right end and a brake (set for the abstract moment) on the right flange. Between the middle and left posts, about 2-1/2 feet apart, the line-shaft carried a second drive sprocket and a third heavy chain. This chain connected back 11 feet down to a sprocket on the rotary table's shaft, about 3-1/2 feet left of the derrick floor's center. The table, weighing complete about 1-1/4 tons, sat at the floor's center about 2-1/2 feet high. It served to convert rotation from vertical to horizontal. Its shaft, also borne in babbitted boxes, had a jaw clutch (disengaged for the moment) inside the sprocket and a beveled pinion exposed on the inner end, to engage the beveled gear teeth exposed in the underside of the flat-topped cast-iron master wheel. Maybe 36 inches in diameter, so rated 14 inches for the diameter of the hole through its center, centered over the floor's very center (open below), the wheel rested on steel cone rollers on a cast-iron bed plate bolted down to oak skids on the floor or sills. On top of the wheel, doweled into it, to turn with it, sat a cast-iron frame with four vertically mounted grip rings adjustable by screws to close in squares for circles from 14 to 3 inches. The pumps, each about 6 feet long and weighing about 1-1/2 tons, sat waterends facing along the right side. They served, one at a time, to keep the mud going down the pipe. Double-acting, duplex, and piston-packed, they were probably 10x6x12's. Their 5-inch suction pipes reached off right down into the slush pit. Their 4-inch discharge lines, each with a gate valve, connected above through a manifold to two 7-inch stand pipes that rose outside and against the derrick's right side up to the third girt.

In an abstract sequence these machines had three connections to the drilling tools. First, from the drawworks, spooled on the drum and coming up in back, was a "casing line," probably 7/8-inch steel-wire rope, drawn tight up to the steel, probably 5-pulley crown block and threaded through four of its pulleys and the three of a 26- or 28-inch triple-sheave casing pulley block, to the upper becket of which its deadline was fixed and from the lower becket of which hung a strapped C-hook, from which hung as high as 30 feet, as low as 10 feet, a maybe 4-1/2-inch casing hook, from which on a probably 2-inch thick bail hung a probably 4-inch "water swivel," a hollow steel, iron, and brass "ball-and-roller-bearing affair," maybe 5 feet long and weighing 700 lbs., the top of its fixed upper part a short 4-inch gooseneck pipe, the bottom of its rotatable lower part, capable of 60 rpm., a short 4-inch "water tube" connected by a sub probably to a "grief stem" a joint of 6- or 4-inch drive pipe that was the top of the screwed-together column of 6- or 4-inch line pipe down in the hole, the so-called "drill-pipe," if 6-inch, for a 10-inch or bigger bit, maybe down as deep as 1,500 feet, weighing 14 tons, if 4-inch, for a smaller bit, maybe down as deep as 3,000 feet, weighing 16 tons, on the end of which connected by another sub, was the bit. Secondly, from the pumps, the stand pipes at the third girt each connected with a probably 30-foot wire-wrapped 2-inch hose reaching over the girt and into the derrick, where one of the hoses connected to the gooseneck. And thirdly, below, the grip rings gripped the grief stem, in principle tightly enough for them as they rotated to rotate it, loosely enough to roll it down unscored and even, for the weight on the bit to press it into the bottom of the hole.

In drilling then, the brake more or less off, the rotary clutch engaged, the noise on the floor seemed "incredible" for its loudness and constant confusion. It came from numerous and simultaneous mechanical rhythms and their slippages and ponderous metallic abrasions--the engine at maybe 90 rpm. (Two--thirds speed), the line-shaft at 45 rpm., loose bearing-fixtures squeaking, chains rattling and waving on sprockets, a pump's pistons each thumping and its exhausts each puffing 60 double strokes a minute, an empty elevator on the casing hook rattling and bumping against the swivel, the rotary shaft at 135 rpm., the table rumbling around, clockwise, at 40 rpm., the grief stem groaning down through the grip rings, as unseen and unheard under the burden of the pipe far below the bit on the bottom screwed continuously into the earth. Meanwhile also inaudibly maybe 3-1/2 gallons of mud a second rushed from the slush pit up through a suction pipe, under 125 psi. Through a pump, under 210 psi. Up through a stand pipe, over through a hose, and down through the swivel into the column of mud moving continuously down inside the drill-pipe, as far below another 3-1/2 gallons a second shot from the whirling bit's outlets, to cool the bit, flush its cuttings from the bottom, and rise with them into the ring of mud moving continuously up the annulus, like liquid casing around the drill-pipe, overflowing continuously under the floor into a trough down into the ditch and visibly then oozing of "returns" back to the pit.

So different from the standard outfit's were the markers to measure progress. Instead of a derrick string, there were tallies cut on the drawworks' right post of how many joints of pipe were in the hole, and numerals chiseled every foot up the grief stem. And so different too were the tools and supplies on the floor. There were tools like those used on a cable-tool floor only to run casing, a pipe hook, elevators, chain tongs, a 16-lb. Sledge hammer. There were others that ordinarily stayed in an engine house, such as several machine wrenches. There were yet other things specifically for rotary operations, slide tongs, a pot of heavy oil and a mop to lubricate chains and the table, a water hose, maybe 250 feet of 1-1/4-inch manila rope for a catline. And usually there were two or three bits standing upside down on their pins in a corner, "fishtails,' quite unlike a pounding bit, steel, but short--an 8-inch fishtail being only about 18 inches long, weighing only about 150 lbs.--and basically wedge-shaped, the outlets front and back at the thick top, the thin, cutting end split, its right side bent forward, its left side backward.

The forge for dressing these bits stood conveniently in the tool house. There it had a steam-powered blower. There was a full pot of babbitt, hot enough to light a pine stick, charcoaled, resined, stirred over and over. And there besides most of the standard toolie's blacksmith tools and supplies were several others, a set hammer, hot and cold cutters, a fuller, a combination vise, several big files, big pipe- and thread-cutters, much packing and many valves for replacements on the pumps and manifold, and a small and odd assortment of fishing tools.

The drilling crew was therefore different too. Like a cable-tool crew, it worked under a pusher and in two tours. But it had more men, on a wildcat typically 12, six a tour, and the tours were usually on "the Texas method," "daylights," preferred, from 6 a.m. to 6 p.m., "nights" from 6 p.m. to 6 a.m. Four of the men on a tour would be more or less multiply skilled, and more than between a cable-tool driller and toolie the hierarchy among them would be definite, elaborate, and often explicit. First, directly in charge of all operations, and most multiply skilled, was the driller, or "rotary runner." He ordinarily had a watch, and worked bare-handed. Scorned by cable-tool drillers as a "brake rider," "swivel neck," "Johnson-[bar idiot," "clutcher," "chain breaker," "mud eater," he returned their contempt in references to "jarheads" and "rope chokers." He had his station on the floor at the drawworks' right side, by the cord's telegraph wheel and the reverse rod and the drum's clutch bar and brake lever. There he ignored the mechanical confusion, concentrated on significant information, shouted commands to his subordinates, to whom he was "the teacher," and kept (with his opposite) a log in some terms apparently standard but altogether rotary in meaning. The three other skilled men worked as his immediate helpers off and on the floor. They ordinarily wore heavy leather gloves. They were the roughnecks, each specialized, in hierarchical order the bit dresser, the pot man (or fireman), and the derrickman (also known as "monkey," "tower bird," or "biscuit cutter"). The unskilled men, typically watchless and gloveless, were the roustabouts. Unlike around a cable-tool rig, they were members of the crew, not of a separate gang. But as common laborers they were not to go on the floor except at the driller's command to help the roughnecks.

Consequently also work on a rotary rig differed impressively from work on a standard rig. It was more mechanical. It had none of the standard rhythms. It was more dangerous: the chain from the line-shaft halfway across the floor to the rotary shaft was running almost all the time, at full speed from sprocket to sprocket in about 1-1/2 seconds. The work was dirtier, because of the mud and grease. And most significantly it not only involved more subdivision and specialization of labor, but also evolved as the hole deepened, from an almost continuous array of separate operations to a continual but unpredictable alternation between this array and increasingly longer and ultimately definitive episodes of intensely combined and coordinated cooperation

For the first several hundred feet down drilling went on practically 98% of the time. During this period and later, farther down, while drilling at any depth, the fellows on tour did their duties apart. The driller himself, daylights or nights, typically impatient, itching to make more footage than his opposite, but obliged (since Dos Bocas) to drill “with extraordinary care,” stood at his station most mindful of the speed and weight on the bit at the bottom and the circulation and pressure of the mud in the hole. The speed he wanted no more than the swivel’s limit, but as fast as under the rule of care the drill-pipe and bit could take in the formation he thought he was drilling, with a big bit, for example, maybe 35-40 rpm. In “limestone,” but maybe only 12-15 rpm. In “gumbo.” This force he controlled at the engine by the telegraph wheel. The weight, from the swivel, grief stem, and drill-pipe, he wanted heavy enough to drill even through “boulders” or “hard shell” at a reputable rate of progress, but not so heavy that in hard rock he drilled too crooked or in soft rock bogged down and risked a “twist-off,” a bit broken off in the bottom. The available force he controlled by the brake, “slacking off” or increasing the load (by letting the lever up to let the brake out more or less for hard rock, “holding up” or decreasing the load (by pushing the lever down to put the brake on more or less) for soft rock, and intermittently in a formation slacking off some when the bit had drilled off and holding up to let it drill deeper. The mud he wanted flowing and thin enough to keep clearing the cuttings, so that they did not “ball up” on the bit, resist rotation, maybe plug the outlets, even stall the pump, but thick and sticky enough to keep the hole’s walls plastered and firm all the way up to the surface. These forces he controlled by commands, to the derrickman to turn higher or lower the pump’s steam-valve, to the roustabouts to run water or shovel clay into the slush-pit. His only indicators were his senses, how the revolving chains and the table and the grief stem looked to him, how the brake felt in his hand, how the engine’s speed and exhaust and the pump’s sounded, and how the mud returning in the ditch looked, felt, and tasted. But he knew what they were telling him: if suddenly, after smooth running at the speed and load right for clay, the engine started racing and snorting, the chains waving, the table clattering and jerking, the stem jumping up and down, the bit was drilling into a much harder formation, e.g., limestone; if suddenly, after smooth running at the speed and load right for sandstone, the engine and the table started slowing and the pump’s “tune” changed, abruptly slowing too, its exhaust barking louder and louder, the bit was drilling under a cave or into a much softer rock, e.g., gumbo, and if then the stem started rising from the hole, the bit had balled up badly; if the returns ran too fast along the ditch, too much dirt had accumulated in the bottom of the ditch, the cuttings were not settling, and the mud in the slush-pit was thickening; frothy returns showed gas in the hole; gritty mud in the pit, sand in circulation, which told not only of extra wear on the pump but also that if the pump stalled, the drill-pipe and bit would quickly “freeze in”; salty mud, caves coming.

He knew a few other things too: a joint of 6-inch pipe that weighed 375 lbs. On the floor weighted only 320 in the hole; drilling from hard into soft rock, the bigger the bit, the faster it had better slow down and hold up; it took at least 40 of the 6-inch joints on a big bit, say 13 inches, to drill limestone carefully but also at a reputable rate, for such a bit, sharp, a foot an hour, but only 14 such joints on a 13-inch bit in gumbo would bog it down; the circulation in a 13-inch hole would flow the same in a 9-inch hole below with only about half as much mud; pumping at full speed, it would take about three minutes for every 100 feet down to bring the cuttings up from a 13-inch hole, but only about a minute for every 100 feet down in a 9-inch hole; and so on. And from all the things he knew, he could figure many more, so many that it typically seemed to his subordinates, when he deigned to explain anything to them, that he “could figure you out of your socks.”

But no more than a cable-tool driller could he ever know or figure when he would hit the next formation down or what it would be. Unlike a standard driller, he could not even tell whether or not he was drilling a straight hole. And although it was simpler to fish for a lost tool, typically a twist-off, it was much less likely than in standard fishing that he would finally catch the thing and pull it out. This was why he stood at his station so concentrated and so vigilant--and why rotary drillers said they aged at the brake.

He had it easiest and most frustrating at the start. He did not spud in; “the bit begins at the surface to make a hole,” but very slowly. With a 13-inch bit in formations that he would log as clay and shale, he would watch the table’s peed, around 15-18 rpm., but disregard weight, there not being enough so shallow and at that speed to stick the bit in anything, leave the pump at full pressure, probably 210 gallons of plain water a minute, and simply,, sorely, wait, the bit at first making only about 8 inches of hole an hour, hour after hour, tour after tour, then under heavier loads making more, but only 18 inches an hour by the fourth day down. If at about 120 feet he “got a bone,” hit something hard, something he might figure for limestone, he would check the depth on the stem to make a note for the log, open the throttle to run the table at maybe 35 rpm., in a few minutes call a roustabout to get a bucket and catch a sample of the returns, and resign himself, for lack of weight, to maybe only two inches down an hour, until he or his opposite deepened into clay and shale again.

By 300 feet down, however, he had a load of nearly 3 tons available, enough to plant the bit deep in gumbo. Then (if not before) he would hang a brakeweight on the brake lever, to quicken control of the load, and concentrate ever more sensitively on keeping the balance of forces in due adjustment. At about 600 feet, for example, drilling below so far consolidated formations in something he figured for sandstone, he would have the table at probably 30 rpm., jerking some, the brake off, the whole load (about 5-1.3 tons) on the bit, the pump wide open, the bit making maybe 1-1/2 feet of hole an hour. If there he hit something soft, maybe clay, he would quickly throttle down, reverse the engine, praying it did not stop on center, and brake, shift the engine to forward again, run the table to maybe 15 rpm., hold up about half the load, watch and feel and listen that the adjustments were in the range of right and he was not just “fanning” the bottom or bogging down, check the depth on the stem and the time, and remind himself to call a roustabout in 20 minutes to catch a sample. Soon,, maybe before he got the sample, he might “get a ball on,” and forget the sample to spud the ball off--reverse, engage the drum’s clutch, open the throttle and release the brake to run the engine into the load, in some seconds hoist the column a few feet, throw out the clutch and put down the brake, lower and hoist the spinning column three or four more times, until the bit was clean, throttle down, shift the rotation to the right again, run the table at maybe 12 rpm., and lower the bit back down to the bottom, but under less of a load than before. If at about 800 feet he went from clay or gumbo into something much harder, limestone, he would increase the speed to maybe 40 rpm., slack off the whole load again (there nearly 7 tons), check the depth and time, and 25 minutes later call a roustabout to catch a sample. Under clay and sandstone at about 1,600 feet, drilling with a 9-inch bit in a nice, soft shale, rotary runner’s heaven, he would have the speed at about 40 rpm., only about a quarter of the load (there with 4-inch pipe, nearly 87 tons) on the bit, and the pump at only about 100-110 gallons a minute. The bit making 4-5 feet of hole an hour, he might rest his eyes, or hang an extra little weight on the lever, or let a roughneck spell him, and for relief go check the mud. But he could never safely take any distraction. If at about 1,800 feet, drilling in hard shell, he was duly running the table at 60 rpm. And had over half the load (there almost 9 tons) slacked off, and somehow, despite the din, unforgivably, his eyes rested, he might awake to the grip rings screeching and the engine snorting and dying, in instant reaction throttle down and reverse, but before the last shifted power turned the fly wheel backwards, feel the load on the brake suddenly lighten and hear the pump begin to race, its exhaust softer and softer: the bit probably in a new layer of gumbo would already have twisted off, and he had a fishing job to do.

Meanwhile, at any depth, the other fellows would be on their own or on command at various other labors. The bit dresser might be on the floor cleaning away half-dried mud or daubing oil on the running chains, or he might actually be out in the tool house, heating a pot of babbitt, threading a nipple, or dressing a bit, which although smaller than a cable-tool bit took longer to draw out, turn, point, resharpen, and temper. The potman might be on the floor helping clean things, oiling bearings, or her might be down oiling the engine, or actually out checking the water and fuel tanks, or oiling the feed-pump, or blowing down the boiler. The derrickman would usually be on the floor at the pump not in use, repacking it, or replacing a leaky gate valve, but he might be down kicking the engine off dead center, or actually up in the derrick, greasing pulleys or fixing platforms. If the driller called him, any of these three, all typically sick with "brake fever,' would jump to do a spell at the brake, but rarely have it for more than a few minutes. And as the drilling proceeded, the roustabouts would be together or apart thinning or thickening the mud in the pit, cleaning the ditch, catching a sample, digging an extra ditch or pit, carrying tools between the tool house and the rig, or out picking up junk or clearing brush.

About every 20 feet from the surface down, since the grief stem was only about 20 feet long, drilling stopped, and all six men worked together to "make a connection"--add another joint of pipe below the grief stem in order to drill that much deeper. But since the rate of progress down changed gradually as the hole deepened and unpredictably and sometimes suddenly from formation to formation, this cooperation happened sporadically. In a 300-foot hole drilling through 20 feet of limestone might take five tours. At any depth 20 feet of gumbo might take an entire tour; as the bit balled up, the driller might spud it clean, but then pass the next hour or two drilling the ball up. Anywhere below 500 feet in soft shale he might deepen the hole so fast, even taking care, that making a connection would happen two or three times a tour.

Moreover, whether it took plce seldom or often, it was "scarcely any interruption." As the grief stem's collar rotated down to just above the table, the driller would assemble his roughnecks and roustabouts on the floor. At his station then he would stop the engine and put on the brake, have the bit dresser throw out the table's clutch and screw open the grip rings around the stem, and have the derrickman stop the pump, shut the maniffold gate valve, and open the bleeder (to drain the mud from the standpipe, hose, and swivel). These disconnections made, he would engage the drum's clutch, open the throttle wide and release the brake, on sevenplies in about 75 seconds hoist the column of pipe 20 feet, and slow, brake, and stop, so that the grief stem and the top of the joint below rose dripping mud from the hole and stopped, the latter joint's collar about 6 or 8 inches above the grip rings. The pot man and a roustabout would lay the slide tongs flat on the rings and close the jaws around the pipe. The derrickman and the other roustabout would set an elevator on the tongs, the same size as the elevator up on the casing hook, and latch it around the pipe. And the driller would gently lower the column to rest the muddy collar on the elevator. The bit drewwer would "sound" the stem, bang it once or twice with a hand hammer to tell it was emptyof mud, and hose the mud off the outside. The pot man and a routsabout would latch Maude, the No. 16 chain tongs, aroung the stem. The driller would open the throttle very sligihtly, for the slightest tnesion on the casing line. And as the bit dresser uphanded the collar with a calfhead, the other roughnecks and both roustabouts would grunt, push, and tug counterclockwise on the handle to break the connection. When they had it broken, the derrickman would climb up on the stabbing board, and the pot man and the roustabouts would take equidistant places around the table, pass the tong handle around from fellow to fellow, probably 19 turns, and unscrew the stem. As the tension on the line lifted the stem free, the driller would stop and brake. The pot man and a roustabout would take off the tongs. The derrickman above and the pot man below would swing the stem out of the way right and stand it leaning top-heavy back against the stabbing board. The derrickman would take the swivel's bail out of the casing hook. The driller would lower the hook, with the elevator on it. The roustabouts would push or dolly a joint of pipe collar forward through the V to near the table. The pot man and they would latch the elvator on the hook under the collar of the joint. The driller would hoist the joint, lower its protected end over the open collar below, and brake. The pot man would take off the joint's thread protector, and the bit dresser would dope the threads and the collar. The derrickman would stab the joint, the driller would let it delicately drop into the collar, and the pot man would turn it for the threads to catch. He and the routsabouts would latch Maude on the joint, take their places again, and pass the handle around clockwise 19 trns to screw the pipe as tight as they could. The bit dresser would bump the handle around another half turn to make it up. The pot man and a routabout would take off the tongs. The driller would hoist the column a few inches. The pot man and a roustabout would unlatch and take off the elevator on the slide tongs. The driller would lower the column until the elevator under the new joint's collar rested on the slide tongs. The pot man and the roustabouts would take the elevator's links out of the hook, lay them down, and put the other elevator up to the derrickman. The derrickman would put the swivel's bail back on the hook, and with the pot man below swing the swivel and grief stem over the table. The bit dresser would dope the stem's threads and the new collar. The derrickman would stab the stem, the driller would let it delicately drop into the collar, and the pot man would turn it for the threads to catch. The derrickman would come down, and the pot man and roustabouts would screw the stem into the collar. The bit dresser would make up the connection. The driller would hoist the extended column a few inches, brake, and throw out the drum's clutch. The pot man and roustabouts would unlatch and take off the lower elevator, and open and remove the slide tongs from the grip rings. The bit dresser would reset the rings and reengage the table's clutch. The derrickman would close the bleeder, open the other manifold gate valve, and start the other pump. The driller would cut another tally on the post, open the throttle and release the brake as much as he thought right, watch, listen, and feel, and drill ahead. And the other fellows would return to their separate labors. The task together would have taken but maybe 15 minutes.

Drilling also stopped occasionally because of a mechanical failure. The hose might break at the standpipe or at the gooseneck. The swivel's water tube, its packing scored, might go to leaking. Manifold valves "gave much trouble," sticking and leaking. The pump in use might foul with trash from the slush-pit (despite a strainer), or its new packing might grind out after only a few hours. The grip rings would knock loose. The rotary chain "would break at the slightest provocation." And sooner or later a line- or rotary-shaft journal would get a "hot box," the babbitt melting and running out of it.

But such mishaps occurred seldom enough to count merely as a driller's bad luck. The interruptions for repair did not last long. And they did not involve but a man or two. Unless the chain in breaking had whipped around a post or one of the fellows on the floor, it took only a minute for a roughneck to detach the broken link, fit a new link in its place, pull the ends together, and relink them. And unless the hot box had galled the shaft, it took only several minutes for the bit dresser and another roughneck to remove the box's cap, chock the journal up level, shine it with an oily rag, clamp it and the box in position, beside them hand and chock the cap upside down under the shaft, shine the shaft there, clamp it and the cap in position, clay the open ends, heat the box and cap, bring the pot of babbitt to the floor, ladle the molten metal in a slow, steady, thin stream along the top of the journal and the shaft over the cap, take off the clamps, pick out the clay, let things cool to the gloved touch, take down the chocks, and bolt the cap back on the box, leaving the bearing ready as soon as the driller could feel it bare-handed.

All six men on a tour worked together to run casing. Except for the differences between operating a drawworks' drum and operating a calf wheel, the work was much the same as casing a standard hole--and except for the repetition to make the string, virtually the same as the middle part of making a connection. The driller would be at the clutch, telegraph wheel, and brake, hoisting latched joints of casing and lowering the string down the mud-filled hole. The derrickman would be up on the stabbing board, stabbing the latched joints as they came. The bit dresser below would be unscrewing thread protectors, brushing and doping threads, and making up joints in the string. And the pot man and the roustabouts would be moving joints onto the floor, latching on, screwing stabbed joints into collars, passing the tong handles around and around the table, unlatching, laying links down, joint after joint.

But the task did not occur so often as on a standard hole. Since the rotary mud served instead of casing for considerable depths, a rotary-drilled hole would want not three or four strings but only one or two, typically a 10-inch to 1,000-1,500 feet and an 8-inch to 2,000-3,000 feet. And since enough men were on duty day or night, it was possible to run a string in daylight or under yellow-dog light. It took as long and as much sweaty labor to do as in a standard hole, probably eight hours for a 10-inch string to 1,200 feet, 15-16 hours for an 8-inch string to 2,500 feet. But through all the many weeks of work on a deep hole it might happen to the fellows on one or the other tour only once, and that for only three or four house toward the end of the hole.

The distinctive episodes of cooperation on a rotary rig were the "trips," when all six men on a tour toiled together to "pull out" the drill-pipe and "run in" again. These bouts included "making a trip" before and after casing, or in order to fish for a twist-off. But most common and most important was a "round trip," coming out of the hole to change a worn bit for a sharp one, going back in the hole to drill ahead. This happened at least once a day. Starting his tour with a sharp bit, drilling down through a nice clay or soft shale, a driller might drill 12 hours (except for two or three connections), deepen the hole 55-60 feet, and log off feeling the bit was still sharp. But two or three hours deeper in the same formation his opposite would feel the bit slower in drilling off, and an hour farther down, pure rotation. In gumbo a bit would no dull, but several times a tour might ball up so thick that it would not spud clean. In limestone it would war from fresh to flat maybe every half hour. Or it might act up otherwise for other, mysterious reasons. Anyway, for his impatience, the driller would not delay his orders. "One of the oldest rules in drilling is, when a bit isn't acting just right, pull it."

A pull-out began like the first part of making a connection. While the driller operated the engine and the drawworks, the roughnecks and roustabouts would stop the table and the pump, take the grief stem off, and stand it aside. But then, at a hole of any depth below 60 feet, the special strains and discipline of the task became clear. The derrickman would climb from the stabbing board up the ladder and onto the board across the seventh girts, the "thribble board," maybe two feet back of the casing line, take his positions, his left foot on the thribble board, his right on a "finger," a plank fixed from over the rear girt forward over and a little beyond the thribble board maybe two feet left of the casing line, look down at the driller, and wave and yell that he was ready. Meanwhile the pot man and a roustabout would have taken the elevator on the casing hook off, raised the links on the elevator on the table, and put the hook on them. At the derrickman's signal the driller would engage the clutch and pull the throttle wide open, on seven plies in nearly 4 minutes, the bit dresser hosing the pipe as it went up, hoist the mud-dripping column about 60 feet, and throttle down and brake. The pot man and a roustabout would latch on the next joint below. The bit dresser would sound the pipe. The pot man and a roustabout would put Maude on it. The bit dresser would tap the collar. The pot man and the roustabouts would break the connection, and unscrew the pipe. As the "stand" of three joints, a "thribble," lifted lightly free, the derrickman above and the pot man below would swing it leftward around the front of the finger, and, as the driller gently lowered it, "tail" it a little forward it, so that its top leaned to rest "racked back" against the thribble board, between the finger and the left side of the derrick. Quickly the derrickman would unlatch the elevator, the driller would lower it, and the pot man and a roustabout would take it off the hook, raise the links on the next joint, and put the hook on them for the next hoist. Each stand took about eight minutes to hoist, break, unscrew, and rack. So through the same motions on every stand driller, roughnecks, and roustabouts would repeat their combined labors for as many thribbles and remaining single joints as there were in the hole. And so the work became both almost automatic action and an impressive experience. A trip of 100 feet was nothing much, scarcely more of an interruption than making a connection. But to pull out from 600 feet –the grief stem, nine thribbles, and two singles—was already an hour-and –a-half-long episode of close, muddy, sweaty collaboration; from 1,600 feet, through 28 successive, almost identical actions, from three and a half to four hours in a muddy, sweaty, unified force.

That would be the easy half of the round trip. With the last pulled stand (or single) made up in the sub on a fresh bit, the run-in to go back in the hole commenced. This wsa like the last part of making a connection, except that the derrickman, still up on the thribble board and finger, did the latching and headed each stand around the finger before stabbing it—and the mutual maneuvers of commection were almost automatically repeated stand after stand until the column again stood ready to drill ahead. Ordinarily slower than a pull-out (because of doping and stabbing), a run-in to 1,600 feet would take from four to four and a half hours.

In a hole so deep then working together on a round trip would last most of a tour. By 2,400 feet down changing a bit would be extemely filthy, tedious, exhausting, and frustrating, it it happened to start a tour the work of the entire tour, in shale the work of every other tour. Most significantly these episodes were also very dangerous. Dramatic danger loomed whn comping out or going back in, the drill-pipe stuck in the hole. If th driller could not yank it loose straight with the drawworks, he and the derrickman might rig up a luff line and double lifting capacity. Obviously risky, a good way to free the pipe or pull in the derrick, this rarely caused casualties. Before making the pull, the driller would usually have everyone else leave the floor and prepare himself to bolt for the brush. The routine dangers were the worst. The drum's clutch bar, the "Johnson bar," which the driller shifted sideways with his knee, slipped out often enough that another name for a rotary rig was a "knee-buster.
With every hoist a cracked piece in the drawworks might break and fly like shrapnel across the floor. With every brake on a hoist, the brake lever, an iron bar five or six feet long, threatened to slip the driller's grip and kick head high. If a too impatient driller let the big hook and empty elevator down swinging and too fast and low, they might hit anyone around the table. If he took the empty hook up swinging, it might knock the derrickman off his platform and racked stands lose in the derrick. An elevator would easily crush a derrickman's fingers, or slip off the hook and fall onto the men below. Or the derrickman might mislatch a stand, which, weighing over 1,100 lbs., would drop onto the floor, whence the nickname "biscuit cutter," or onto a foot, when other names. The longer the trip, the likelier luck would go bad. Drilling in limestone 2,400 feet down actually meant scarcely any drilling at all between almost continuous and ever more dangerous round trips, during which, tour after tour, the men would be working together practically under a death warrant.

Most dangerous would have been controlling a rotary-drilled hole that made a well in the Tampico region, where wells often came in by blowing out. Under the rain of oil, slipping every which way in the blown-out mud, amid long twists of blown-out pipe and the roar and stench of vapor and gas, the entire crew might have needed several days together to prevent sparks and fire, put on a casing head and gate valve, and close the well for proper production. But no such event occurred. The rotary-drilled holes between Tampico and Tuxpan in the??? 1909-10 were all dry.

* * *

The development of an oil field began with the construction of a pipeline to carry the crude oil off to use. Like building railroads, this happened on order, out in the open, over long distances, and all in broad daylight. It was episodic, multifarious, coordinated, and dangerous work, largely by gangs and crews of laborers. Moreover, since it proceeded to make connections between distinctly different places, its sites continually changed along the chosen way. In particular, building a pipeline meant arranging an entire "spread," mobilizing a force of 200-500 men, and constructing a system not only of roads but also of telegraph or telephone lines, gathering lines, field storage tanks, pumping stations, and terminal storage tanks as well as one trunk or main line. Most peculiarly, it was always both unpredictable and urgent: in the industry then a newly discovered field wanted a pipeline as soon as possible. Speed of construction depended on terrain, weather, supplies, experience, but mainly on the size of the force at work. The general measure of progress was lengthwise, the number of joints or feet of pipe laid per "laying gang" per day, excellent progress being 250 joints of eight-inch pipe, a mile a day, fair being half that. The latest record was for the Gulf Pipe Line Co., between Watkins Station, Oklahoma, and Sour Lake, Texas. Beginning in February, 1907, a force that would grow to 1,500 men, including at one time nine laying gangs, had ready to run by August that year, only six months, six stations, 56 tanks, and the complete eight-inch trunk line 419 miles long.

The crude-oil pipelines in Mexico by 1910, all in Veracruz, were much smaller and more slowly constructed. The first and smallest was Pearson's in the Isthmus, for 10,000 barrels a day from the San Cristóbal field to the experimental refinery in Minatitlán. A force of some 120 men took from March to November, 1906, to build a 2-1/2-mile standard-gauge railroad from a landing on the nearest navigable river to San Cristóbal, a parallel water system, telephone lines along the same way and from San Cristóbal to Minatitlán, field tanks, gathering lines, a mahogany pumping station with a 350-h.p. boiler, a Worthington 16x25x7x24 pump, and 42,000-barrel steel working tanks, one 42,000-barrel storage tank at the refinery, and the six-inch main line 14-1/2 miles long. The second and most difficult construction was Pearson's for Oil Fields of Mexico, to connect the Furbero field, in the hills west of Papantla, with a point on the coast. Imagined in December, 1907, to go southeast to a terminal at Tecolutla or Nautla, it became a definite project in March, 1908, for 14,000 barrels a day to go northeast to the right bank of the Tuxpan River, across from Tuxpan town. And in June, in the rain, gangs at the Cobos terminal began working on a 56-mile narrow-gauge railroad and six-inch pipeline planned for completion by March, 1909. Eventually imported into the force were some “300 labourers from Cuba.” The work neared completion during the summer of 1909. Then it went to ruin in the hurricane of August 26. The reconstruction, begun in September and complete by January 1910, included the railroad and telephone lines, three bridges, field tanks, gathering lines, pumping station with two 200-h.p. boilers, two Worthington 16x25x18 pumps, and 42,000-barrel working tanks, and identical station and tanks about midway, and the main line, except that its terminal was no longer at Cobos. The pipe went another 7-1/2 miles under the river, “nearly as broad here as the Hudson,” and down to Tuxpan Bar. In new construction there were another powerful station, two 55,000-barrel storage tanks, and most remarkably, more than a mile out into the Gulf, a six-inch submarine line, projected to end some 30 feet under water in a universal joint and a flexible tube, this to be chained to a buoy on the surface, where it could be hauled up for leading anchored tankers. Then in a Norther the submarine line disappeared. Reconstruction resulted by March, 1910, in two six-inch lines, one 3,608 feet and the other 3,150 feet long some 40 feet below high water, each jointed to a 120-foot armored hose chained to a buoy.

The longest and least slowly constructed pipeline was Huasteca Petroleum’s, to move 30,000 barrels a day from the Juan Casiano field north to the right bank of the Panuco River across from Tampico. In October, 1909, while Juan Casiano’s first wells flowed into ground tanks in the field, gangs at the projected terminal (three miles south of the Pánuco) began work behind the west bank of the new Chijol Canal and along the west shore of Tamiahua Lagoon for a 65-mile eight-inch line. Without roads along the canal for the lagoon, supplied from Tampico by barges, a force of hundreds had built by February, 1919, a 55,0000-barrel storage tank in the field, two 40,000-barrel storage tanks at the newly named Terminal, and the line about 40 miles southward. Problems in securing right of way through 7-1/2 miles farther south along the lagoon stopped the line’s direct extension. Instead gangs and crews of altogether some 1,200 men concentrated on gathering lines, pumping stations, more storage, and a road and the main line’s farthest 12-1/2 miles, from the lagoon south into the field. On July 26 Mexico’s biggest well since Dos Bocas, Juan Casiano No. 6, came in flowing 8,000 barrels a day. The initially denied right of way promptly secured, as many as 2,000 men worked there and elsewhere on the spread “with all possible speed.” On September 11 Juan Casiano No. 7 blew in flowing 60-70,000 barrels. The next day the company declared the project finished, including telephone lines from Terminal to the field, a water system, five almost equidistant pumping stations, each with three 200-h.p. gas- and oil-fired boilers, a Wilson-Snyder crank-and-fly-wheel 23x54x8-1/2x36 and the main line from the field all the way to Terminal and its tanks. But as the oil accumulated daily, some gangs and crews continued building. By December, 1910, they had made nine 35,000-barrel storage tanks at Terminal, and begun work on a 1,250,000-barrel concrete reservoir there and another tank farm 2-1/2 miles south.

Such work happened in complicated sequences and patterns. On any spread, however small or large the force at any time, at least 15 and maybe 20 different sorts of working groups would have come and gone by the end. In more or less overlapping successions, based together in a spread camp while their stints coincided, generally at the disposal of the spread foreman, but under a specific boss's command for their daily parts, from sunup to sundown six days a week, some when done gone for good, others to return, they would form from stage to stage several quite different combinations. Some of these groups were like those on other major projects. There would come and go surveying parties, to map and stake the building sites and the right of way 16-20 feet wide (a stake every 200 feet) from the field down to the terminal; a pioneer gang, to prepare the camp for the men to follow; clearing gangs; road-building gangs; hauling outfits, to bring supplies and equipment inland and string telephone poles and pipe along the way; grading outfits; maybe, as from Cobos to Furbero, gangs and crews to build a railroad; a telephone-pole gang; a telephone-line crew; a water-line laying gang; crews of masons, crane men, and structural-steel workers, for the foundations, installation of boilers, chimneys, engines, and forming of a water plant and pumping stations; crews of carpenters, roofers, and glaziers, to close and wire the buildings; machinist crew to install the pumps; a connection gang to tie everything from the field to the terminal together; and an inspection team to test the system and declare it set to carry. But besides there would be other sorts of groups especially for the peculiarities of a pipeline.

One would be tank-building crews, "the meanest men in the oil fields," to hear them tell it. These crews were each to build tanks complete, one tank after another, as many as ordered as fast as they could. Generally a crew comprised a foreman, called the "tank setter," his assistant, or "second guy," and their "tankies," more or less skilled in rigging, cooperage, boiler-making, and structural-steel construction. Different kinds of tank, however, determined differences in numbers, tools, and the time on site. Field tanks, likely to be temporary were small and made of hooped wood staves. The biggest of the common tapered wood tanks, to hold 1,600 barrels of oil, measured 16 feet high, 23 feet across its bottom diameter, 25 feet across the top. To build a battery of several such tanks would take a crew of five or six men with braces and mauls maybe two weeks. But field tanks projected as permanent and all working tanks and terminal storage tanks were large and made of riveted steel plates. The biggest steel tanks, the "55"'s (for 55,000 barrels), would stand 30 feet high and 114-1/2 feet in diameter, bottom and top. All were "hickory jobs," the riveting by hand. The tools were wrenches, tongs, drifts, hickory-handled hammers. To build one 55,000-barrel tank would take a crew of 25 men from start to finish a good two months.

The second stage was making the "tub," assembling the tank's bottom and the first course of its shell, like making a round barge. Since the assembly had to be on supports, to allow the riveting, the supplies would include scores of barrels, boxes, "pig barrels," on special saw horses three feet high and 18 feet long. Two horses, to commence, a few tankies would carry over the grade and put parallel three feet on either side of the circle's center stake, ends even. After them 10 or 12 fellows would carry over the grade the first steel plate, 5'x15' from center to center of the pre-punched rivet holes, 650 lbs., lay it beside the horses, and as the foremen directed center it exactly. Parallel and even with the first two horses, perpendicular to the length of the plate, and every six feet across that middle line of the circle out to both edges, the tankies would array 13 more horses. Taking turns, they would carry the other six rectangular plates one by one for the middle row, lay each across

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Then the setter would organize the tankies for the riveting. Three named for roustabouts would bring the tools, 80-lb. Sacks of 7.16-inch "soft flat-head tank rivets" (3/4-inch long), and buckets of drinking water. Eight to be riveters would get 2-lb. Cross-peen riveting hammers. Eight for holder-ups would each get a 10-lb. Heavy hammer and a sack of rivets. The other four, the calkers, would get closing hammers. The foremen, who needed to keep their hearing, would get some distance away. And the riveting would begin, the riveters and calkers in the open air on top of the bottom, the holder-ups underneath. From the bottom's center outward along the middle row four riveters on their knees above and four holder-ups on their knees below would rivet in one direction, each riveter paired with an older-up, and the other four riveters and other four holder-ups would rivet in the other direction. The hammering made noise even on top 1,000 times that in a factory, deafening and ceaseless, but no one in the din needed to hear to work. Plate by plate in either direction the four riveters moved as the holder-ups under them moved, two riveters along each plate's 15-foot seam with the next row on one side, two riveters along the seam on the other side, the outer riveter and holder-up along each successive seam driving a rivet in its outer corner, the inner riveter and holder-up driving a rivet in the middle, each pair filling the gap from the corner to the middle, removing bolts as they came to them; periodically, along each 5-foot cross-seam with the next plate out, a pair from both sides would fill the gap. Hammering the rivets was work of intense visual concentration and fast, very repetitive action. As soon as the rivet's end was up in the hole and still, the riveter would hit it lightly and straight down to plug the hole. Steadily then but ever harder he would beat it down. After maybe 40 blows in maybe a minute he would have the rivet tight and its end made up flat, and be looking for the next one. So, each averaging about 50 rivets an hour, the two riveters on a long seam, 120 rivets, would flatten them in about an hour and 10 or 15 minutes; a cross-seam, 40 rivets, 25 minutes. Following a plate behind the riveting along each seam, a calker would go on his knees at about the same speed, inch after inch about 12-1/2 feet an hour in extreme repetition, pounding the overlap into the seam to seal it. The work underneath was much worse. There, in noise 10,000 times that in a factory, at the threshold of pain, kneeling low under the trembling steel in a gloomy forest of supports, the shafts of light long the seam showing the holes yet to do, a holder-up under a hammering riveter would hold up the heavy hammer against the driven rivet's head. When the riveter stopped (a last tap), the holder-up would lay down the heavy hammer, reach into the sack beside him, pick out another rivet (maybe wait for the riveter to drive a drift pin into the next hole and pull it out), poke the rivet up into the hole, and press on its head with the heavy hammer. Then taking a blow every second and a half for a minute, he would strain 40 times during the minute not to be jarred off, until he could lay the weight down again, and reach for the next rivet. So altogether in about five hours and 20-30 minutes riveters and holder-ups would finish the middle row, go back to the starting line across the center, and start on the next two seams out, as before in either direction along each seam two riveters and two holder-ups, followed by a calker. Occasionally the foremen would climb onto the bottom and test the rivets, sounding them with a hammer, listening for the dull click of the loose ones, doctoring these with a cold chisel, or dutifully ordering them cut out and replaced. In maybe 5-1/2 or six days of work, having driven some 2,000 rivets and calked over half a mile of seams, the crew would hopefully have the bottom tight.

Then it began the shell. Hammers aside, the tankies would bolt 16 22-1/2-foot-long curved 4”x4”x1/2” steel angles (and shoes) to the bottom’s circumference, lay skids on the ground to slide the curved rectangular shell plates each to its arc of the circle, bring a tripod or two to move around the rim, slide the first course’s 24 specially marked and pre-punched plates into position, hoist, hang, and bolt them horizontally to the angles below and vertically to each other, and build chicken ladders to climb into and out of the tub. (One plate had three big pre-cut holes, the biggest a 20-inch manhole, used instead of a ladder only in emergencies.) The plates were also 5x15 from center to center of rivet lap, but they were ½-inch thick, each weighing about 1,200 lbs. Their holes lengthwise, horizontally, were every 2-1/4 inches, but on the sides, vertically, they were every three inches and in three rows, for a triple-rivet lap. For ½-inch plate and these holes the rivets were ¾-inch cone heads, 2-1/4-ionches long, driven hot. As the setter reorganized the tankies for this riveting, 23 men would work as two heaters, four “hot gangs” (each for a quarter of the course) each comprising a catcher, a holder-up, and two riveters, after them four calkers, and in constant demand on all sides a water boy.

The heaters tended two portable rivet forges hoisted inside the tub and kept near the shell on opposite sides. They would fire the rivets red hot, several in the forge at a time, and each supply the two gangs on his side. The gangs first riveted the angles to the bottom, then the plates to the angles. In the deepening clamor inside the shell about every minute and a half a gang’s catcher would hurry to his side’s forge with a rivet tongs, pick out a bright red rivet, and hurry back to the gang’s holder-up, crouched down at the angle being riveted. In a few seconds the gang’s two riveters, outside on the ground, would stop hammering (except maybe to drive a drift). The holder-up would down the heavy hammer, grab the short tongs lying beside him, take the glowing rivet, poke its end into the next hole, and put the heavy glowing rivet, poke its end into the next hole, and put the heavy hammer against the head. Outside, the two riveters would resume hammering; taking turns beating the end. In maybe a minute and a half they had the rivet down and probably tight, its end made up, still dull red, hot enough to cook a squirt of tobacco juice into instant cement. By then the catcher would have returned with another rivet. So the gangs would go slowly around their arc, pausing only to remove bolts and swig water. And training the holder-ups around the inside, the calkers would go hammering to seal the angles, first against the bottom, then against the plates. The horizontal riveting done, the ringing of steel on steel would stop for a few hours while the tankies rigged scaffolding around the outside of the tub. The clamor would resound again as soon as the heaters had the forges refired and rivets hot and the gangs started riveting the vertical laps, the holder-ups inside as before, and the riveters outside on the scaffold. The triple rows took 60 rivets; a gang would have one probably tight about every hour and 40 or 45 minutes. Then trailing the riveters on the scaffold around the outside, the calkers would go sealing the vertical seams. After probably five days of work, 5,780 rivets and 840 feet of seams supposedly tight, the tub would stand ready to test—some 69 tons resting on the horses.

The test was easy. The spread foreman would have already arranged for sufficient water, hose, and a pump on site. The crew would hoist out the forges, clear the bottom, and rig the hose and pump to fill the tub maybe overnight five inches deep (adding 134 tons to the weight on the horses). Underneath and outside the sett3r and his second would mark leaks, and have the water pumped out. Depending on the pump, this might take an entire day, ideally for the setter a Sunday. Then the tankies would make faults tight, doctoring the detected loose rivets, or (as ordered) cutting them out and reriveting the holes, and recalking bad seams.

The third task was the most delicate, lowering the tub to the ground. "…an event resembling in importance the launching of a ship," it was typically "attended with some degree of anxiety." The foremen would not only give orders, but check closely and continually that all really was right. Having removed ladders and scaffolding, the tankies would set 20 heavy screw-jacks every 18 feet around the 360-foot rim, each jack in a frame standing just clear of the rim but with a foot projected underneath it to support the bottom. One man then at a jack, the setter would shout commands. And as one, 20 tankies would crank the nuts on top of the frames around and lift the bottom plumb off the horses. Crawling under the impending steel, they would putt the horses out lengthwise and sideways. This gave room for several hours of the most despised work. As many fellows as the setter could bend to his orders would crawl back udner the bottom with short mops and buckets of hot asphalt, coat the steel overhead, crawl back udner again with short rakes and buckets of oil, and from the dark center out toward the light scratch the oil into the ground. Then at the jacks again, as the setter commanded, 20 men would synchronously screw the feet down and in half an hour lower the thing plumb to grade.

Fourth was erection of the shell's five upper courses, each like the first of 24 duly curved and marked 5x15 plates. To recommence, the tankies would clear the jacks, rehoist the forges onto the bottom, lift inside and put in the middle (out of the way) a 30-foot-long 6- or 8-inch swing pipe, move timber inside too, build there a 40-foot gin-pole, and rig scaffolding outside and inside around the shell. Then as on the first course they would hang and bolt the second course (lapped inside the first), 7/16-inch plates, each nearly 1,500 lbs., which also took ¾-inch red-hot rivets, horizontally and in triple rows vertically. And reorganized as heaters, hot gangs, and calkers, they would rivet and seal the plates, heaters, catchers, and holdings inside, riveters and calkers outside, except that on the third day of riveting and calking, which would be the last on that course, only one gang and calker would be hammering steel, while close behind them, organized as a shell gang, several fellows using the gin-pole would be rigging the scaffolding higher and hanging and bolting the third course. So they would go up with "ascending inside courses," but faster on each course, because of thinner plates, fewer rivets, smaller rivets. The third course's plates were 3/8-inch thick, about 1,300 lbs., with ¾-inch rivets horizontally and in two rows vertically. The fourth's were 5/16-inch, about 1,050 lbs., again with ¾-inch rivets horizontally, but with 5/8-inch cone heads in the double vertical rows. That high, standing on the inside scaffolding 15 feet over the steel bottom, a hot gang's catcher earned his name, catching in a can the red-hot rivets that the heater below tossed up to him, for him to pass to the holder-up. When the rivets in the fourth course were all down, the work went yet faster. The fifth course's plates were ¼-inch thick, about 850 lbs., with 7/16-inch flat head rivets horizontally and in two rows vertically, driven cold. The setter therefore had the forges hoisted out, more men riveting, and more men in the shell gang. The sixth and last course's plates were like the bottom's, only 3/16-inch, with 7/16-inch rivets horizontally and in only one vertical row. Outside around the top riveters and holders would finally hang, bolt, and rivet 16 angles (and shoes), but lighter than those inside around the bottom, every 4-1/2 inches a 7/16-inch rivet, cold; and calkers outside would seal the joints and the seam. All the work since the tub had gone down to ground, the rigging, driving over 18,000 rivets, closing over half a mile of seams, would be a matter of probably 12 days.

Before the top angles were all on, the setter would have most of the tankies at the fifth task—making the roof. One of them he would have outside bringing carpentry tools and timber to hoist or hand into the shell, others inside taking loads of long 2"x8"'s, 6"x6"'s, etc.,

and stacking them on the bottom. As soon as the riveting and caulking around the top were done, the crew would take down the scaffolds, build ladders again up the outside and down the inside of the shell, and start on the roof' supporting structure. On the bottom around against the shell the tankies would lay 24 15-foot-long 2"x8"s for sills, and fix midway on each sill a short "x8" footing. Then using the >>>pole, they would raise an "outer circle" one after another on the footings 24 probably 28-foot-long 6"x6" posts upright (some to serve also as ladders), tie one after another together about 20 feet up with 1”x6” braces, and spike edgewise on corbels from top to top 24 5"”12"”girders. Likewise in a “third circle” about 14 feet in from the shell they would raise upright 16 probably 29’6”-long 6”x6” posts, tie them to the outer circle’s posts and together with braces, and spike on their 16 5”x12” girders. From the outer to the third circle of girders some fellows would lay edgewise 120 2”x8” rafters, sloping upwards about 5º, while in a “second circle” about 14 feet farther inward other fellows would put up 10 31’-long 6”x6”’s, tie them to the third circle’s posts and together, and spike on their girders. As the raftering continued between the third and second circles, the men on the bottom would put up about 15 feet around the center a “center circle” of four probably 32’-long 6”x6”’s, tie them out to the second circle and together, spike on their girders, and in the very center stand one probably 34-foot-long 6”x6”, tie it high and low out to the center-circle posts, and cap it. Then they would take down the gin-pole, and clear the tools, loose timber, scrap, and trash from inside. The rafters on the girders up to the central post’s cap, the crew would reorganize to lay the roof. A few tankies on the round would hoist materials to others on plank platforms on top. The fellows up there would nail 1”x6” or 1”x12” boards across the rafters for sheathing; on that, roofing felt; and on that, maybe 370 No. 24-gauge 3’x10’ black steel sheets. All this, the supports and the low-toned, supposedly waterproof roof, would take probably two more weeks of work.

A roofed shell, however, was not yet a tank, for working at a pumping station or for storage. There were various appurtenances necessary outside and inside. On the ground a hot gang and calker would rivet and seal to the shell a cast-iron or steel neck through the 20-inch hole in the first course, for the manhole, and likewise fasten flanges through the two smaller holes, usually a few feet to the right, the nearer and bigger of them 6- or 8-inches for the “suction line,” or oil outlet, the other maybe 4-inches and lower for the pipe to draw off bottom water. And just to the right of the manhole, left of the suction-line flange, they would raise, rivet to the shell, and bolt onto the roof an iron ladder. Inside on the bottom a few fellows would install the 30-foot pipe till then often in the way, screwing a swing joint into the suction-line flange, screwing the pipe’s bottom end into the joint, and fitting on the other end, clamp to which they attached a 50-foot wire cable. Up on top directly over the joint other fellows would cut a maybe 3’x3’ hatch through the roof, bolt on a specially punched plate, and install a winch box and windlass, on which they would wind the other end of the cable. If the tank was to be a working tank, there would be about a foot right of the winch box over the side just under the top angle a pre-cut 5- or 6-inch hole in the plate, where they would rivet (cold) a flange for the “discharge line,” or oil inlet, the holder-up inside at that height tied to a chicken ladder to have both hands free. For a working or a storage tank, about four feet right of the discharge-line flange would be a couple of maybe 2-inch holes, where they would rivet flanges for steam pipes, to choke fire. Farther up on the roof, near the center, they would cut a maybe 8-inch hole and fix a "gauge hatch." These essentials 23 tankies could finish in but several hours. Then the fellows outside would join any inside, and clean the bottom.

Everybody out, the covering plate bolted on the manhole, all flanged up and plugs tight, the tank stood complete—except for the final test and last task. With the strongest pump then probably available the test might take four or five days. So would the task. While the setter had 55,000 barrels of water pumped into the huge steel container, the tankies would clear the surrounding grade and build a dike around it, for a firewall. Ordinarily the tank would not spring an egregious leak. Before it was empty again, ready for oil, the tankies would have loaded tools and equipment on wagons and left for the next job.

During the same months it took to build a line's tanks, the other groups peculiarly required to construct the line would be laboring under the same sun up and down the right of way. As soon as the hauling outfit had pipe strung on the ground, these groups would have commenced the task of connecting it—for gathering lines from the field tanks to the initial pumping station and for the mainline between the stations and the terminals—and the three other tasks involved in putting the main line underground. The work on the main line was at best daily exhausting. The joints of line pipe strung along the way, in random lengths averaging 20 feet, were steel, lapweld screw pipe, an average joint of the 8-inch size weighing about 550 lbs. On the front end of each joint was a 6-inch-long collar with 0 threads inside, on the back end a 3-inch-long protector over 20 outside threads. The ditch for an 8-inch line, on the general rule of "two sharp-shooters wide and two sharpshooters deep," was about 16 inches wide, side straight down maybe 24 inches, so that every joint lowered into the ditch and covered counted also as three tons of dirt dug up and backfilled. The only means for handling the pipe and moving the dirt were a few simple tools and human muscle, common labor. Muscles often failed before a day was out. As common as the labor were broken hands, smashed feet, ruptures, and heat prostration.

To construct the line fast, the smallest force would be around 160 men, divided according to task in maybe five specialized gangs, moving one after another along the way. (As they made about 2500-3000 feet a day, they remade camp about three miles ahead of their point of progress about every two weeks.) Ordinarily first would come the laying gang, <u>la cuadrilla de tiende tuberos</u>, the Mexicans called them, a foreman and 40-odd men. Laying the pipeline meant screwing one of the strung joints after another into a thereby continuously lengthened line on the ground alongside the surveyor's staked line. It was a task at once heavy and delicate, requiring intense care, patience, and precision in successive coordinated maneuvers and quickly shifting rhythms, repeated usually 150-200 times a day. In the detailed sub-division of the gang's labor each fellow had a definite sequence of parts that he did again and again. The different routines varied in stress and inevitable effort. "Old cats" would have the commanding and coordinating positions, foreman, stabber, collar pounder, and point. They also typically and the "snaps," the lighter duties. A couple of snappers would be ahead along the string, with a 2-foot swab and a monkey wrench, swabbing joints clean of dirt and animals and removing protectors. The other snaps were clubman, barman, jackman, jackboardman, growler-boardman, ropeman, and mope. The other fellows had the "ass work," subordinate, messier, and more strenuous duties, greaser and tongman. Snappers rarely changed places with ass workers. But the cooperation among the 30-odd fellows who actually screwed the joints together was practically intimate.

Every four or five minutes the gang would have a joint just laid. At that moment the 20-foot-long steel pipe would be up on two pipe jacks, one forward toward its collar maybe four feet off the ground, the other toward its back end, just set up tight in the joint behind, maybe three feet high. The foreman otherwise preoccupied, the stabber would be standing in front of the joint, looking back at it and the men on either side of it. Next to him would be the clubman, club in hand, the ropeman, with four 25-foot lengths of 1-inch rope, and the greaser, with dope pot and brush. A few feet away at the string a couple of barmen would be lifting with caliper tongs the back end of the next joint to lay, and another snapper would be wiping the threads lean. Usually on the left side of the joint as the stabber looked back, a jackman and jackboardman would be holding firm the front pipejack and its brace, some 10 feet to the rear another jackman and jackboardman would be holding firm the back supports, and by them the growler-boardman would be waiting. Behind them, at the connection just made, the collar pounder would be standing, a 2-lb. Ball-peen hammer in hand. Just behind him but out at the end of a maybe 15-foot-long wooden lever, the mope pole (its short end stuck over a block and under the new connection), the mope would be waiting. On the right side of the joint, a foot or two behind the new connection, the backupman would be holding up the end of a five-foot-long pair of tongs hooked under the previously laid joint. Forward from him, opposite the jack- and jack-boardmen, would be a crowd of probably two dozen tongmen, pulling down in hard strain on four five-foot-long tongs hooked over the joint. In detail these were the ace, deuce, three, and four lay tongs, hooked respectively at four, eight, 12, and 16 feet of the joint's length; each tongs would have probably six men on it, three on each side, facing each other, called from the inside out butt, five, four, three, two, and point. At that moment the stabber, collar pounder, and four pointmen would have clearly in mind how may joints in a row they had just done, for every 10 they would rest for the next 10, their places taken by another stabber, another collar pounder, and four other pointmen.

Immediately the stabber would command amid oaths of encouragement and insult, "Undress…! Up on the mope…! Out, growler board…! Next joint…! Bar her over…!" The tongmen would unhook the backup and lay tongs, which each weighed about 100 lbs., and drop them, watching out for feet. The man at the end of the mope pole would pull it slightly down, lifting the joint slightly off the pipe jacks. The jackmen and jackboardmen would throw down the jacks and braces and pull them away, the growlerboardman would pull out the growler boards (the foundations on which the supports had stood), and the mope would let the joint down. The growler-boardman would drag the boards forward to their places for the next joint. The jack- and jackboardmen would bring the supports forward to the boards. The ropeman would ready the ropes in four piles near them. The mope would bring the pole and block forward and fix the leverage under the just laid joint's collar. And maybe 10 tongmen would bring the tongs forward. Meanwhile maybe 10 others, "heavers" for their next maneuver, would step with a couple of carrying bars to where the barmen had the next joint, take almost all the weight, and carry the joint over to the line. Into the joint's front and the clubman would poke the club, as a steering stick. The joint's back end the barmen would hold just in front and above the last laid joint's collar. There, probably on the left side and swearing again, the stabber would command, "Dope them threads…! Up on the mope…! Heave…! Put her in the bell…! Up in the round-eye…!" The greaser would paint dope (crude oil and graphite) on the exposed threads, the mope would lift the last joint's collar maybe 2-1/2 feet off the ground, the heavers would raise the next joint high and angled enough, the barmen would move the end to the collar, the clubman in front would align the joint, and the stabber in back would put his arm around it and try to catch its threads in the collar's, praying they would not cross and jam. "Let me feel it," the stabber would bellow. "there she is…! Catch her there, jack…! The other pin…!" Instantly the back and front jack- and jackboardmen would fix the supports at the proper height, again at about three feet in back, four feet in front, to take the weight and keep the alignment. The clubman would withdraw the club. The barmen would remove the calipers. The relieved heavers would toss aside the carrying bars.

At once the stabber would bark, “She’s loose as a goose…! Wrap your tails around her…! Give her an honest roll…! Breakout deuce…!” And he would take his place at the new front end. There he would see four tongmen on the joint’s left side each wrap the short end of a rope two or three times over and around the joint and grip the end tight, 16 tongmen on the right side, four on each length of rope (the points resting), grab the lengths, the collar pounder begin hammering a cadence on the collar of the new connection, then the men on the first and third lengths all pull hard, turning the joint toward them probably a full revolution and screwing a full thread into the collar, then, while they regained slack, the men on the second and fourth ropes all pull hard, turning the joint probably another revolution, and so on in cadenced, alternate, double pulls, until they could not turn it any more.

“Take off your tails, cats, and put on the hooks,” the stabber would command. The fellows holding the ropes on the left would unwrap them, the ropeman collect them, the fellows on the right position the tongs, the backups behind, handles low and tight, the ace, deuce, three, and four on the new joint, handles high and open, and all the tongmen take their places. “Deuce and four, ace and three…!” The points on the second and fourth tongs would press the handles together, so that those tongs’ jaws bit the joint. The collar pounder would begin hammering a cadence on the collar again. As one, the six fellows on the second tongs and the six on the fourth would pull down and turn the joint maybe an eighth of a revolution. Instantly on the collar pounder’s beat the two points down would open handles, the other two points would close handles, and as one the ace and three tongmen would pull down for maybe another eighth of a revolution, by which instant the deuce and four men would have recovered for the next pull. So, fast and as rhythmically as the hammer rang, the tongmen would iron the joint on, but not to the end. Maybe two or three threads still to go, the turns would be too short for the strain. “Now all together,” the stabber would command. The collar pounder would change his beat, and as one all 24 tongmen would pull down for maybe another full quarter turn, again and again. “Hit her like you live…! Hard…! High like a tree and down to the velvet…! Bounce, you cats, bounce…!” Maybe the stabber would see some of the second and third tongmen failing. “Windrow,” he would bark, “snappers load on…!” The exhausted tongmen would stagger aside, replaced by a clubman, ropeman, and growlerboardman. The stabber would know precisely when the fellows on the tongs had buried the last thread into the collar. “That’s high!’ he would cry. “Ring he off, collar pecker!’ And that ring would mean that joint laid. This was how mountings happened maybe 200 times a day on level stretches, in 200…moments of collective…concentrated…length summoned and spent…and again, until the foreman screwed the bull plug to the front collar for the bit (Towl, 414) ?

Where the surveyor's line went through hilly country, the laying gang made slower progress. Every 10 or 12 joints it might have to spring or bend a joint. Ordinarily it did the bends cold, the joint already set up, the biggest tongmen sitting on the front end extended over a pipe jack. Occasionally a joint would buckle, or break out of the collar behind. Then the gang would have to unscrew it, dump it aside, rob the string for a replacement, lay it, and try the bend again.

Crossing water was slow too. In swamps and shallow streams the gang would simply use boards for footing, build dams, get wet, and raise the jacks higher. Across a river it would lay the joints on a raft tethered from bank to bank and pulled along as the line lengthened. Struggling against disastrous shifts of balance on the raft, the tongmen would bolt around each connection a 500-lb. cast-iron clamp, to strengthen the line and weight it so that it would sink. The slowest struggle was laying the submarine lines off Tuxpan, one 3608 feet, the other 5150 feet from the beach out into 40-odd feet of sea. The two gangs there laid the lines as if across a river, hauling the first lengths through the breakers, laying the rest from continually reanchored barges to extend the lines as far as ordered; and the diver who rigged the armored hose on the ends reported bad bends and twists in the last joints.

About a day behind the laying gang on a hurried cross-country pipeline would come the second socialized group, the ditching gang. It would consist ordinarily of a foreman and 40-odd "muckers," i.e., common ditch-diggers, zanjeros as they called themselves. From surveyor's stake to surveyor's stake, with picks, No. 2 round-point, long-handle shovels, sharpshooters, and No. 4 square, short-handle shovels, these fellows would open the ditch, trim it to specification, and crumb the rocks and loose dirt from the bottom, banking the spoil alongside the ditch opposite the laid line. Driven hard, they would make the same linear progress as the laying gang before them, the maybe 30 round-shovel men digging each on the average about nine feet of ditch an hour, all the men together removing daily some 370-450 tons of dirt.

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Pull out the three skids to the rear, and a fellow in front would pull out the next three. At two places the foreman indicated, usually about 1100 feet apart, two or three other fellows together on one or the other side of the lifted line would stick pry bars down into the ditch as guides to the opposite side of the bottom. The men on the windlass would then lower the six suspended joints to the bottom, unhitch the rope, and go to the next position. The fellows with the bars would pull them out, shovel enough spoil on the slack to hold it, and go ahead too, leaving the line behind staggered and half-buried in the ditch about every 100 feet. …swamper and teamster would follow, loading the loose skids on the wagon. Averaging six or seven lowerings an hour, the gang would have some 3000 feet of line in the ditch and some 150 skids in the wagon by 10 a.m. At that point the line ahead lay curved aside and still on the ground along the ditch. There maybe 1500 feet behind the ditching gang, the foreman would have the windlasses set aside and reorganize the gang to move the foregoing line over the ditch. The teamster and swamper would proceed stringing the skids. The other fellows would follow in a file about 60 feet long. Three or four on the ditch's spoil side would carefully put the skids one after another to get each behind a collar, while the other 10 or 12, along the outside of the line on the ground, would continually advance sticking pry bars under the joints and squeezing the progressive curve of the line over onto the skids. Averaging 500 feet an hour, the gang by the end of the day would be (as it had been the previous evening) only 300 feet short of the ditch diggers, with 3000 feet of line on the skids behind to lower tomorrow morning.

If the ditch for tomorrow ran through alkaline soil, however, or near brackish water, a responsible foreman would not continue the lowering-in until he had the line going in the ditch protected. Probably the next morning he would have on site not only the regular gang but also a special section of maybe 20 men, in all 35-40 fellows whom he would organize as a papering gang to paint the cool, bare steel line with hot asphalt and wrap it with tar paper. The regular teamster and swamper would continue to load, haul, an unload, but the equipment and supplies were special, axes, a heating frame, maybe 10 or 11 52-1/2-gallon (500-bls) barrels of hard asphalt, rolls of paper, wire, and there was a sled and kettle to drag from site to site along the line. Likewise the fellows who carried and operated the windlasses would work as usual, but with only one hoist, again about every 120 feet, but only to lift the line for painting and papering, then let it back onto the skids. Four others would go ahead as brush and sack men, scraping dirt, blisters, and mill scale off the line into trash sacks, which they left along the way. The newly arrived fellows worked in a kind of shifting purgatory. A kettleman and a dipperman took the worst heat, standing at the kettle of boiling pitch. About every hour, when the painting had progressed about 150 feet beyond them and the kettle was running low, they would have the teamster move the frame and kettle forward about 300 feet. There they would reset the fire, strip the staves off a barrel of asphalt, chop the big black block into handy pieces, dump them in the kettle, melt them, and heat the liquid to 300-350º. Meanwhile nearby a couple of other newcomers would reset a frame horse, unroll paper over it, measure for joints and collars, and cut the pieces. Not far behind, soon alongside, in an hour at least 150 feet ahead, would come a long file of eight painters, each with a 3-1/2-gallon bucket, five painting hot pitch on the joints (two coats in 15-20 minutes), three painting collars. A full bucket would just do for an 8-inch joint, short of the collar, so that every few minutes a paint carrier, one of four such unlucky fellows from the regular gang, would appear at the boiling kettle with an empty bucket, which the dipperman would fill, and then carry the bucket, 30 lbs. Of molten tar, back (or forward) to a painter. Next, as close as they could stay behind the painters and not burn themselves on the still sticky paint, would come in a pack the paperers, three wrapping joints, three wrapping collars. On their heels would come another painter, sealing the paper seams. A few minutes behind him would come the last man, another unlucky regular, wrapping wire tight around the paper. By evening, if all 3000 feet of line needed protection, the covering gang would have it ready for lowering-in tomorrow morning. If this day's new ditch also threatened bare steel, the foreman would probably have 15-18 more laborers on site tomorrow to go ahead with the special section, while the lowering-in gang, reorganized as before, would return and lower the line it had helped to cover.

At the end of the construction, a day behind the lowering-in gang if hurried, would come the covering-up gang. Under foreman, 25-30 laborers in a long line on the spoil side, a fellow with a round-point shovel about every five feet, would steadily work ahead, throwing rocks in the spoil away, backfilling the ditch, and leaving a nice, fresh ridge, each fellow every day moving about 15 tons of dirt. In the rear would be four or five more fellows, picking up thread protectors, broken tong keys, and joints, and other odds and ends, and loading the debris on a slowly advancing cleanup wagon.

So in 1910 the work proceeded for Mexico's (and Veracruz's) fourth crude-oil pipeline. By mid-May Aguila managers had two fields in the Tuxpan district to develop, Potrero del Llano and about 2 miles as the crow flew northeast Tanhuijo, where three freakishly shallow wells were already good for 125 barrels a day, only eight miles southwest of the south shore of Tamiahua Lagoon. They therefore ordered construction to connect both fields with Tampico. The immediate project was a Decauville railroad and a 6-inch pipeline for 6,000 barrels a day from Potrero del Llano through Tanhuijo to a terminal on the lagoon, barges to ship the oil from there to the lagoon's north shore, and another 6-inch, 6,000-barrel line thence north to a terminal on the Panuco River across from Tampico. Promptly a surveying party began mapping and staking a way from about 150 yards north of Potrero del Llano No. 1, the site of the first pumping station, north-northwest through another Aguila lease, northeast through Tierra Amarilla and Tanhuijo, sites of the second and third pumping stations, nearly to the lagoon, north across Las Milpas Estuary and through the little town of Tamiahua, and north-northwest to the right bank of Tancochin Estuary (beyond which lay Mexican petroleum property), altogether about 39 miles. And it found sufficient sweet water for the stations' boilers year round only a few miles up the Tancochin. In June, supplied from Tampico, a clearing gang, hauling and grading outfits, and the other necessary gangs and crews built a landing about six miles up Las Milpas at a place on its right bank called La Peña, two miles northeast of Tanhuijo camp, and began building a wagon road, telephone line, railroad, and pipeline. By July they had the road open from La Peña through Tanhuijo and Tierra Amarilla to Potrero del Llano, about 26 miles. During the summer rains, which slowed but did not stop them, they made alongside the road the telephone line and railroad from La Peña to Potrero del Llano, and did 78-1/2 miles of pipeline from Tanhuijo down to the bend north across Las Milpas. By December they had "near completion" the pipeline from Potrero del Llano to Tamiahua.

Meanwhile in the field, development was usually simple and straightforward. A field or lease boss took charge. A geologist planned a system of locations for drilling holes around and away from the discovery wells, to determine the extent of the pool below. Rigging crews erected as many derricks as current production and expected transportation warranted. Construction gangs made buildings to work and live in. Following the logs of the discoveries as guides down through the formations, drilling crews drilled. Where the holes were dry, as at Juan Casiano No. 3 and No. 5, they marked the pool's assumed limits in their directions, and the next holes in other directions were drilled. Where the holes were producers, so called "inside wells, " e.g., Juan Casiano No. 6, they were piped to storage or shut in to wait for transportation, and drilling continued farther out. Tank-building crews might erect more tanks. And connection gangs, special outfits of pipelayers and pipefitters, connected wells to tanks and eventually the tanks to the pipeline. But development too sometimes presented surprises, the greatest of them in 1910.

The first was in the Juan Casiano field. There, only 10 miles south of Dos Bocas, the big gusher that the frilling crew brought on at No. 6 in July 16 increased its flow to 14,000 barrels a day in August, and the whale that blew in at No. 7 on September 11 at 60-70,000 barrels flowed steadily at 35-40,000 barrels a day. It seemed natural to the men in the field that so close to Dos Bocas there was so much oil. It was the oil's evil stink that surprised them. Dos Bocas's vast and poisonous gases were supposedly vapors, the result of the oil exploding and burning and steaming in the crater. There was no fir or steam at Juan Casiano. Yet the oil smelled like an emanation from hell, so "very sulphurous'; that a good whiff would give a splitting headache, and a couple of minutes of it would knock a man cold. Nothing extraordinary (by oil-field standards) proved necessary to control the oil. In mid-August Nos. 1, 2, and 6 were easily shut in. No. 7 was harder. Although the blowout was shut in, the flow would not be stopped. Its pressure rose so high, 535 psi at the valve, that it lifted the casing off the bottom and made oil springs come up 100 yards away, 3,000 barrels a day. But in short order tankies built a 10,000-barrel iron flow tank on a hill 1,500 feet north, and a connection gang cemented the casing and laid a 6-ionch line from the well head up to the tank and another from the tank eastward down to the field's two 55's. Under 400 psi. at the valve, with some leaks, the well flowed about 15,000 barrels a day into storage. But the stink only reconcentrated at the flow tank. "…a continual cloud of gas floats over it," spreading whichever way the wind went, across the public road nearly a mile north, into the settlement of Chapopote on a ridge a mile south. And as around Dos Bocas, animals, birds, and the fish in the streams around Juan Casiano began dying, insects disappeared, and soon the grass and weeds and tress died. In mid-November the gas killed three local people in their house.

The most annoying surprise occurred, however, at Potrero del Llano. After well No. 2 came in on May 12, proving the field and "its enormous gas pressure," development there took shape according to progress on the pipeline. As the consulting geologist instructed his young American protegé in charge of the field, drilling was to make holes at as many locations as possible, but none as deep as the known pay sand until the pipeline was almost ready for oil. Well No. 3, over a quarter of a mile north-northwest of No. 1, deepened easily. On May 7 the drilling crew had spudded through 20 feet of gravel and heavy chapopote into blue and white marls and shales. Crew and roustabouts had set and clamped 13-inch casing at 72 feet. And the footage then came very fast. Running a screw every hour and a half or two, the drillers kicked down nearly 500 feet a week, past a show of gas at 420 feet, more gas and some oil below 1375, for 10-inch casing to 1435 feet. Into reddish shales at 1735, limestone at 1835, the crew had a big hole for the intended pay string of 6-5/8-inch casing run to 1878 feet. Down through two more feet of limestone, two feet of iron pyrites and limestone, four feet of marl, then into sandy limestone, it got 189- feet by

June 4. There only four weeks after starting it stopped drilling, supposedly "at the top of the Tamasopo limestone," hopefully just above the pool, and [capped] the hole.

The summer rains did not interrupt the work in the field either. Nor did it matter that the pebble pup took a French leave (to get married in Oklahoma and install the bride in Tuxpan). A rigging crew finished the derrick at No. 4, about 330 yards west-southwest of No. 1, down by the banks of the Buena Vista. From No. 3 roustabouts brought the cordage, machinery, tools, and appliances. And after refitting connections from the field boiler, another cable-drilling crew rigged up, put on a roof for the rain, and spudded in No. 4 on June 9. This hole was harder and slower going, but nevertheless promising. Through sandy gravel and boulders crew and roustabouts sank the drivepipe to 45 feet, and the drillers spudded to 35 feet by Saturday, June 11. Into blue marl and shales at 52 feet on Monday the drillers pounded down for crew and roustabouts to pull the drivepipe and [set] 13-inch casing at 77 feet. As the hole deepened, the drilling went faster, down to 400 feet by June 18. Below 700 feet by the middle of the next week the crew found oil flowing heavily, almost filling up the casing. Even so, continually bailing the oil, it had 835 feet by June 25. The pebble pup returned, reported to his chief in Washington, D.C., and promised him frequent bulletins on the field. Below 900 feet the flow of oil ceased, and the drilling slowed, to 1127 feet by July 2. That deep on Monday, after shortening the first string, crew and roustabout [set and clamped 10-inch] casing. The drillers made footage only to 1473 feet by July 9, 1755 by July 16. The next week the bit hit lime shell at 1814 feet, and oil began seeping into the hole behind the 10-inch casing. Into sandy shell at 1819 feet, lime rock at 1845, oil still seeping, the crew deepened for 1846 feet of 8-inch casing. This, because of the seepage, it cut short at the top inside the 10-inch to 8-inch, which it also cut short, fitted with a 10-inch to 8-inch swedge nipple, reclamped, and retopped with a 3-1/2-foot 8-inch piece for the head. At 1856 feet on July 23 it stopped drilling and shut the hole in.

Meanwhile construction gangs supplied both from Tumbadero and from La Peña had built and fenced a field camp. Along the hillside from 200 yards southeast to 400 yards south of No. 1 were a blacksmith shop, corrals, a storehouse, an office, a library, "men's quarters," and "married quarters." North and farther south were "peon houses."

On July 29, over a quarter of a mile south-southeast of No. 1, a rotary crew commenced drilling No. 5. Through the same formations as at the other locations it made hole at fine speed, setting 13-inch casing at 37-1/2 feet and cutting down at nearly 600 feet a week to 1836 feet on August 20, when it stopped, set 8-inch casing, and [capped] it. By then the pebble pup had made five more locations farther out. On September 11, about 300 yards east-northeast of No. 5, a rotary crew using the machinery from No. 5 commenced drilling No. 6. Through yellow, sandy clay, gravel, and boulders to 30 feet, where it set 13-inch casing, down through layers of blue marl, limestone, and shales, it deepened the hole to 1835 feet by October 13. And [shut it in].

The consulting geologist advised drilling the four suspended holes before trying outer locations. As the rains ended and work on the pipeline proceeded, laborers and teamsters with fresno scrapers dug a reservoir between Nos. 1, 2, 5, and 6 to hold some 50,000 barrels. Told the pipeline was "near completion," the pebble pup on December 1 had Well no. 1 opened into the reservoir, and from December 4 to December 11 had No. 2 opened into it too. He estimated the combined flow as he expected at about 1,000 barrels a day, not enough for the pipeline, and ordered a cable crew to drill ahead at No. 4, where more tools remained than at any of the other locations. He would have the other holes deepened as soon as he could. It would take 112 500-barrel wells to run the pipeline at capacity.

On December 23, a Friday, the new crew reopened Potrero del Llano No. 4. It found so much oil in the hole that it spent hours bailing it clean before drilling ahead. On the Saturday tours the drillers deepened from 1856 feet into a formation they knew from the slush was hard shale. They therefore did not bother to put a control head on the casing; they would put it on when they hit the Tamasopo limestone, or some other reason for precaution. They noticed but did not worry that the bit was wearing on one side, as if drilling in faulted and broken stone. Sunday, a day off and Christmas besides, the consulting geologist himself visited the location. The hole was then 1904 feet deep. A "somewhat discouraged" driller wondered if the crew should go deeper. The geologist predicted "a good supply of oil" just 12 feet farther down. He and the pebble pup left for Tuxpan. The Monday tours passed, much bailing to clean the hole again, a little drilling, still in hard shale, and still without a (control) head.

At 2 a.m. Tuesday, December 27, the pusher later recorded in the log, "We struck oil at 1911 feet. The well broke loose absolutely without any warning, throwing the bailer, which was in the hole at the time, clear out of the hole. We got boilers shut down at once." The driller on duty gave a longer and more pungent account to the pebble pup a few days later:

"I had just come on the Blankety blank tower and we had a blankety little blank blank gas. I run a littler water in the blankety blank old blank but she wouldn't mix. I says to [the toolie], 'Stick the blank blank pipe in the blank bailer and tie up the blank dart.[‘] We run in some more water and I stuck my hand over the blankety blank hole and felt a little gas. I says to [the toolie], [‘]See what a little blank water will do’. Jist then the old blank shot the bailer up against the roof and the blank blank blank things comes down through the derrick roof. [The toolie] fell out backwards through the blank forge room and by blank blank blank I crawled through the blanked little hole under the bull wheel and run my blankedst out into the mote but I couldn't hardly get to camp and the blanked thorns tore my face and by the blankety blank blank I wuz gassed. I crawled on my knees a trying to get the blanked fire out an when they wuz I wuz gassed. I'll tell you, it's the blankedst blank biggest well I ever worked on and the gas is so bad that I wish that I hadnt ever seen the blanked blank thing and the blanked blank gas certainly is bad.”

In fact this was one of the biggest wells anyone anywhere in the world had ever worked on. Through the dark hours of Tuesday morning its terrific roar and gas (carbon dioxide, methane, hydrogen sulfide, butane, and propane) spread fear among the men in the camp that the entire field would explode. The night sky rained hot oil and chunks of hard, white, flinty limestone. The air because heavy, foul. By the early light the great gusher was finally visible. From up on the hillside, oil rain soaking into their skin, the constant roar in their ears, a choking stink in their nostrils, heads aching, eyes burning, the men saw an 8-inch column of black oil rising from No. 4 some 230 feet into a gigantic black plume of spray 425 feet high. Only parts of the derrick and rigging still stood. The bull wheels lay broken in two, blown from the floor 24-30 feet away. Oil slick covered everything for a mile around, and oil streams were running into the reservoir and down into the Buena Vista, covered from bank to bank by oil on its way down to the Tuxpan River and on to the Gulf. Measured later, the pressure at the casing head was 850 lbs. Psi; the oil's temperature, 147º. The pressure estimated in the pool 1911 feet below was 1555 lbs. On Thursday, december29, the drill who had made the strike left the field. The same day the company's general manager arrived. He calculated the well's flow then at “over 1000,000 barrels in 24 hours,” but still going grandly into the air and downriver. Figuring the pipeline would take another three or four weeks to be ready to operate, he immediately ordered work to enlarge the 50,000-barrel reservoir to hold 3,000,000 barrels.

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The work of pipeline transportation began in Veracruz in November 1908, when San Cristóbal No. 3 oil was moved from field storage down the Pearson line 14-1/2 miles to terminal storage at Minatitlán. By late 1910, on the three crude-oil pipelines then complete, 21 wells were connected to terminals, and the work happened in several districts. Until lately it had been happening only off and on. For lack of oil, the Pearson line could not be operated but once a week, or two, or three, in 1907, 1908, 1909, and 1910. For the same reason the Oil Fields of Mexico line from Furbero to Tuxpan was also much more idle than in use in 1910. Huasteca, however, had oil aplenty for its pipeline, and the work that began from Juan Casiano to Terminal on September 20, 1910, continued without interruption. For lack of storage at Terminal this line did not carry its capacity. Even so, from September through December 1910, it transported nearly 15,000 barrels a day. Added to the other lines' freight carried, this brought the year's total pipeline product to some 18,000,000 ton-miles.

Like operations on a railroad, the work of pipelining generally comprised measurement, movement, and maintenance. It happened in systematic coordination over long distance. As on a railroad division, a superintendent managed its organization through subordinates in charge of sections; on the Huasteca line the main office was at Terminal. And from railroading came many pipelining words: "run," for example, a definite quantity of oil taken from a field to a terminal. But because the freight was liquid, moved only one way, in flowing became the medium of transportation, and (in Mexico then) belonged to the company that owned the line, the work had special characteristics. It did not involve "running crews," but "station crews." It took place far from public view, strictly in private, practically in secret. And for the work done, the workers themselves were few, only about 300. [see 107, 149, in notes.]

Measurement in the field and at terminals required no more than half a dozen men a line. It occurred first whenever a new tank stood ready to hold oil, as "strapping." On assignment a tank strapper would arrive with steel tapes, depth gauge, caliper, ladder, level, lumber crayon, stencils, brush, paint, pencil, and forms, measure and record the tank's height and circumference, the thicknesses of its shell, and most laboriously its "deadwood" (roof supports, swing pipe, etc.), paint the tank's number on its outside, and finally send the strapping report to the main office. But in all Veracruz over the last several years there had been only 55 oil tanks to strap, and strappers had already done them. To strap Huasteca's new tank being finished at Terminal, one man sufficed.

Measurement also occurred at the tanks in use for storage, regularly and often. As soon as a field tank had filled, it needed running (even on a Sunday). On routine a gauger would arrive with keys, wrench, tank thief, sample containers, gauge pole, thermometer, centrifuge, hydrometer, tank table, pencil, and forms, check the tank's fittings, unlock, relock, open the by-pass, close the tank's discharge valve, drain water off the bottom, close the drain, sample through the gauge hatch the oil in the tank, measure its depth, take its temperature, test the samples for water, sediment, and gravity, record the "turn-on" results on a form, unlock and open the tank's suction valve to turn the oil into the line, leave for the next tank that needed running, return when the run should be finished, close and lock the suction valve, measure the remaining contents, record the "shut-off" results, open the discharge valve, unlock, shut, and relock the by-pass, figure from the tank's table the volume taken, record the run in barrels, and finally send the form as the "run ticket' to the main office. At a terminal too at least one gauger, with identical tools and instruments, sampled and measured the tanks' contents before and after delivery, and sent their records to the office.

But all the sources of oil and terminals in Veracruz then were only 24, and of the 60-65 tanks in use, the ones for storage were about 45. As of September 20, stinking to high heaven, Juan Casiano No. 7 lone was producing the continuous runs through the Huasteca line. For its two 55,000-barrel field tanks there was but one gauger, and aside from the gas, he had it easy, running one big tank for three and a half days, the other the next three and a half. At Terminal, for the two 40,000-barrel tanks and the nine 55's in use there by the end of the year, a couple of gaugers sampled and measured the line's delivery and the runs by subriverine siphon to Tampico.

As on a railroad, movement by pipeline included two paramount prerequisites, one supply of water and fuel for power, but for stationary steam plants. The work to supply pipeline water took place therefore at pipeline waterworks. Their locations differed from more to less pleasant. Most tranquil and charming was the topical park in the green hills 12 miles northwest of Juan Casiano. There in natural fragrance, beside "one of the most beautiful of the smaller rivers in Mexico," stood Veracruz's largest pipeline water plant, Huasteca' Esperanza. Equipped like Huasteca's oil-pumping stations, this was a complex installation. Across its several cleared acres it showed filter beds, storage tanks for raw and filtered water, a 10,000-barrel water tank for local consumption and make-up, gas and fuel-oil tanks, a barn, and a big (about 60x100 feet) concrete-floored, steel-framed, corrugated-iron, electrically lit pumphouse, partitioned into an office, a nicely ventilated boiler-room with three 9 x 19-foot 200-horsepower water-tube boilers and an 80-foot chimney, an auxiliary equipment-room, a storeroom, a repair shop, and a pump-[room with its overhead crane and on the floor like great automatic guns two Wilson-Snyder pumps. With these it could send 100,000 gallons of water every 24 hours down a 4-inch main northeast to the Tamiahua Lagoon, then south up to Juan Casiano, north down to Terminal, in all about 78 miles. No such volumes were yet necessary, however. At all the pipeline waterworks pumping was intermittent. At Esperanza, where it was regular and most frequent, it happened daily, but only for some 15,000 gallons, which took only a few hours during the working day. Housed in a couple little dwellings on the plant's grounds, the operating force was only three men, hierarchically an engineer, a pumpman, and a fireman. There was also a helper and a fellow who did the cooking and laundry.

Every day the men in operations worked around the same cycle. At 7 a.m., when it was light outside enough to see, the engineer would gauge the river's flow, check the intakes, filters, and gates, look for leaks around the tanks, note the water and gas pressures, sample and test the water, make the rounds of cold inspection through the pumphouse, start the dynamo in the auxiliary room, and from the office report by telephone to Terminal, to make sure the telephone was in service and to confirm the pipeline's needs for the day. Meanwhile inside the pumpman and the fireman would make their respective preparations. The pumpman would check the machinery, the main pump, Unit No. 1, which was the 28 and 54 x 6-1/2 x 36", a 62-1/2 ton, 20-foot wide, 40-foot-long high-duty Corliss-type crank-and-flywheel cross-compound condensing duplex pumping engine, and the auxiliaries, the condenser's air-and-circulating pumps, the hot-well pump, the feed-water pump, and the fuel-oil pump, feeling and seeing that connections were strong, joints tight, stuffing boxes well packed, valves and seats tight and smooth, all easy working, the engine's valve-gear disengaged, bearings adjusted and greased, and all oil cups clean and full. And the fireman would gauge the oil tank and check the hot well, the feed-water heater, the fuel-oil heater, and the boiler to be used that day, its exterior, fittings, fixtures, water level, and gas- and oil-furnaces. Meanwhile outside the helper would clear the river intakes.

About 8 a.m. the engineer would order "starting operations." He himself would open the by-pass gate, counting the turns to make sure it was open. The fireman would lift the boiler's safety-valve, pump water by hand into the drum to due level, purge the furnaces, open the damper duly wide, light a torch in the gas furnace, turn on one burner for ignition, look through the peephole for a clear blue flame, let the furnace and water-tubes slowly heat, turn on the other burners one after another for more heat, keep checking for the blue flame, wait a few minutes until steam rose from the safety-valve, open the stop-valve, close the safety-valve, with mounting steam-pressure turn on the feed-water pump, turn off the gas, cut the damper, turn on the fuel-oil pump, the atomizing steam, and hot oil, and get ignition again, then gradually increase the spray for full heat, peering through the peephole to see that he had a soft, voluminous, yellow-white blaze, no sparkles, a slight bluish haze in the gases. In time with him as soon as the boiler began to heat, the pumpman would open the main pump's discharge, drain-cocks, and throttle and the condenser-pumps' cocks and valves, let the boiler's hot air and vapors through the engine's cylinders, bar the engine over by hand a few turns, with mounting steam-pressure give the engine some very slow turns to clear any condensation, close the drain-cocks, engage the valve-gear, oil the governor's gear, and watch and listen as the motion accelerated to full (but idle) speed, around 4 rpm. Finally about 8:00 the engineer would very slowly close the by-pass, counting the turns, gradually giving the engine its full load, up to about 1200 psi in the main, to take evenly through the pump about 78 gallons a minute and move evenly forward through the long pipe some 1120 tons of water at about 120 feet a minute.

There ensued "normal operations," which took about three and a quarter hours. The engineer would make the mechanical and hourly recording rounds. The pumpman, walking slowly around and around the great engine, would simply watch and listen to its slow, regular motion, see that lubrication continued, wipe errant drips of oil away, feel that bearings stayed cool, periodically check the condenser, and pray that nothing broke. The fireman, "cool, calm and collected as a sexton in a church," would blow off the gauge-cocks, blow down the water column, wipe any wet surface dry, then simply watch the pressure-gauge for steady steam, listen to the constant muffled roar in the furnace, keep an eye on the water level and the fire, periodically check the feed-pump and fuel-pump, and pray that nothing exploded. And through the tropical morning the helper would tend to the filter beds and grounds.

Near noon the engineer would order "shutting-down operations." The fireman would gradually turn down the oil to off, wait a few minutes until the steam pressure fell below 50 lbs., blow off the mud drum, wipe the wet away, wait a few more minutes until the pressure-gauge read zero, slowly close the stop-valve, and button up to save heat for tomorrow. As the engine slowed nearly to stop, the pumpman would disengage the valve-gear, watch the motion die, and close the throttle. The engineer would let the discharge pipes drain, close the head and tailgates tight, and finally by noon close the main pump's suction and discharge.

The rest of the working day was almost like trade school. The engineer would do inspection, minor adjustments and repairs, and the daily report in the plant's log. The pumpman would study pump connections, joints, packing, valves, gears, journals, bearings, cylinders, and piston rings, and polish brasses. The fireman would research that day's boiler for scale, oil, soot, silt, sticking or dripping valves and cocks, bad rivets, blisters, cracks, and rust, and clean its gauges and peephole. And inside for the tropical afternoon the helper would tend to the plant's buildings.

The work to supply fuel was also intermittent, but much less powerful. It happened for Esperanza usually once a week, when a boat crew from Tampico brought a launch through Tamiahua Lagoon and some 25 winding miles upriver, to deliver 10 or 12 barrels of oil and a couple cylinders of bottled gas (and groceries0. It occurred directly and easily at pipeline stations, usually twice a week at a Huasteca station: one of the crew would open and close a few valves to take 100 barrels of oil from the station's storage into its low fuel tank.

On the consequent steam, movement took place at pipeline pumping stations to make the runs of oil go from field to terminal. Unlike operations at waterworks, this work was never pleasant. It happened on strict schedules, hourly sequential, minutely repetitious, in constant tension, and most heavily in the mind, combining some of the sorts of attention exacted at power plants with some of the sorts exacted at railroad stations. "Normal operations" were exhausting. On the intermittently pumped pipelines they typically lasted four or five tours in a row, long enough to overwhelm any relief at shutting down. On the Huasteca line normal operations were morning and afternoon tours every day and night, every week, month after month. It was this work that took the most pipeliners, on all lines some 75 men. On the Huasteca line, for both tours at five stations, the men in operations usually numbered 42.

The locations of pumping stations differed from more to less godforsaken. On a pipeline with two or more stations, they also differed as between initial and intermediate, and ordinarily in elevation. Of Huasteca's five, the first (as the oil went) was Casiano. Up in the field nearly two miles east of the poisonous well, but often befouled in a sulfuric stench, it stood in desolation behind a rise 500 feet above sea level, south of a broad valley open eastward to the flats along the Tamiahua Lagoon. About eight and a half miles north-northeast as the crow flew, 10 miles by the company's road, 20 kilometers by the pipeline's curves eastward and big bend north-northwest, was the second station (in smelling distance of Dos Bocas), San Geronimo. It stood 15 feet above sea level, on the right bank of an estuary into the lagoon. Another 20 kilometers north-northwest on the line was the third station, La Laja, 65 feet above sea level, on the right bank of another estuary into the lagoon. Yet another 20 kilometers north-northwest was the fourth station, Horconcitos, at the same elevation but in the downs a couple miles inland from the lagoon. Twenty-four kilometers farther north-northwest was the fifth station, Garrapatas, 35 feet above sea level, behind a dune overlooking the lagoon and before the line's last 21 kilometers north-northwest to terminal (about 65 feet above sea level).

As an initial station, Casiano had two distinctive workers. Day and night seven days a week in the recurrent stink, in a special office with operating maps, charts, and tables, blinking, ever short of breath, often fighting nausea, a morning or an afternoon dispatcher controlled by telephone the maneuvers at Casiano and the four other Huasteca stations to move the oil in relays from station to station, under about 200 psi. in the line, at not quite two miles an hour, down to Terminal. Since production was steady, runs continuous, dispatching there was very repetitious and almost all mental. (The principal complication was the gas.) Staying conscious, which was hard enough, a dispatcher might pass his entire tour in accumulating and examining information. Hourly, according to the daily synchronized station clocks, he heard by phone reports from all five stations on the pumps in operation, pressures and speeds, and on the gauged quantity, gravity, and temperature of the oil each had received, into which working tank, every hour about 620 barrels at 23º Beaumé and 123.8º Fahrenheit going into the line. Hourly he also heard from terminal on the oil taken there (the same number of barrels, although heavier and cooler) All these figures he recorded. Studying them by the hour, he looked for signs of increasing friction in the line, change in the oil, and any "over" or "short" (evidence of possible leaks along the way). But the moments of action were critical, to dispatch necessary and exactly correct orders. Some were necessarily experimental or occasional, a call, for instance, for a station to raise or lower its pumping pressure so many pounds. Others came as periodic climaxes; four days a week, three days a week twice, at the right time day or night, one or the other dispatcher would call an operating order to the station nearing top on receipt and bottom on delivery, to open and close the valves to switch its tanks and keep the runs continuous.

Otherwise, in plant, program, personnel, and practice, the five stations were virtually identical. Each on its few cleared acres showed a pair of reeking 55,000-barrel working tanks, a manifold, California-style oil heaters, a 10,000-barrel water tank, gas and fuel tanks, and as at Esperanza a big electrically lit pumphouse partitioned into an office, a boiler-room with three 200-horsepower water-tube boilers, an auxiliary room, a storeroom, a repair shop, and a pump-room with two great Wilson-Snyder pumps. At each station Unit No. 1 was as at Esperanza a 28 and 54x 6-1/2 x 36" Corliss-type crank-and-flywheel cross-compound condensing duplex pumping engine, able on power from one of the boilers to pump 25,000 barrels of oil a day. From station to station, given the different elevations, different underground water, steam, and oil connections, and different profiles and distances to overcome, given also the experimentation going on, the boilers made steam at different rates and the pumps ran at different pressures and speeds. But the differences were slight, in pressure, for example, for 180 to 220 psi.), and as particularly set, adjusted, and readjusted, all to carry only 60% of capacity, all five boilers and all five pumps on the line functioned together, each in the same way its counterparts up or down the line functioned, all to take and send down 620 barrels of oil an hour. (Unit No. 2 at each station, the 24 and 42 x 9-1/2 x 36", a 25-ton, direct-acting compound condensing duplex, was for stand-by, able on power from two boilers to pump 30,000 barrels a day, but much less efficiently.) And at each of the five stations doing the work was its "station crew." Housed in three or four little dwellings, the operating force was ordinarily eight fellows, hierarchically a chief engineer, an assistant engineer, two telephone operators, two pumpmen, and two firemen, four fellows on the morning tour, four on the afternoon. There was besides a couple of helpers and a cook and his helper.

A station's chief engineer bore enormous responsibilities. These included the pipeline and the oil in it from the station half-way to the next stations up and down the line (from Casiano west to the well), the station's underground connections (the location of which supposedly only he knew), the oil in the working tanks and heaters, and the buildings, machinery, equipment, and supplies. But as day after day passed in constant service, without a breakdown, the chief and the other fellows in the force worried not over enormities but over operating details, no starting, no shutting down, all intensely normal.

Tour after tour, the details were therefore almost the same. From midnight to noon the assistant engineer was in charge. Hourly in the station'' office, with its map, chart, tables, and the information he had collected, he composed the report for the dispatcher. Often in the pump-room he checked the pump in operation, reading its gauges for pressure, speed, and temperature. At least once in the auxiliary room he checked the dynamo. And whenever a dispatcher's order came, he took it, recorded the time on it, signed it, filed it, and himself executed it, going out to the manifold once or twice a week, opening the by-pass valve, turning the gate valves to switch the nearly full tank from discharge to suction and the nearly empty from suction to discharge, shutting the by-pass valve, counting the turns on every valve. Hourly in the office too the telephone operator called the engineer's report to the dispatcher. At 7 a.m. and thereafter on the hour to noon he tightened his guts, went out and always on the windward side gauged the working tanks, figured to "over" and "short," and reported to the engineer. At least once a tour in the auxiliary room he checked the switchboard. And whenever the telephone rang, he hurried to answer, transcribed the message in duplicate, handed one copy to the engineer, and filed the other. Meanwhile hour after hour in the pumproom, walking slowly around Unit No. 1, its great crank turning and turning at say 21 rpm., its big cylinders steadily breathing steam, its small cylinders steadily sucking hot oil, steadily discharging hot oil, the pumpman watched the exactly regular motion of the eccentrics and rods and rocker arms, listened in the silence of noiseless gliding for any knocking or pounding or groaning inside, wiped and wiped, every few minutes read gauges and felt main bearing caps, and hourly checked the lubrication, most carefully that oil still glistened on the steadily stroking piston rods. Once a tour he briefly left the engine to check and oil the hot-well, feed-water, and fuel pumps. Meanwhile alone hour after hour in the boiler-room the fireman stood in front of the boiler in use, watching pipes and valves for drips of water or fuel, every few minutes reading water, fuel, and pressure gauges, and peering through the peephole to see that the fire remained a steady yellow-white, no sparkles. Once a tour he blew down the water column and checked the gauge glass. During the night the helper tended to the pumphouse, in daylight to the grounds.

From noon until midnight the chief engineer was in charge. As the morning fellows had done on their tour, so he, the afternoon telephone operator, the afternoon telephone operator, the afternoon pumpman, the afternoon fireman, and the afternoon helper on theirs, with four extra details. On the last hour before dark, when the operator took the day's last gauge of the working tanks, he also took the day's only gauge of the water and fuel tanks, for report to the chief. Toward the end of the tour the pumpman gauged the lubrication-oil barrel, figured the day's use, and reported to the chief; and the fireman checked the safety valve and blew off the mud drum. And at midnight the chief did the station's daily log—maximum hourly pump pressures, barrels of water and fuel used, gallons of lubricating oil used, etc.

Pipeline maintenance happened meanwhile as the main offices generally directed men continually on the move. It resolved in practice to four routines, keeping the right of way clear, looking for trouble on the line, stopping oil leaks, and cleaning oil tanks. This being Veracruz, brush and vines growing rampantly, every right of way had a clearing gang reclearing it every few week. Worse than the overgrowth was trouble, anything else that threatened the flow down the line. Naturally it could appear any day anywhere on any line: deteriorated or damaged telephone line, boggy backfill (underground corrosion), but primarily leaks (too small yet to show in loss of pressure, but sure if neglected to threaten the flow eventually) and washouts, which could suddenly let the line shift or fall, break and lose thousands of barrels of oil.

On every line therefore looking for trouble was ordinarily a daily movement. Like railroad trackwalkers and powerline patrolmen, the men who did the looking were "linewalkers," who did not just walk but "covered" the lines. They were very few, one for the Pearson line, two for the Oil Fields of Mexico line, two for the Huasteca line. Rain or shine, they daily hiked alone and sharp-eyed up or down the respective right of ways. Doing the job right, they did not go the straight and narrow shortest way. Since a little leak might seep to surface 50 feet off to the side of a line, they zigzagged the ways from side to side, often walking twice the distance they covered. And they did not go lightly. Along with slicker, troublebook, and pencils, a line-walker usually carried some 50 lbs. Of gear; climbers, wire stretcher, pliers, plug boxes, portable telephone, hatchet, shovel, hammer, caulking chisel, and if he was pessimistic or smart (or both) extra boots and a pistol. If he found no trouble, he would cover 12-15 miles a day, walking that day or however many more were necessary from the head of the line to its terminal, then back, then forth again'; nights he would report all clear and sleep at a station or way shack or the terminal. So every week the two Huasteca linewalkers, one from north to south, the other from south to north, weekly changing about, covered the 65 miles between Casiano and Terminal plus midway the trip up to Esperanza and back, in all 88 miles. By the end of the year each of them in his searches had walked probably 2,000 miles or more.

Trouble appeared in all its natural forms most often on the bejungled and beswamped San Cristobal-Minatitlán line, where by 1910 the Pearson main office dismally directed the state's champions at stopping leaks. On these lines as on the others when a linewalker found any trouble, he would note it in the troublebook. If it looked as if it could wait, he would report it that night. If it looked urgent, a leak or a washout, for example, he would climb the nearest telephone pole, cut into the line, and report to the office. Most leaks looked minor, meaning ones that a linewalker himself could stop. Following the seepage, maybe digging for hours, he would find the source, commonly a bad collar, caulk it tight, refill the ditch, and hike on. But the line sprung so many leaks that some days a linewalker spent less time hiking than climbing, regrouting, digging and caulking. And increasingly by 1910 the leaks were major, from corrosion, cracks, and breaks in the pipe. To stop such a leak it took special pumping operations that drained the line of oil—and a special repair gang, a ditching, laying, papering, lower-in, connections, covering-up gang all in one, which would go out on call to the trouble, trench along the bad joint, maybe just patch it, but maybe cut and remove the bad piece, lay in its place a good piece, true the fit, flange the end tight, and solidly rebury the line.

Every day anywhere from Casiano to Terminal, from Furbero to Tuxpan, from San Cristobal to Minatitlán, linewalkers also looked for human trouble, not persons in distress, but people with “no business” along the way. Main offices had special forces of pipeline guards to prevent and eliminate these threats. If a linewalker found intruders, he was to chase them off (if he safely could and at the next opportunity report them. A seemingly innocent boy might be a scout. Maybe idle wanderers were really out to take revenge on the line, to vandalize it, burn a telephone pole or shoot into the line where it crossed a creek. Maybe, particularly around Minatitlán, they were bandits or rebels. Even if the linewalker found only trances of such trouble, the guards were to search the troubled area. Ordinarily stationed at the head of the line, they were only a few men, four or five, but armed and mounted, with reserves if advisable, they would quickly ride down and usually catch, questions, and punish some suspects.

The contents of oil tanks made cleaning them periodically necessary. All Veracruz crude oil came blown with gas, but cut with water, salts, sand, asphalt, resins, paraffin, and dirt. Any tank small or large into which crude was discharged and from which it was sucked gradually collected under the oil ever more water and under the water an ever deeper and ever heavier emulsion, ”b.s,” for “bull shit” or “bottom settlings.” This accumulation mattered mainly as a waste of the tank’s capacity.

Of all a main office’s operating concerns then, cleaning tanks figured least. It was never an emergency, only a recurrent nuisance, a series of expected jobs. And it never took more than irregular cleaning gangs of common laborers. From routine gauges of all the tnaks on a line, the office would keep track of all the various rises in water and b.s. Eventually one or another tank’s waste would reach the customary limit, 3% 4 inches below suction. The office would order a cleaning, at a time least inconvenient for the tank to be down. The gauger or engineer responsible would run the tank’s oil, but take no more. And the gang having arrived would remove the waste and leave the tank restored to capacity. No tank got a cleaning very often. The neediest were field tanks, where crude oil cam fresh from the well and cut the worst, but even the busiest field tank was down only about once a month. No gang was large, for a 2,000-barrel tank only two or three men, for a 42,000- or 55,000-barrel tank only 10 or 12 men. And no job took long. A 55 with water and b.s. a foot deep on it bottom could be quite clean and ready for use again in four days. By late 1910, in all the fields and at all stations and terminals, there were on any day probably only four or five cleanings going on, involving altogether maybe only 40 men.

But of all the work in pipelining, this was the most dangerous and despised. Any tank down for a cleaning was awful inside, a room dark as a dungeon, not as a mine, in fact a death trap, its b.s. no barnyard muck, but flammable, gassy in strengths to anesthetize, blind, and kill, and on the skin inflaming, ulcerating, and poisonous. The main equipment was shovels, the only protection rubber boots. The work was as simple as could be, but impossible to do without feeling helpless and getting filthy, sick, and full of sores. Every time a job happened, it was like an atrocity. Typically only the foreman of a gang, the "watcher," had serious experience of tanks' insides or b.s.; most if not all of the laborers, the "cleaners," would be new, because few who had been cleaners once and lived would ever go into a tank of residuos again. As every week the work took but maybe 40 new victims, over the months at different times and places it happened to hundreds.

The nastiest jobs were the biggest, the 55,000-barrel tanks. Cleaning one of them carried only one advantage, the longest reprieve from the worst. The whole first day ordinarily went no harder than in factory-yard duty. In the morning the watcher checked that the tank's discharge and suction lines were shut and tight, opened its manhole, sniffed the gas, measured how deep its water and b.s. were, and turned on its steam (to blow gas out); and next to the tank, from below its draw-off pipe along the side away from the manhole, as he told them, 12 cleaners rebuilt (or built for the first time) a 0- or 25-foot-long pit and from it a ditch down to the nearest ravine. Then the watcher turned off the tank's steam, opened its hatches, and opened its draw-off, letting its water gush out into the pit; the cleaners kept the flow in the ditch's banks. And when the gushing subsided, the watcher had some cleaners erect a tripod above the other end of the pit and string up block and tackle. It might take 10 hours, into the night, for the level of the water (and increasingly b.s.) in the tank to fall from 12 inches to the depth of a draw-off at 6 inches. But as the flow slowed and thickened, before daylight was gone, the awful part became obvious. The watcher with a gun-metal hammer and chisel, making no sparks, cut the rivets out of the tank-shell plate right over the pit. A couple of cleaners on life lines entered the tank through the manhole and fixed boards edgewise along the bottom sill behind the lower rivet holes, to dam the escaping b.s. When the watcher cut the next to last rivet, the cleaners outside put the tackle hooks and pulling ropes on the plate. And when he cut the last rivet, they hoisted the 1,700-lb. 5'x15' arc from the shell, pulled it away, and set it down. The air was suddenly thick with a stink of swamps and sulphur. By the late light through the door the cleaners could see into the gloom where they would suffer tomorrow. It looked like a giant hanging hall, giant gallows standing in black liquid. The second morning the watcher went into the tank and smelled around. The cleaners saw how carefully he moved in the b.s., very carefully in a putrid, oily, liverish, curdled glue 6 inches deep on a steel bottom "slicker than an eel's hide." They saw how confidently he soon came out, very confidently, very soon, and told them there would not be enough gas to bother them. (He might, however, cut out another door for a crosswind.) Then they took the tools he handed the, push brooms and wooden scoop shovels, nothing to cause a spark, and stepped to their places. As the watcher watched, 10 cleaners went into the tank, every one wondering at least to himself if the gas would explode, or choke him, or what if he slipped and fell down. Five of them had brooms. They went maybe 15-20 feet inside, spread out, and began pushing b.s. toward the door, stirring up new gas, intensifying the stink. The other five had scoops. They stayed by the door, and began shoveling b.s. out into the pit. The two outside kept the b.s. in the pit running down the ditch. Depending on the strength of the bas and the endurance of the cleaners, maybe every five minutes, maybe every half hour, the watcher had the men inside change places with the men at the door or outside. Soon whether inside or out the cleaners no longer smelled the stink, or felt the heat or the hurt of a knock or fall or the tears in their eyes, only like vomiting, and they were all sneezing, weary, breathing hard, coughing. So by the end of the day they had shoveled out maybe 90 cubic yards, 120 tons of b.s., leaving it still a little over three inches deep. And by then where b.s. had got on skin from a splash or fall they found red and pimply blotches. They cleaned themselves with kerosene, and slept nearby. The third day they began in pain, noses dripping and galled, eyes burning, swollen, itching, pussy, and shy of light, throats raw, heads splitting, lungs aching, yesterday's blotches become blistery, itching sores. On the turns with the brooms they went farther inside, around the darkest edges, and their pains vanished. But the turns shoveling were heavier. And inside and out they labored and rested dizzily, breathing in fast gasps, often retching, continually coughing and spitting phlegm. By that day's end they had shoveled out maybe 85 yards, 115 tons, leaving less than half an inch of b.s. on the bottom. Their painless sores looked like dirty, torn burns. They cleaned themselves again with kerosene, particularly their sores. From new splashes and falls they found new blotches. Tired as they were, they could scarcely sleep. The fourth day was the shortest and the most awful. The cleaners arose in torment, nearly blind, panting to breathe, coughing incessantly, spitting pus. If there was a hurry, the watcher might declare the tank as it was clean enough. If there was time, he had them as they were take mops and brooms inside, and in a couple of hours shovel out the last 11-12 yards, some 16 tons, leaving only smears of b.s. on the bottom. But either way there was no longer any relief from heat, or hurt, or pain, and the tank had yet to be closed up. The watcher checked that all the cleaners and tools were out, stood a couple of apparently not yet very wrecked men back just inside the door, handed them some bolts, a wrench, a sack or ¾-inch rivets, and a gun-metal heavy hammer and caulking hammer, and told them what to do. As he directed, the others hoisted the removed plate back into its place. He put the nuts on the bolts to hold the plate tight. Then he, the apparently most durable cleaner, both of them with gun-metal riveting hammers, and the two inside made a riveting gang, driving the big rivets cold, 280 in all, a toil of at least nine hours. The men inside, their eyes resting in the dark, their heads pounding from the hammering and reverberating echoes, took turns holding up and calking. The last seam sealed (more or less), they came out through the manhole into the day's last light and silence. The watcher closed the hole. Meanwhile in stupefying and staggering pain the other cleaners had shoveled the b.s. in the pit down the ditch, and backfilled. Done with the job, the gang left and disbanded. But the job was not done with its survivors. A day or two later one might collapse and die. Maybe another would god down with pneumonia. Another's eyeballs would peel. Days later wherever they had scattered the living were still red-eyed and shy of light, puffing for breaths, coughing and spitting pus. It took weeks for their sores to heal.

Of the nastiest jobs, the most terrible were juan Casiano No. 7's two 55's. The deaths in November, 1910, proved how "very poisonous" the gas there was. The "very sulphurous" vapors had high concentrations not only of sulphuretted hydrogen but also of carbon disulphide. The same work as happened on other big jobs took place there but in a strange and numb agitation, and with more gruesome consequences for the cleaners--all the pains and woes of other survivors, compounded with depression, blindness, euphoria, paralysis, hallucinations.

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The work of transporting oil by water to Veracruz had been happening for nearly 25 years by 1910. Since the mid-1880's Standard Oil tanker crews had been bringing crude from New York to the Waters-Pierce refinery in the port. Since March, 1904, Higgins Oil and Fuel, Gaffey Petroleum, and Texas Company tanker and barge crews had been bringing fuel oil from Port Arthur, Texas, to Puerto México for the Tehuantepec Railroad and S. Pearson and Son. But because of the surprises of development in both the Tampico and the isthmus regions, much movement of oil by water had happened within the state in the last two years.

During the summer of 1910 the busiest and foulest such movements were on the Tamiahua Lagoon and Chijol Canal. Since Huasteca had Juan Casiano oil filling its storage in the field, but did not yet have its pipeline connected northward, it had the oil pumped to San Gerónimo and daily barged in putrid bulk 55 miles north across the lagoon and through the canal to Terminal. Because of the limits of these waterways, however, the shipments were on the scale of lightering, and as tricky. The lagoon then was quietly and wildly beautiful. Despite the continuing eruptions from Dos Bocas, which poured "millions of barrels of scalding hot water every day" into it and sent floating "on the surface…for miles in almost every direction…chunks of chapapota [sic], with a thin scum of grease, moving slowly from place to place as the wind shifts," it still harbored in abundance of plankton, shrimp, oysters, crab, mullet, bream, bass, shad, trout, grouper, tarpon, and other fresh- and salt-water fish, many out-of-season egrets, flamingos, herons, geese, and ducks, and crocodiles. It was also very shallow in most places, 40 feet deep behind Calaveras, the peninsula that separated it from the Gulf, but only 5 or 6 feet at low water out in the middle and westward. It held large, shifty, sandy islands close toward its north and south shores where in the summer local fishermen in canoes and rowboats crowded night and day. And it had very strong, 2-ft. tides, in the summer high in the morning, low in the evening, flood and ebb northward. The canal, 18 miles long between the lagoon and the Pánuco River, was very shallow too, at low water, after an official dredging, only 5 feet deep. And it was very narrow, officially 40 feet across the bottom, with the summer rains caving down its banks more like 30 feet in some sections. The boats to tow the barges were therefore small, typically 40-foot, light-draught, stern-wheel paddlers, and the barges were the Texas coastal class, ordinarily only 90 feet long, 20 feet beam, 4 feet draught, not much more than steel scows with thwartship and longitudinal bulkheads taking in five starboard and five port tanks only 1,000 barrels, not quite 165 tons of Juan Casiano oil. The boats had gasoline engines, 2-cycle, 4-cylinder, 20-hoursepower, new-fangled machinery in Veracruz in 1910, and free on the Pánuco could make 7 knots corrected. But through the shallows and narrows they plied, only in daylight, one towing a loaded barge could not average better across the lagoon than 5 knots—through the canal, 1-1/2. Every day then but two boats and barges went the whole distance, one boat and barge reeking like 1,00 barrels of rotten eggs making the trip north to terminal, the other pair reeking of its cargo's residue making the return south to San Gerónimo.

Either way the crew would usually be only four men, the pilot, a couple of deck hands, and a barge-man. Their route and schedule were tight. Their day began very early. In the stench at the San Gerónimo wharf at dawn a crew would board a fully fueled and lubricated boat and a loaded and gauged barge, both docked harborside. The pilot would unlock the boat's cabin, stow the day's drinking water and groceries, and check the binoculars and compass, his watch, the fuel tank, water pump, fire extinguisher, and chest of tools, spare parts, and mechanical supplies. Meanwhile the deck hands would check the paddle-wheel, the bilge and the lines, tackles, and other gear, and on the barge maybe 20-30 feet back the barge-man would check the lines and the tiller.

Then came the first, the greatest, and the essential trick, the latest skill in Mexico in 1910, starting the gasoline engine. The pilot in the cabin would check the control cables, throwing the engine into and and back out of forward and reverse gears, check that the spark and throttle levers were in retard position, put the key in the switch, pull out the priming rod, take two or three short pulls on the crank, let the priming rod go, adjust the carburetor to a rich mixture, advance the spark elver maybe three notches, the throttle lever maybe five, turn the switch to magneto, and yank the crank for all he was worth. One yank was almost never good enough. The reason might be any of numerous things wrong, a mixture too rich and flooding the engine, or a mixture too lean, or water in the gasoline, or the magneto not in contact, or its wire to the coil loose, or the coil vibrators out of adjustment, or timer wires loose, or wet or fouled spark plugs…or a yank too short or slow. Ordinarily the third or fourth yank at ignition, a backfire, and at the exhaust a clatter and a billow of black smoke. The pilot would advance the spark lever about half way, seventh notch, let the engine warm up, cut the carburetor back to running position, retard the spark and the throttle to two notches, to idle. If the engine did not keep backfiring, misfire, skip, knock, squeak, whistle, wheeze, miss, puff, or lose power, and the exhaust's black smoke turned a nice blue, the boat was ready to run.

As the pilot ordered, the deck hands would shift the bow line to an after bow spring, hang a second fender forward, and cast off the stern. The pilot would turn the wheel to port helm, advance the spark to five notches, the throttle to four, throw the engine into forward gear, bringing the stern dead slow away from the piles, shift the engine out of gear, have the spring cast off and the fenders pulled up, turn the rudder amidships, shift into reverse, go dead slow astern, a little port helm again, back toward the barge, ticking the controls between reverse and neutral to a stop maybe 8 feet forward from the barge, and retard spark and throttle to idle. A deck hand at the stern would heave the tow-rope over the paddle box onto the barge's bow. The barge-man would make the rope fast on the forward towing-post. And the deck hands would make the other end fast on the boat's tugging post, aft the cabin, and coil the docking lines. The barge was ready to tow.

It would then be 6 a.m. As the pilot ordered, the deck hands would take their proper stations as lookouts at the bow and stern, and the barge-man would let go the barge’s fasts, coiling the lines as he went, and take his station at the tiller. The pilot would whistle a long blast, turn starboard helm, advance spark and throttle to dead slow, and throw the engine into forward, taking the strain very slowly on the rope. The strain full, maybe 10 feet of rope between the boat and the barge, he would gradually advance spark and lever to five or six notches, giving the barge slow headway, and the barge-man would steer it away from the wharf. Headed eastward out into the lagoon, toward the sun over Calaveras, the pilot would turn starboard helm again to head almost due north, and gradually advance spark and throttle to full power. This made an awful chattering vibration in the cabin, a very hot engine and exhaust, a staccato road at the stack that resounded far over the lagoon, and a speed of about 5 knots. So too it made a refreshing breeze for the lookouts, who kept watch for fishing boats and any unscheduled Huasteca or Águila motorboat; but it added a continuous fog of blue fumes to the continuous stink the barge-man faced. At nearly 8:30 a.m., approaching the lagoon’s northern islands, the lookouts studying the changing shades of the water, the pilot would whistle another long blast, retard spark and throttle to 4 knots, round the bend between the little Isla de Barros and Calaveras, and turn starboard helm to head northwest between the long Isla de Juana Ramírez and the peninsula. At about 11 a.m., near the northern end of Juana Ramírez, he would whistle a short blast and pass port to port the daily southbound boat and empty barge. At 1:30 p.m. he would sight ahead the day-beacons marking the channel in the lagoon, retard spark and throttle to 3-1/2 knots, and enter the canal. During the afternoon rains he would have the boat’s lamps lit and hung, and every few minutes whistle a fog signal, a long blast and two short ones. At about 5:45 p.m., having whistled a long blast, he would exit the canal, enter the rain-swollen Pánuco, turn starboard helm, and head upstream in the easy water along the river’s right bank, increasing the power against the current (maybe 6 knots in midstream), slowly approaching the Terminal wharf, and the deck hands and barge-man would ready lines and fenders on the port side.

Finally, at 6 p.m., they would dock at Terminal. The pilot would bring the barge like a riverboat dead slow alongside the wharf, pray against suction, and retard spark and throttle, enough to stop headway but still hold position as close as he could to where the wharf pump would be broad on the barge'' beam. Smartly the barge-man would heave and make fast the barge’s bow, after spring, forward and after breast, and stern lines. The deck hands would lose the tow-rope. The barge-man would come forward, let go at the towing port, and heave the rope over the paddle box onto the boat's stern. And the pilot and deck hands would dock the boat. Meanwhile a Terminal gauger would have boarded the barge and be gauging its tanks. The pilot would record the trip in the boat's log, leaving the engine at idle to cool down, listening with one ear for trouble. The deck hands would clear the boat's deck, check its fasts, and douse lamps. The barge-man would check the barge's fasts. The pilot would kill the engine, lock the cabin, and, the gauger having finished, order all ashore. On the wharf the crew's day ended.

It was for others to maintain the boat and discharge the barge's cargo. Before dark, if the engine had given no sign of trouble, a Terminal mechanic would take the boat up the wharf and into a fueling slip, gas it up, add the lubricating oil, bring the boat back down, and dock it ready for tomorrow. Some time the next morning a gauger, a pumpman, and two or three helpers would come down to the wharf, hoist a red flag, and run the barge's tanks into Terminal storage. This was very simple, but there too was a method, not to let the barge list too much toward the river or trim by the head. The gauger would open the wharf manifold's discharge valve on a gathering line to one of the big steel tanks. The pumpman would warm the pump. The helpers would haul the pump's rope-served, wire-wrapped, 6-inch hose onto the barge's deck, stand a low derrick with a strop hanging over the hatch on the No. 3 (midship) starboard tank, hang the hose through the strop, open the hatch, and feed the hose down into the oil to the tank's bottom. The pumpman would start the pump. The helpers would stand back from the fumes and watch the hose's flanges for leaks. In about 22 minutes the tank, 20 feet long, 10 feet wide, 3-1/2 feet deep, holding 1265 barrels, would be practically empty. Together, the gauger would close the manifold, and the pumpman stop the pump. The helpers would pull out the dripping hose, close the hatch, move the derrick and hose over the hatch on the No. 3 port tank, open its hatch, and feed the hose into the oil. Together, the gauger would reopen the manifold, and the pumpman restart the pump. In about 22 minutes that tank would be practically empty. So the discharge continued, in due order at No. 4 (forward) starboard, No. 2 (aft) port, No. 4 port, No. 2 starboard, about 25 minutes a tank, then at the 10-foot-square tanks at the bow and stern, no. 5 starboard, No. 1 port, No. 5 port, and No. 1 starboard. Altogether it took about four hours, done before the afternoon rain.

The return was quicker, but the working day was even longer. In the stench at the Terminal wharf at dawn usually the same men who had made the trip the day before would board maybe the same boat, but a different, empty barge, and make the routine checks. The pilot would start the engine, with the deck hands turn the boat at the wharf, get clear, go dead slow stern ahead downstream, and stop in forward gear against the current maybe 18 feet dead ahead of the barge. The deck hands and barge-man would connect the tow. At 6 a.m. the barge-man would cast off and take the tiller, the deck hands would take the lookouts, and the pilot would whistle, take the strain on the rope, and give the engine the power to tug the barge clear against the current. It took all the pilot's experience and attention at the spark, throttle, and helm, and all the barge-man's experience and attention at the tiller, to turn around in the river with a current 4 or 5 knots abeam, and then downstream turn port helm out of the river, southeast into the narrow canal. Against the flood through the canal the pilot would keep power for 4 knots. At 10 a.m. he would head between the daybeacons out into the lagoon, speed up to 5 knots, and head between Juana Ramírez and Calaveras. At about 11 a.m. he would whistle and pass port to port that day's northbound boat and loaded barge. At 12:45 p.m. he would whistle again, round Barros, turn almost due south, and speed up to 6 knots. At 3 p.m., usually in the rain, he would have the barge and boat docked at San Gerónimo. While the San Gerónimo gauger gauged the tank for empty, the pilot would do the log, and the deck hands and barge-man check fasts. Then, in the rain, as a mechanic took care of the boat, they had to load the barge. The pilot would hoist a red flag and take cover on the wharf to supervise. The gauger would open the wharf manifold's suction valve on the line from one of the station's tanks, a pumpman would warm the wharf pump, the deck hands would bring canvas to drape over the derrick, and the barge-man would stand the derrick over the no. 1 port tank, under canvas strop the 5-inch hose, open the hatch, and hang the hose into the tank. The pumpman would start the pump. The barge-man would back out into the rain. In about 11 minutes the manifold would be shut, the pump off, and the tank full. The barge-man would pull out the hose, close the hatch, and with the deck hands move canvas, derrick, and hose forward to the No. 5 starboard tank, likewise in 11 minutes full. So the loading continued, No. 1 starboard, No. 5 port, No. 2 port, No. 4 starboard, No. 2 starboard, No. 4 port, and finally No. 3 port and starboard. This would be done, hurrying, by 7:15 p.m., when the gauger would still have light for long enough to gauge.

The 1,000 barrels of oil daily that these crews transported during the summer of 1910 seemed very little later. But they were moving, these 15 men, including gaugers, mechanics, and helpers, more oil than many more men were moving on the pipelines then in operation, from San Cristóbal to Minatitlán or from Furbero to Tuxpan.

In contrast to the boom around Tampico, the surprise in the development of the Isthmus was unhappy. After S. Pearson and Son had its refinery at Minatitlán in operation, started the price war with Standard and Waters-

Pierce, and received ever declining production from its San Cristóbal field, its drillers proved other fields in the region in 1909 and 1910. But at a time when Pearson and Aguila needed gushers, these fields were only of tricklers. Already by mid-1903??? Pearson managers wanted crude oil from elsewhere to supply the refinery, which would require moving the oil by water to Puerto México and up the Coatzacoalcos River to Minatitlán. Until the Furbero-Tuxpan pipeline commenced runs or Aguila drillers around Tampico discovered oil they could control (unlike Dos Bocas's), the best source of supply would be farther north, the main source for the past four years of fuel oil for the isthmus. On October 9, 1908, the same oil tanker that had carried the first shipment of fuel for the Tehuantepec Railroad in 1904, the Texas Company's Northtown, sailed from Port Arthur carrying 23,455 barrels of "Gulf crude" for Pearson to Puerto México, for transshipment thence to Minatitlán. In November Pearson's Compañía Mexicana de Vapores del Aguila took the sea-going wooden barge that the Northtown had towed on it first trip to Puerto México, the Gusher, with a capacity of 9,000 barrels, and had Higgins Oil and Fuel load it with Texas Company's crude and tow it to Puerto México and Minatitlán. It also started construction of an 8-inch pipeline for refined products from Minatitlán to Puerto México. And in December it began taking from Orange, Texas, southward the first of 20 coastal barges, presumably to Tuxpan, but really to Puerto México for lightering the imported crude upriver. The supplies from Texas for the refinery then became continual and impressive. In the 27 months from October, 1908, through December, 1910, at least 33 shipments of Texas and Gulf Company crude for Pearson moved by tanker from Port Arthur to Puerto México and thence to the refinery.

This work was therefore mostly marine. Its scene included the Gulf of Mexico, the ports, and the Coatzacoalcos Rover. The route barely varied. On a direct line only slightly northeast-southwest it was about 700 nautical miles across the Gulf between Port Arthur and Puerto México, plus 24 miles up the river to Minatitlán. As the seasons changed, however, so did the route's condition. There were conventionally then two times of year on the gulf, the "trade-wind season" from April through September and the "norther season" from October through March. The trade-wind months featured wind from the east and east-southeast and a main current from the Yucatan Channel set westward and of feeble drift (maybe half a knot) along the 100-fathom line around to the Straits of Florida. Practically this season was 2-1/2 seasons. "During April, May, and in June until the rains begin the winds are moderate and steady and the weather superb," skies clear and the temperature around 75-80º. Through June, during July, and in August it rained almost every day, the wind often falling calm at night and again at mid-day, the temperature rising as high as 90º, easterlies in the afternoon freshening into black squalls, leaving the sky some evenings serene, other evenings "thick and cloudy"; occasionally "the heavenly bodies are obscured for many days together." Through August and September the weather continued squally, except that about every two weeks a "West India hurricane" formed in the Caribbean and whirled 300 miles wide north by the Gulf or northwest across it. The norther months were practically 1-1/2 seasons. They began with the second six weeks of the threat of hurricanes. By mid-November they featured their definitive cycle, which would turn ever more regular until March, a prevailing trade wind from the northeast for four or five days, then the wind shifting to the south, calming, and warming, then a norther blowing down a strong squall and two or three days of violent winds, maybe causing a southerly set all over the gulf and lowering the temperature into the 40º's.

The ports on the gulf were both of them new, compact, with good facilities, busy, and safe. Port Arthur, built since 1895 on the west shore of Sabine Lake, had the Kansas City Southern's southern terminus and by 1908 a Southern Pacific station, a 250-by-1,500-foot shed "of modern construction and well equipped in every detail," a new cotton and cotton-seed warehouse, a 3000,000-bushel grain elevator, a main wharf, four pipeline terminals, four refineries, three "also…modern" oil-loading wharves along a turning basin dredged 300 feet wide, 1,500 feet long, and 23 feet deep, and 46 vessels registered, including 14 tugboats and 9 tankers. For protection it had at least 10 miles inland as the wind blew from the Gulf. Ships of draft as deep as 22 feet left the port southward by the Port Arthur Canal dredged behind the west shore of the lake 250 feet wide at top, 1000 feet at bottom, 23 feet deep, a channel dredged 250—300 feet wide and 23 feet deep down the half-mile-wide Sabine Pass, and a channel dredged 100 feet wide, 23 feet deep, between parallel concrete jetties nearly half a mile apart three miles out into the sea. On the Mexican side Puerto México, opened in 1907 on the left bank and at the mouth of the Coatzacoalcos River, was by 1908 "the most modern and fully equipped harbour in the Gulf of Mexico." It had the Tehuantepec Railroad's northern terminus, seven steel warehouses each with a capacity of 6,000 tons and floors to stand 5 tons a square meter, a 35,000-barrel oil-storage tank, a submarine cable station, a timber wharf with a 5-ton and a 10-ton steam crane, six timber-decked steel wharves each with three 3-ton electric cranes and five 1-ton electric capstans, altogether nearly a mile of frontage along the water, and minimum depth alongside 32 feet. It had only one tanker registered and one new tug on duty, but regularly served the ocean-going steamers of eight international shipping companies. Its protection was the river, a natural harbor, with two converging stone jetties at its mouth, the eastern

1,500 yards out from the coast, the western 1,280 yards, their heads 280 yards apart. Ships of draft as deep as 28 feet cleared the outer bar at low water, entered between the jetties the channel 330 feet wide and 33 feet deep at high water, passed the narrows at the mouth of the river (there 525 yards wide), and not 800 yards ahead, just before the wharves, found the river more than half a mile wide and in the channel anchorage of 42 feet. In a norther, which would cause a very high tide, they had even better anchorage above the port under the lee of wooded hills.

The 24 miles up the Coatzacoalcos were broad and southerly with bends westward, around several islands, an past four tributaries, the last the wide Uxpanapa, about five miles before Minatitlán. The banks on both sides lay low; in the rainy season the river overflowed them. The current ran strong, 6-1/2 knots from July to December, 4-1/2 in the winter and spring. The depth in the channel ranged from 24 to 42 feet, but for three bars, the shallowest abreast the mouth of the Uxpanapa, 21 feet after rains, 18 feet in the dry season.

Minatitlán was an old port. On the river's left bank at a bend from the south eastward, it offered complete shelter from the Gulf and westward and inland connections east, west, and south. (Before the Tehuantepec Railroad, from 1826 to 1883 and again, briefly, in 1898), it had been the isthmus's officially "recognized" port. For 80 years then it had been the only upriver site off which ocean-going ships had anchored for loading and discharging. By December 1908, it had a ?? railroad branch station, a pipeline terminal, a 42,000-barrel oil-storage tank, a refinery, a pipeline to Puerto México under construction, and a wharf, Pearson's, depth alongside 22 feet.

Back and forth between Port Arthur, Puerto México, and Minatitlán from October, 1908, through June, 1909, this work in transportation took place seven times. The places where it actually happened then were Port Arthur-registered tankers and in Mexican waters Tehuantepec Railroad and Pearson tugs and Pearson barges, nothing (except for some names) different from the places of such work at the port of Veracruz, and nothing new at Puerto México, the tankers locally inaccessible, tugs and barges familiar. Significantly, however, beginning in July, 1909, at least 19 of the next 26 shipments of crude oil from Port Arthur to Puerto México happened on the one tanker registered and familiar at Puerto México, Aguila's San Cristóbal. Moreover this tanker could go loaded up to Minatitlán—and did.

Like most other tankers on the Gulf in 1909-10, the San Cristóbal was a recently built steel single-screw steam schooner. She had certain outstanding features. The only tanker on the Gulf bearing Lloyd's highest classification (+100A1) and "of especial interest on account of the novelty of design," she had the heaviest ratio of load to draft. At 253 ft. long, 46 ft. 2 in. beam, and 18 ft. 3 in. in moulded depth, she could carry 3,000 tons of crude oil, some 21,000 barrels, on but 16 ft. 4 in. She was the only one with a trunk deck: between a short forecastle and poop, 31 ft. and 33 ft. respectively, a continuous trunk amidships, 194 ft. long, about 18 ft. wide, and 3 ft. high, with a harbor deck along either side about 14 feet wide. In the hold below she had nine transverse bulkheads making eight tanks subdivided by a bulkhead amidships into 16 compartments, and "arrangements for pumping and distribution of cargo…of the most approved and up-to-date description." This special "cargo oil system" included a deck delivery lines through the trunk and down into the pump room aft the tanks, two double-acting duplex 12x12x10 pumps in the pump room, two 10-inch main pipelines forward through the tanks, one low on either side of the longitudinal bulkhead, crossovers between them through the longitudinal bulkhead aft in the pump room and forward between the first pair of compartments, and from either main line eight suction lines, one extended transversely at the after end of the e opposite compartment, with a valve on either side, for "two valves on each suction" and two suctions in every compartment. Otherwise there was the usual low, open bridge amidships, electric lighting, and machinery aft. Below the poop in the boiler room, abaft the pump room, were three steel single-ended Scotch boilers, each 12 ft. in diameter, 9 ft. long, and fitted on the Flannery-Boyd system to burn coal or oil in two furnaces, their combined heating surface 3,684 sq. ft., supplying steam at 180 psi. abaft the boiler room in the engine room was the vertical inverted direct-acting triple-expansion main engine, a good 18 ft. high and 20 ft. long, its cylinders 20-1/2" x 33" x 54", x 36", indicating in good repair and fairly set horsepower, enough to propel the fully loaded ship at 10 knots.

In certain ways work on an ocean-going steamship resembled work on a train or a riverboat. It took men to stay on route and on time, to generate the steam for locomotion, and to maintain the machinery and the conveyance along the way and between runs. But the deep sea being deep sea, the route was a course to be navigated, time was by the sun, the stars, Greenwich, and the local mean, there were no depots or division points or wharves or piers or landings along the way, and the runs took some days and nights together to make. So the men who started a run were (except for any overboard) the same men who finished it. They had to number enough for work to happen both day and night. And they needed their provisions.

On the San Cristóbal in 1906, '07, '08, when her voyages were trans-Atlantic, her whole company would duly have numbered about 35. But like freighters of every type then she often went undermanned. In 1909-10, the master, officers, and crew usually numbered no more than 24 all told, and the various divisions of their labor separated them at work in port or at sea into very small groups, or solitude. Under the supreme command of the master, the technical and hierarchical divisions were in three "departments": in the "deck department," two mates (officers), a boatswain, a carpenter, and six deckhands; in the "engine department," a chief engineer (an officer), two assistant engineers (also officers), two firemen, two oilers, and two wipers; and in the "commissary" or "steward's department," a steward, a cook, and two messboys. Another division occurred by shift. The master was in principle on duty "at all times." Officers and crewmen, however, never in fact left the tanker unattended. In port, before and after loading or discharging, there would be on board at least an "anchor watch," a mate, a couple of deckhands, a fireman, and an oiler, taking turns with their inactive counterparts in the day and night shifts at sea. The mates, deckhands, assistant engineers, firemen, oilers, and wipers were divided "as equally as may be' in two 3-man "sea watches," the first mate, three deckhands, an assistant engineer, a fireman, an oiler, and a wiper making the "port watch," the second mate and the other men making the "starboard watch," each watch "standing watch" in turns with the other by the customer of "watch and watch,' four hours on, four off. The boatswain, the carpenter, the chief engineer, the steward, the cook, and the messboys, collectively the "idlers," since they did not work in shifts, worked from 6 a.m. to at least 9 or 10 p.m., maybe midnight.

Yet another division was by stations and duties. At sea only the master could properly be anytime anywhere on the ship. The mate on watch ought to be on the bridge. The boatswain during his 15-, 18-hour day would be either in the storerooms or out on deck where the mate on watch had ordered him to direct and supervise work. The carpenter during his long day would be either in the shop or out finding his work at one or another deck machine. Tank, lifeboat, mast, boom, or pump. The deckhand told off as helmsman had to be at the wheel on the bridge; the deckhand told off as lookout, on the forecastle head or aloft in the crow's nest on the foremast; and the other deckhand, on deck where the boatswain had directed him, with the boatswain or alone. The chief engineer, of all the officers the most responsible, therefore most peripatetic, would during his long day be on his duty at one or another time in the boiler room, the engine, or the steering-engine room, or along the steam-pipe or water system or the electrical wiring. The assistant engineer on watch had to be below in either the boiler or the engine room, the fireman in the boiler room, and the oiler and the wiper back and forth between these rooms. The steward during his long day would be going continually between the provisions room and the galley and pantry in the deckhouse in the poop and the officers' mess and cabins on the bridge. The cook had to be in the galley, one of the mess boys in the officers' mess and cabins, the other in the galley and the mess and cabins in the deckhouse. There being so few men, so divided, so scattered, every duty was very hard.

The voyage and the duties began at Minatitlán. There one afternoon about every two weeks during the norther season of 1909-10, December 4, for instance, a Saturday, the San Cristóbal would be if not "Bristol fashion" at least ship-shape for the run to Port Arthur. Telegraphed U.S. weather reports that day forecast a norther in Texas that night. From S. Pearson & Son in Mexico City the master would receive instructions at the refinery to sail the next day before the winds hit Puerto México. He would pass the work to "secure the ship for sea" to the second mate and the chief engineer. The mate would call the boatswain and carpenter, who would go with the chief engineer down to the wharf. The tropical heat and the refinery's stink would be heavy on the river and the tanker, moored starboard-side, stream-anchored off the port bow, down to her tropical fresh-water line in the easy water, 17'4". Amid the noises of work on the wharf and distantly from ships at anchor in the road upriver the only sound from the tanker would be the steady plashing of the cooling-water overboard discharge. On board (16 raised hatch covers would show all the tanks and trunk full to the hatches of Coatzacoalcos River water, and there would be a faint, quick throbbing. The first mate would be on anchor watch on the bridge, a deckhand as guard at the gangway, another as watchman on deck, and a fireman and an oiler (doing for ???? on a donkey watch below, in the heat and smell of steam, bilge water, burnt rubber, sweat, and electricity, the fireman tending one boiler live and rumbling but at low pressure, the oiler tending the auxiliary pumps and the donkey engine running the throbbing, sparking dynamo that lit the room and the rest of the ship.

The boatswain, carpenter, and the chief engineer would come aboard. They would stow their things in lockers in the deckhouse, unlock the storerooms and shops, inventory stores and tools, relock the doors, and commence their preparatory work. The boatswain would hoist the Mexican national flag on the ensign staff at the stern and the blue peter on the foremast, then examine the foremast and mainmast stays, funnel guys, ventilators, paint, coiled cordage, and the lead and the patent log and their lines. The carpenter and the chief engineer together would examine the steering-engine and its gear and steam connections, the deck winches and pumps and their connections, and at the bow the windlass and its connections. Then the boatswain and carpenter would together examine the derricks, crutches, masts and mastheads, gaffs, goosenecks, travelers, guides, hanks, chain spans, blocks, and tackle, the scuppers, the hatch covers, and the lifeboats and their gear, two boats canvas-covered on chocks aft the deckhouse, two more uncovered and swung out on davits on either side. Then they would separate. The boatswain would go examine the shrouds, sails, and running rigging, the sounding line, the stream chain in the port hawse, the stopper, the three bower anchors and the kedge anchor, and below deck the chain locker and its three 240-fathom 3-1/4-inch steel-wire tow-line, two 90-fathom 6-inch hawsers, and two 90-fathom 5-inch warps. The carpenter would go examine the side railings and ports, the deck ladders, the stay and guy turnbuckles, the sounding machine, and the sounding pipes and caps, sounding as he did these the bilge, the fuel tanks, the fresh-water tank, the cofferdams, and the fore and aft peak tanks.

Meanwhile the chief engineer would have examined the fuel settling tanks, then gone below. In the engine room at the throttle station on the working platform he would read the Cuaderno de máquinas, the "Machinery Book," or engine-room log. Then he would examine the gauges, revolution counter, barometer, thermometers, telegraph, gong, and jingle, the platform, handrails, and ladders, the floor plates, the bilge, the sea valves, the boilers and their attachments and water, the fuel pumps, heaters, filters, lines, and valves, the burners and supply pipes in their racks, the blowers, the steam and water pipes and valves, the auxiliary pumps, the feed heater and main feed pump, the main condenser and its pumps, the evaporating and distilling plant, the bilge pumps, the fire, fresh-water, and sanitary pumps, the donkey engine and dynamo, the switchboard, the ice machine, and the main engine, silent and massive, towering 18 feet high on its three cast-iron columns and support bars and bed plate 10 ft. wide and 24 ft. long, all its dully gleaming iron, brass, and steel parts still, balanced, awesome in their triplicate order and their magnitude, from up under the engine hatch down, the three great, jacketed cylinders, their casings 5 ft. deep, three piston rods 5 inches in diameter, three crossheads 8 inches on a side, three connecting rods 7 feet long and bigger around than a man could reach with both hands, three cranks posed with 120º angles between their 18-inch throws, the crankshaft 10-1/2 inches in diameter, and three twinned eccentrics the size of freight-car wheels, from them upward six eccentric rods over 7 feet long, three overarching links nearly 4 feet long, and three valve stems 2-7/8 inches in diameter disappearing up into three valve chests 5 feet deep. Forward in the pump room he would examine the ballast and the cargo-oil pumps their connections, crossovers, and suction pipes, and the rods, green-, white-, and black-painted and numbered valves. Back in the boiler room he would order the fireman to begin raising steam in all three boilers. He himself would go up and slacken the funnel guys. Then he would go follow the systems of steam, water, and cargo-oil piping and electrical wiring, junction boxes, and lights below and on deck, seeing that they were all tight and dry.

As the chief engineer had ordered the fellows below would turn to starting up. The fireman would open the dead boilers and their auxiliary check valves, increase the steam in the heaters, take a couple of clean No. 12 burners from the rack, lock one into one of the two furnaces in one boiler, another into a furnace in the other, connect supply pipes from the boilers' distributing valves to the burners, crack and shut tight all the distributing valves to the burners, crack and shut tight all the distributing valves, and open the boilers' master valves. The oiler would gradually increase the fuel pump's speed, making black smoke at the funnel. When they had the fuel circulating by the boilers properly hot again, maybe 240º, and the boilers fed about three-quarters full, the fireman would close the circulating valve by them, making more black smoke at the funnel, and close their check valves. As soon as the pump's delivery pressure rose over 50 lbs., he would turn the burner valve on one of the furnaces wide open, see that no oil dripped inside, lever the furnace's air doors nearly shut, make a torch inside, very gently open the distributing valve to the burner, and get ignition. In a minute he would have the distributing valve wide open, lever the air doors open, draw the valve for air around the burner open, and start the blower, making white smoke at the funnel. Likewise with the oiler at the pump he would light off the other boiler. Then as at his directions the oiler adjusted the pump's speed and the steam in the heaters for a pressure around 25 lb. On the line he would adjust the air for the same combustion in every furnace—from a point about an inch from the burner's nose a flame opening into a cone, dazzling white at its center, malting away into red at its periphery, faintly violet at its far end just beyond the quarls, no fire in the ashpit, and no black or white smoke, only a light-gray haze over the funnel.

During the afternoon the second mate, the assistant engineers, the steward and his idlers, and most if not all of the rest of the crew would come aboard and stow their things. On the first mate's orders the boatswain would have deck hands overhaul anything he had found wrong. On the chief engineer's orders the carpenter or the assistant engineers would overhaul anything he had found wrong. As soon, however, as the first mate could reclaim an assistant engineer, he would order the ship trimmed. The assistant engineer would go to the pump room, review which valves were which, and set on open the after crossover valve. About 4 p.m. the mate would go forward to tank No. 7, set on open its two red and two green deck cargo valves, opening no. 7's port and starboard suctions port-side and starboard-side, signal below, and open one after another the cargo valves to Tanks No. 5,3, and 1. At the mate's signal the assistant engineer would open the pump room's port sea valves. And shortly the water in these tanks, over 475,000 gallons, oily and stinking, would begin flowing back into the river. Meanwhile the commissary fellows would have turned to their duty. The steward would have unlocked the provisions room, inventoried the stores of victuals, drink, bedding, linens, and cleaning supplies, sent the messboys with edibles and potables for supper to the galley, relocked the room, and with the favorite messboy inspected the officer's cabins and set the table in the officers' mess; and at around 4:00 the cook and the other boy would have begun preparing supper for the maybe 20 men aboard. By 5:00 all the water that could naturally flow from the tanks would have flowed, some 70,000 gallons, and the tanker would be dead still at just above her tropical fresh-water line. The first mate would call a boat and fire drill, starboard watch starboard-side, port watch port-side, following which, as he ordered the boatswain would have deck hands haul up the gangway. The mate would then call the head wharfman for line handlers to stand by to alter moorings, order the boatswain to tend the alterations, and himself go close all the cargo valves except to No. 7's port compartment. The boatswain would go forward to the windlass, see that its brake was tight, knock loose the stopper on the stream chain, and station a hand at the brake. And on the chief engineer's orders that favorite assistant engineer would man the pump room, begin warming the ballast pump, and stand by. At sunset, that day 5:25, the wharf's electric lights would go on, the mate would switch on the fore and aft anchor lights, and the boatswain would haul down the blue peter and the ensign and stow them. By 5:30, on the mate's signal, the assistant engineer in the pump room would have started the ballast pump, to force the maybe 50,000 gallons still in No. 7 port-side into the river. At 5:30 the steward would serve supper to the chief engineer, the second mate, and the other assistant engineer; the messboys would serve the boatswain, the carpenter, and the lately boarded deckhands, fireman, and oiler or wiper.

At 6:00 the watch would change for the night. The second mate would relieve the first on the bridge. The boatswain would tell off the relieving hands for night watchman and anchor watch at the windlass. The relieving assistant engineer, fireman, and oiler (or wiper acting as such) would go to their duties below. The relieved assistant engineer would enter the day's work below in the engineer-room log, recording levels of fuel, lubricating oil, and fresh water, temperatures of the engine room, feed water, and boiler room, any bilge water, quality and density of the feed water and water in the boilers, all boilers lit, and the time of lighting off the last two, sign the log, and report it to the bridge. The relieved mate would enter the day's "events" on board (most certainly the inventories, drills, and boilers lit) in the Cuaderno de bitácora, the "Binnacle Book," or mate's log, and sign it. The steward would clear the officers' mess, serve the relieved officers, and after they had eaten, clear the mess again. Likewise the messboys would serve the relieved hands and fellows from below, and after they had eaten, clear those tables. At around 7:00, amid piles of dirty kits, plates, mugs, and utensils, the steward, cook, and boys would serve themselves in the pantry, then clean the messtraps, messes, galley, and pantry, washing, sweeping, scrubbing, squilgeeing, swabbing, and polishing for an hour or two into the night.

Already by 6:30 the tanker would have been a few inches higher in the water along the port bow, listing to starboard, and as the boatswain ordered the anchor watch would have checked the stream chain. By 6:35-6:40 the pump would have practically emptied no. 7 port-side. When it began sucking, the mate would have opened the suctions on No. 7's starboard compartment and closed them portside, and the pump would have begun forcing that compartment's maybe 50,000 gallons into the river. As the tanker rode slowly higher, by the bow, maybe 4 inches in an hour, the boatswain would call his orders, the anchor watch would again check the stream chain, and the wharfmen alongshore would check the lines. By about 7:35-7:40 the pump would be sucking again. The mate would open the suctions on No. 5 starboard-site and close No. 7. In 65-70 minutes that compartment would be practically empty, and he would reopen No. 7 starboard side and close No. 5, to expel No. 7's remaining water. So to No. 5 port-side and so on to Nos. 3 and 1, holding the ship's weight aft, using her lists to remove the last water from her every other odd compartment, continually altering her chain and lines, the fellows on deck, the fellows below, and the wharfmen would bring her ever high in the water. During the night a thick fog would settle on the river. The steady plashing overboard, the steady throbbing of the dynamo and the pumps, and the steady, low rumbling of the boilers would be lulling. But the men working would be so few that none could stop, prick for a soft plank, sleep (at least for long). By 3 a.m. they would have all the odd tanks, empty, all 16 compartments closed tight at hatches and valves, the pump stopped and draining, the pump room's sea valves closed and lashed, the mooring lines again even and secure, the stream chain again stoppered, and the tanker upright and still, not only duly trimmed, by the stern, but also duly in ballast for any norther, drawing about 14-1/4 feet. After 12 or 13 hours of work the boatswain would then turn in.

Meanwhile below the fireman and oiler (or wiper) would have been building power. Since 10 pm (if not before) they would have had steam in the two lately lit boilers, closed their stop valves, fired up their other furnaces, stoppered their auxiliary check valves, and been raising pressure in them too. Near midnight the mate would go take a look in the pump, engine, and boiler rooms, to rouse out any sleeper and make sure that the boilers had plenty of water, steam was rising slowly and safely, and all the burners were on. Lingering, he might see how the fuel pump and the auxiliary feed pump ran, listen to the click of the working auxiliary check valve, feel its cooling pulse, and look that the water fluctuated easily and rose slowly in the working boiler's gauge glass. But shortly he would go up on deck again, and the fireman would resume his lonely vigil, the oiler (or wiper doing for one) his lonely round, listening to the pumps, smelling, feeling, oiling, and wiping them. When the fireman had all three boilers at practically the same pressure (within a couple of pounds0, maybe around 3 a.m., he would very slowly open the auxiliary stop valves on the two lately lit, cut them into service, and begin adjusting all three auxiliary check valves to equalize the feeds. Correspondingly, in the absence of the assistant engineer, still in the pump room, the oiler (wiper) would adjust the stop valves on the auxiliary feed pump and the engine for the auxiliary condenser's pumps.

At about 4 a.m. the cook would turn out and start preparing coffee and breakfast. At about 5:00 the boatswain would have deck hands let down the gangway, and from the dark the stragglers would come aboard. At 5:30 the steward and messboys would serve breakfast to the officers and men off watch. By 6:00 the fireman would have the boilers all ready, their continuous roaring muffled and even, their feeds equal, auxiliary stop valves set the same, cocks tried, scum blown off, glass gauges blown through, and steam at a full head, 180 psi., the surplus bleeding evenly to the auxiliary condenser. At 6:00 the watch would change for the day. The relieved assistant engineer would enter the night's work below in the engine-room log, and report it to the bridge. The second mate would enter the night's "events" in the mate's log, and sign it. The steward and the boys would serve breakfast to him and the other men coming off.

On taking the watch the first mate would order all preparations for getting underway. The chief engineer would order below the four men for a steaming watch. The assistant engineer would slowly open the boilers' main stop valves, try the whistle and siren, and slowly open the valves and cocks on the main feed pump, the main engine, and the main condenser's pumps for them to warm and drain. The oiler would commence connecting the main machinery's lubricators. The wiper would bring fresh rags and swabs. The fireman would even the lift on the main check valves. Once they heard the siren, the chief engineer in the steering-engine room, the carpenter at the stern, and the mate on the bridge at the wheel would make sure that the rudder, tiller, tell-tale, and midship spoke on the wheel were all in line amidships, try the steering gear by hand hard over each way, and see that the helm responded both ways over to 30º. The chief engineer would oil the steering engine, and open it to warm and drain. The mate would try the telegraph, gong, and jingle, sending and receiving, and see that the bridge and engine-room clocks read the same local mean time.

At 6:16 on December 5, a Sunday, a white sun suddenly rose and spread a gray glow up the river. The mate would turn off the anchor lights, the boatswain would hoist the ensign, the blue peter, and the white-on-blue S (pilot wanted) flag, and together they would go with the carpenter on a final inspection. They would reexamine the derricks, bower anchors, chain locker, and windlass, making sure it had steam, the carpenter oiling it. Likewise they would reexamine the side port, the tanks, which the carpenter would sound again, the hatch covers, the stays, the guys, the masts, the sails, the standing and running gear, the log- and lead-lines, the davits, and the boats swung out, seeing that they were ready to lower. All secured from inspection, the mate would order the mooring hawsers and fenders taken in, which the boatswain had the deck hands do, leaving only slip ropes to the wharf. The carpenter would take the draft fore and aft, and report it to the bridge. There the mate would record the inspection and the drafts in the mate's log. By then, about 7:00, the morning light would be golden ether on the river and up the banks. The mate would order the boatswain to bell off a ?? for a helmsman and clear the deck, examine the helmsman for iron or steel on his person, and station him at the wheel. On the bridge too the second mate would have looked over the binnacles and compasses, cleaned the binoculars, readied the megaphone and navigating instruments, charts, and tables, wiped the bridge rail, and most methodically then be winding the chronometers. On deck the boatswain would have deck hands turn to rigging the leadsman's platforms and setting up any loose lashings and coiling down rope. By 7:30 the steward, cook, and boys, having served themselves, would be cleaning their stations.

Below meanwhile the chief engineer would be inspecting boilers, pipes, and machinery. The assistant engineer would have started the main feed pump and the main condenser, stopped the auxiliary feed and circulating pumps, slackened the gland on the stern tube, looked that the crank pits were clear, jacked the main engine over 1-1/2 turns, disconnected and secured the jack, connected the revolution counter, set the indicators, and be wheeling the links full ahead and full astern to keep the engine's warming even. The oiler would have connected lubricators, cleaned them, and be filling low cups. The wiper would be cleaning drips, smears, pans. and the fireman, having shut all the auxiliary valves but to the auxiliary air pump, opened it to the main condenser, and closed the feeders, would have the boilers roaring low at full steam in all the steam space safely possible. Then with the first mate at the wheel, the carpenter at the stern, the chief engineer would take steam on the steering engine, put it in gear, turn the rudder by steam hard over each way, reset the rudder amidship, connect the controlling gear for the wheel, and see that when the mate turned the wheel, four revolutions to hard aport, eight around to hard astarboard, four back to the midship line, the machinery and the rudder responded.

About 7:30 in the still golden light the master and the pilot would board the tanker and go to the bridge. Higher in the sky they would see soft wool pads drifting south. The boatswain would have deck hands haul up and stow the gangway, haul down and stow the blue peter and the S flag, and hoist the red and white H flag (pilot on board) on the foremast. In the chart room the master would read the crew list, store books, and the mate's log, make sure of the register, articles, and the Diario de navegación, the "Journal of navigation," or official log, and sign it. Out on the bridge again he would order the details for undocking. The first mate at the stem and the second at the stern would look port and starboard that nothing could foul the propeller. Below at the throttle station the assistant engineer would have the main engine warm and lubricated, its cylinders and valve chests blown, the main condenser holding a good vacuum, maybe 27 inches. On the master'' telegraphed and ringing command to test the engine, he would answer the command, then wheel the engine'' links forward into full gear ahead, open the throttle just enough, get the start, and study the gauges and the massive mechanical harmony in its very slow motions, the great piston rods successively driving down and taking up the connecting rods, turning the cranks in their angled succession, revolving the crankshaft clockwise, turning the eccentrics, shifting their rods, the links, and the valve stems up and down, all very slowly repeated several times. Then he would close the throttle, wheel the links back into full gear astern, reopen the throttle, and study the gauges and the same massive slow motions revolving the crankshaft counterclockwise several times. Satisfied, he would report the engine ready, shut the auxiliary air pump, adjust the main pumps, blow off the separator, send the oiler to make sure of the lubrication on the thrust block, and wheel the links full ahead again, then full astern again, slowly rocking the engine, standing by.

At 8 a.m. the master would give a long blast on the tanker's whistle, telegraph and ring stop, and megaphone the order to get underway. Beside him the pilot would stand by to take over, the helmsman to steer. Below, having answered the command to stop, the assistant engineer would close the throttle and wheel the links to dead center; the motions would cease. Forward the first mate would command his detail of five deck hands to unmoor, “Stand by your lines…let go one…[the head line]…Take in one…,” likewise for the spring lines “two” and “five,” and finally for the breast lines, “three” and “six.” At the stern the second mate would call, “All clear.” Fore and aft the mates would then stand as lookouts. AS the boatswain ordered, three deck hands would begin coiling down the lines, one would stand by at the windlass’s brake, and the other go with a chain-hook and rope down the chain locker. At the port bow the boatswain himself would see how much stream chain was out. The hand at the windlass would lock the portside driving head to its wildcat and wheel slack into the brake. The boatswain would knock loose the stopper. And the carpenter would open the windlass engine’s throttle for a slow heaving in. The chain would start screeching up through the hawse pipe and the riding chock, clacking over the wildcat, and rattling down through the chain-pipe into the chain locker. The boatswain again at the port bow would study the links coming in. The hand at the brake would leave it, go to the forecastle pump, and hose down the chain through the hawse pipe. The hand in the locker would tier the length coming down in flakes fore and aft, without a kink. Slowly the heaving would warp the tanker away from the wharf, out into the river, toward the anchor. In a few minutes the bow would be apeak the anchor. The windlass slowly turning, the chain would go taut. At once the boatswain would call, “Cable short,” the hand at the pump would go back to the brake, and the carpenter would slow the windlass. The chain would swing onto the stem, “up and down.” At once the boatswain would call, “Anchor aweigh,” actually 11 ½ cwt. Coming up. In some seconds the anchor’s flukes would appear above muddied water. The boatswain would call, “Anchor awash.” The carpenter would slow the windlass again, and as the anchor’s shank came up into the hawse pipe, the hand would wheel the brake tight and unlock the wildcat. The boatswain would stopper the chain, and the carpenter would close the throttle.

At the instant he heard “anchor aweigh,” the pilot would have given his commands to the helmsman and by telegraph and bells to the engine room. At “starboard helm, hard over,” the helmsman would have wheeled left four turns. At “astern full,” maybe “30 revolutions,” the assistant engineer would have answered, wheeled into full reverse, and pulled the throttle wide open. The fireman would study the boilers for any sign of priming. In some seconds the engine’s great moving parts would all be going in their due strokes and cycles complete and repeated in a great “thumpety-thump-thump” nearly twice a second. At the stern the second mate would see the propeller churning, the stern suddenly swinging to port, out and around into the river. At “port helm, hard over,” and “ahead full,” again maybe “30 revolutions,” as the helmsman and the assistant engineer maneuvered and the machinery responded, the stern would kick again out and around into the river. So back and forth in a few minutes the tanker would be backed into the river, headed downstream. The pilot would command, "Port helm, easy…Ahead slow." And as the men worked and the machinery moved, the engine's throttle wide open, its links shortened for maybe 20 rpm., the tanker would slowly gain headway downriver into the channel along the right bank.

Given the current, depending on its strength, the San Cristóbal would steam from Minatitlán to Puerto México in 2-1/2 to 3 hours. Minatitlán still in sight, the master would set the sea watches, the port watch on the "forenoon Watch," and retire to review and make ready the ship's papers. The first mate would station the second and third hands on watch as lookout and leadsman, and commence entering times, places, and remarks in the mate's log, and striking the watch bells every half hour. The second mate and the three starboard-watch deck hands would turn in. On the bridge the pilot would conn the tanker. Studying forward and away on both sides the river's surface, calm, sapphire, turquoise, emerald in the winter, he would note ripples, glance astern now and then to see how the wake rolled, blow the whistle at the bends, and continually command the helmsman to stay in the channel. As commanded, the helmsman would steer the course, along the right bank past …Uxpanapa to Yeguero upland, along the left around it, along the right back again …Diablo ? along the left to the last ?.., then along the right again around the bend and down past the ? bar. Forward along the way the lookout would watch for other vessels, and from one or the other platform the leadsman would continually take soundings and call out the depths, in low water over the bar at the Uxpanapa, "By the mark, three," in the channel on down, "By the deep, four…And a half four..and a half three…" The boatswain and the carpenter would remain forward too, to examine the ground tackle, oil the windlass, and see that the stream anchor stayed ready to let go. Below the chief engineer would take indicators from the engine and examine the main bearings and the thrust block. The assistant engineer at the throttle station, having shut the engine's cocks, adjusted its oiling gear, and taken his habitual stance, erect, legs wide apart for balance so close to such powerful motions, would concentrate on the gauge-board and the great, slow, absolutely regular stroking, whirling, and jigging before him, looking through its continually developing and repeated patterns for any little odd drop of oil, listening through the manifold and rhythmic sounds around the room for any odd clocking or pounding or groaning or rattle or whisper, sniffing for scorched rubber or hot oil. At 9:00 (and hourly thereafter) he would log the level of fuel, pressures in the boilers and the cylinders, vacuum in the condenser, total revolutions, and any water in the bilge. Meanwhile the oiler would make his rounds, feeling bearings and blocks for heat, filling the cups in pumps, the dynamo, and the engine, swabbing rods and stems, ad round complete every half hour. The wiper on his rounds would clean frames, guides, bed-plates, pans, and the floor. The fireman would stand before the boilers, keeping fire, water, and steam steady, watching gauges, listening to the three roars even and low for any whisper, looking for drips of fuel or water. At about 10:00 the steward, cook, and messboys would start preparing dinner. Also about then, properly at four bells, the master, the first mate, and the chief engineer together would begin the daily general inspection on deck and below. With a strong current the pilot would already have conned the tanker over the last bar, some 4 miles above Puerto México, commanded the helmsman to come left past Pajaritos Island, and telegraphed below to reduce power. The assistant engineer would answer, link farther in, and tighten the check valves, and the fireman would blow off the boilers, gradually turn down the heaters and the fuel, cut the air and see that pressures fell slowly and evenly. As the pilot, the helmsman, the assistant engineer, and the fireman worked in about 30 minutes the tanker would steam at bare steerageway from behind Puerto México into the river's roadstead. Her whistle would clear any Sunday canoe trippers.

The master would be out on the bridge again. All across the north by then the sky had gone ?, and it was hot, already near 90º, muggier than usual, and no sea breeze, a strong south wind blowing. The first mate would order preparations to drop anchor. He and the second mate would take their stations as lookouts. The pilot would spy an anchorage. As commanded the helmsman would steer past it on the starboard side, turn the tanker around to the port, and head it upstream into the road's easy current. The boatswain would call the deck hands to the bow. One would stand by at the stopper, the other at the windlass would slack its brake. When the tanker came slowly up over the anchorage, the pilot would command, "Port helm…," say 15º, "astern slow…," and blow the whistle. As the helmsman and the assistant engineer worked, maybe 100 feet beyond the anchorage the propeller would kill the headway, the pilot would blow the whistle twice, and the tanker would begin gaining sternway. Back over the anchorage the pilot would sing out, "Is your anchor ready?," then command, "Stop engine…, rudder amidships…, let go…." Nearly at once the assistant engineer would answer, close the throttle, wheel to dead center, and open the cocks. The fireman would open the bleeders, the helmsman would wheel left two turns and the deck hand at the stopper would knock it loose and stand clear. The boatswain at the port bow would see that the anchor actually roped into the water, and that when the chain slackened, the hand at the brake tightened it slightly. The chain would veer almost straight. When it had run out nearly to its end, the current carrying the tanker slowly back, the pilot would command, “Snub her…,” and blow the whistle once again. The hand at the brake would wheel it all the way down, the carpenter would stop the windlass, the chain would screech, the hand at the stopper would fasten it, and the tanker would stop. The first mate would note the anchor’s bearing, and station the hands as lookouts.

A Pearson boat crew would bring a launch along the San Cristóbal’s starboard beam. The boatswain and the hand who had been helmsman would fasten and lower the pilot ladder, which the boatswain would have the head guard. The master would climb down with the ship’s papers into the launch, and ride over to Wharf No. 1, the customs wharf. At the federal telegraph office he would get the latest weather report. “The fiercest weather of the winter” had hit the Texas coast about 1:30 that morning and gale warnings were up for the Gulf; They would shortly go up at the Puerto México pilot office and lighthouse, At the federal health office, the U.S. consulate, and back at customs he would collect a bill of health, its certification, and clearance outward. Meanwhile on the tanker at 11:30, seven bells, the steward and messboys would serve the first dinner to the starboard watch. At noon, eight bells, that watch would relieve the port watch for the “afternoon watch,” on deck and below “the most unpleasant…of the day….” ?>>>>relieving mate would ? the anchor’s bearing, review the mate’s log, ? local mean time and local apparent time, set his ?-watch and his bridge clock about nine minutes back for “ship’s time.” The heat below as ordered the relieving assistant engineer would reset the engine-room clock. The relieving fireman would notch the steam at maybe 90 psi. The relieved assistant engineer would update the engine-room log, adding to the hourly records the watch-to-watch readings of the temperature of the engine room, feed water, and boiler room, the density of the feed water and the water in the boilers, and the amount of any fresh water made and used, sign the log, and report it to the bridge, where the relieved mate would then update and sign the mate’s log. The steward and boys would serve the second dinner to them, the chief engineer, the boatswain, the carpenter, and the relieved deck hands. Afterward the chief engineer would go below, make sure the clock read right, and order the assistant engineer to stand by to steam, the boatswain would go examine the tackle, oil the patent log, and have a couple hands rig in the leadsman’s platforms, and the carpenter would reexamine and lubricate the windlass. Below as the assistant engineer ordered the fireman would change at one furnace after another the No. 12 burner for a No. 18, and after him the wiper would go cleaning any splashed fuel.

By the hot south wind it was hazing up, and gulls were flying in, low. About 1:30 ship’s time, three bells, the master would reboard the tanker and order the mate to make ready to get underway. The chief engineer would order full power below. As at Minatitlán that morning preparations had happened, so at Puerto México then they would happen again.

At 2:00, four bells, the master would blow the whistle and give the order to weigh anchor and head to sea. As before, all the necessary men on deck and below working together, so the chain would be heaved in, the anchor weighed and stoppered, and the tanker reversed and turned around into the channel toward the sea. Ahead slow as the pilot commanded the tanker would steam out of the river and between the jetties, a launch after her, down the channel past No. 6,4, and 2 red buoys on the port hand and No. 5,3, and 1 black buoys on the starboard, in line with two red leading lights back up on the river's right bank, true N. 18º W., and stand out from the coast, on that side barrier sand hills and beach.

Beyond the outer bar, at sea, still in line with the leading lights, the master would record the standard compass error, resume command, and have the tanker slowed to dead slow. The mate would have the first chart and table out, and see from the vane how the southerly was blowing. The launch would come alongside; the pilot would climb down into it, to return to the port. The boatswain would lower the pilot flag, stow it, and stand by with the third deck hand to stream the patent log.

Then as the master ordered the mate would take the conn. By the standard compass he would order port helm maybe 20º, by the telegraph order maybe 75 rpm., and set the standard course, north on 94º, 25', at standard speed, 10 knots. By the steering compass the helmsman would wheel the tanker to the starboard to the ordered degree, steady her, and head true north.

On the forecastle the lookout would search the clouded, hazy horizon and the gray-green sea for trouble. And below the assistant engineer, fireman, oiler, and wiper would have the boilers burning maybe 2 ¼ gallons of fuel and evaporating maybe 30 gallons of water a minute into steam at 180 psi and the engine's great mechanical motions in all their lawful planes and parallels and circles duly cycling smoothly and cleanly at 75 rpm; flowing maybe 1,000 horsepower, screwing maybe 500 into the sea, in some minutes making the due speed over the bottom. As soon as he saw the boatswain stream the patent log, the mate would take through the haze a simple departure from the Coatzacoalcos light-house, a 40-ft., red-and-white-striped tower on a hill west of the river, lat. 18º 08' 56" N., long. 94º 24' 46" W., and record the position in the mate's log, read the clock and record the time, read the patent-log register and record the mileage, glance at the vane and record the wind's apparent direction and force, and record the barometric pressure about 30.04, and temperature, about 90º. Then he would plot the course for the next hour on the chart, true north 10 nautical miles. Meanwhile the boatswain and the third hand would secure the anchor in the hawse; the carpenter would heave the chain taut to the windlass, stop its engine, open its cocks, wipe away mud and water, lubricate bearings and moving parts, lash a canvas over the machine, and likewise cover the forward pump; and the commissary idlers would be cleaning the pantry, galley, and messes.

Three miles out the San Cristóbal passed into international waters. The boatswain would lower the ensign and stow it. The third deck hand would go trim the ventilators set up stays, and clean the forecastle. The boatswain and the carpenter would look over the lifeboats swung out, then separate, the boatswain to examine the stream anchor, bower anchors, and cables, the carpenter to examine scuppers and sluices. Every half hour, when the watch bells were rung, the lookout would call, "All's well." At six bells, 3 p.m., the mate would have out his sextant, take through the haze another bearing of the Coatzacoalcos light, record it, the time, the mileage, and the barometric pressure, fix the tanker's position on the chart, and plot its course for the next hour, right up 94º 25' 10 nautical miles. By then the chief engineer would have reexamined the steering engine and be on deck studying the funnel for smoke or any flicker of flame. Below the assistant engineer would have shut the air pump's suction on the condenser, adjusted the circulating pump, logged the hourly readings, and be studying the gauges, studying the motions, listening to the thumpity-thump-thump for any odd sound, sniffing for anything too hot; the oiler would be making his rounds, feeling bearings and blocks, filling cups; the wiper would be wiping and cleaning the machines, the floor, and dirty burners; and the fireman would be studying gauges, listening and looking for leaks and danger.

As the tanker made headway, the master would look for the weather ahead. Far westward under the mackerel ? and a whitish haze he would see the blue Sierra de Tuxtla slopes, all around by then scud low flying north, ahead the following sea's small but growing waves and some white foam crests. He would note the barometric pressure, falling, and the temperature, still very high. The norther was fast on its way.

At eight bells, 4 p.m., clouds building in the west, the port watch would relieve the starboard watch for the "first dog watch." As at noon, the relieved assistant engineer would update the engine-room log; the relieved mate, the mate's log. The relieving mate would review the mate's log, try the whistle and the running lights, then record the heading, the ? the mileage, figure the ship's position by dead reckoning, and plot the course for the next hour, same longitude, same distance. The boatswain and the third hand would go scrape rusty spots on deck and prime them. The carpenter would sound the bilge and the ballast tanks, and below repack any leaky auxiliary pump. The chief engineer would examine the stern-tube gland and thrust block. The fellows on watch below would continue the routines here. And the commissary idlers would begin preparing supper. By two bells, 5:00, the western sky was "a heavy high dark bank of clouds" moving to northwest, there was lightning in the northwest, the wind, strong and hot and damp as well, had veered to southwest, a low, thick fog was rolling up fast from the south, and the barometer had fallen lower. At the bells the mate would log the weather, figure the position again by account, and plot the course on the same line for the same advance. AT sunset, 5:23 that day, by then about 30 miles out of Puerto México, nearing the 100-fathom line, he would turn on the binnacle and chart-room lamps and the running lights, white on the foremast and mainmast, green on the starboard side, red on the port. The lookout would call, "Bright lights, sir." The steward would turn on the deck-house and mess lamps. At three bells, 5:30, he and the boys would serve the first supper. In the dark at four bells, 6 p.m., as the lookout called not only, "All's well," but "bright lights, sir," too, the starboard watch would relieve the port watch for the "second dog watch." The reliev3d officers would update the logs. The commissary men and boys would serve the second supper. From the position again by account the relieving mate would again plot the course north at 10 knots for the next hour. The helmsman with his eyes on the binnacle before him would keep ever the same heading. Forward the relieving lookout, scanning the misty dark, waiting for his night eyes, would see continual lightning northwest. The third hand would go scrub toilets. After supper the boatswain and he would inspect the boats. The carpenter would inspect the fire gear and sluices. At six bells the mate would log lightning in the northwest and north, thunder, the wind strong and hot from the west, the barometer lower, and yet again draw the line north an hour. The third hand would dump the day's trash and garbage overboard. Below the work would continue to produce power and 10 knots over the bottom.

By 7:45 there was a great, dark bank halfway up the northern sky, with incessant flashes of lightning all across the northern horizon, the thunder close, the barometer steady, about 29.8. Then the wind suddenly veered north by west and went cold. The mate would reckon the position at 19º 04' No. on 94º s? The sea glittered. A roaring came from the north. The barometer rose. Ten minutes later the temperature was down to 60º. Then the norther hit, a wind of Force 8, a good 35 knots, a not yet fully risen sea, but waves anyway up to 15-20 feet, 200 feet long, breaking in white foam and spray. On the mate's orders, as the tanker began pitching every several seconds and the engine's governor commenced its correspondent throttling, the assistant engineer would steady himself and lengthen the links for maybe 90 rpm. To hold the speed at 10 knots. As he ordered the fireman would inverse the air and heated fuel into the furnaces.

In the cold gale at eight bells, 8 p.m., the port watch would take the ‘first watch.” The boatswain would station its third hand on the poop as boatkeeper. When the engine-room and the mate’s logs were updated, the position figured by dead reckoning, and the course plotted for the next hour, the relieving mate would make the eight o’clock reports to the master. On the master’s “very good” he would initial the night orders, and with the boatswain go make the rounds on deck to see that all was secure. Then the boatswain would retrim the ventilators, and turn in. The carpenter would sound the tanks, the last time that day, and go rest. The commissary fellows would clean their stations, turn off the maps, and turn in. On the half hour the lookout would call that all was well and the lights bright.

By about 8:45 the bank of clouds, the lightning, and the thunder were in the south, but the gale was blowing north by west in all its force, the barometer at about 30.5, the temperature in the 50’s. Over the long sea north the night sky towered above high broken clouds and twinkling stars. Having unshiped his sextant and hack watch, the mate would take between clouds the altitude of Polaris, record the time and the mileage, take sights of Procyon or Sirius or Pollus and Castor in the east and Vega or Deneb in the west, record their times, find the right ascensions and declinations in the Nautical Almanac, work the observations out in the sight book, fix the tanker’s position, 19º 14 N., 94º 25 W., and plot the fix on the chart. At two bells, 9 p.m., he would order “lights out” in the deck house, return to the chart, and from the fix plot the course, always the same. At six bells as ordered the boatkeeper would begin his two-hour trick at the wheel, the helmsman would begin his two-hour spell as lookout, and the lookout would begin his at the boats 9a good place to rest his eyes). For finding any change in compass error or only for practice the mate might obtain an azimuth of Dubhe or Betelgeuse of Markab, but hourly determine a fix for the hourly projection of the course. Below as before, the fellows there doing their duties, the engine thumpity-thump-thumping maybe 90 times a minute, power would flow in its continuous motions to make 10 knots good.

Likewise as the gale blew and the tanker pitched and pitched the starboard watch would stand the “gravey-eye” or “middle watch,” from midnight to 4 a.m. A sharp-horned and silvery last-quarter moon rising, the logs updated, the course plotted from a fix or a position by account for the next hour, the mate would go inspect the boats (and if need be rouse out the boatkeeper), and take a look below. For the compass or for his practice he might then obtain some azimuths, maybe of Regulus or Alpheratz, but by account do the hourly plotting. Regardless of the stars the hand at the wheel would study his guide, "the tiny circle of light in the binnacle," leading still true north on 94º 25'. Every half hour on the bells the two on the bridge would hear the lookout's call. Always, so surely that they would forget they were hearing it, there would sound aft and from below the engine's steady thumping.

At eight bells in the cold night wind the port watch would take the "morning watch." IT would begin like the one before, but at three bells, 5:30 a.m., the commissary idlers would turn out, light up the galley, and at four bells serve out coffee to the other idlers and the fellows on watch. The boatswain would then send the boatkeeper for his trick at the wheel, inspect the boats, oil davits, and as soon as the hand who had been at the wheel took the lookout put the hand who had been lookout to hosing the boats and swabbing down the deck. The carpenter would sound the bilge and the tanks. The assistant engineer would do the daily tests of the whistle, siren, and quality of the water, move the auxiliaries, and have the fireman try the boilers' cocks, blow off scum, and blow through glass gauges. In the twilight the mate would take time sights of Vega or Arcturus in the east, Sirius or Procyon in the west, and work them out for a new fix. The chief engineer would review in the engine-room log, take indicators, and examine the steering engine, main bearings, and thrust block. At sunrise, 6:23, by then about 160 miles north of Puerto Mexico (about 170 east of Tuxpan Bar), the mate would turn off the binnacle and chart-room lamps and the running lights; the steward would turn off the galley and pantry lamps. In the gray hour before seven bells the mate would wind the chronometers for the day, bring the dead reckoning up to the time, take a time sight and obtain an azimuth of the sun, glaring from the southeast white across the sea, work out a fix, obtain the compass error, record the fix and the error, and make the rounds of the deck. At seven bells the steward and boys would serve the first breakfast, at eight bells the second.

That morning (because of the dog watches) the starboard watch would stand the forenoon watch. Under light, bright, blue sky it would face practically the same cold wind, but a fully developed sea, waves 20 to 35 feet high and 350 feet long, their foam stretching south, spindrift flying. Like the first mate 12 hours before, the second mate as soon as he had the logs updated and si$_5$ned and the course plotted would make the eight o'clock reports to the master, then go with the boatswain on the rounds of the deck, then return to the bridge to conn and hourly fix or reckon the tanker's position and plot another advance. The helmsman would do his trick at the wheel, the lookout would do his spell on the forecastle, and as the boatswain directed the third hand would do his tarring down brown rigging, setting up slack stays, greasing rusty turnbuckles with white—leaded lard, swabbing, scraping, priming, painting. At four bells as by then usual they would change about, and the commissary idlers would tarn from cleaning to preparing dinner, At six bells the master and chief engineer would meet to do the daily general inspection. The carpenter would have done the watch's soundings, examined scuppers and sluices, and be packing any leaky pump. Below as before the routines would continue for power, propulsion at 10 knots, and the hourly records. Between his routines the fireman would make the daily change of fuel filters and wash the dirty ones clean ? And at seven bells the steward and boys would serve the first dinner, at eight the second. The only officially remarkable event, however, would be the "noon sight": after striking seven bells the mate would reset the bridge clock if necessary on the reckoned L.A.T., compute the constant for the sun' s meridian altitude, about 11:50 commence observing the sun, and when the clock read noon and the sun went "on a stand" measure altitude, deduce latitude, 21º 45' N., and compute longitude, sure enough 94º 25' W., for the tanker's position then in the Gulf, about 215 nautical miles north oaf Puerto México. This with the patent-log reading he would record in the mate's log, for his relief to fix the position on the chart and reckon the afternoon's advances.

So that afternoon the port watch would stand watch. And practically the same routines as the afternoon before the officers and men on duty on the bridge, in the chart room, on deck, in the pantry galley, and messes, and below would repeat. The only officially remarkable events, about 22º 20' and 250 miles north of Puerto México (about 190 off Tampico), would be the mate's recomputation of the standard compass error and his order to ease the rudder accordingly, maybe but a 15th of the wheel.

So too practically the same as yesterday's except for the cold wind would be the dog watches. Just before the sun set, a pale pink that evening, the mate would take a time sight, obtain an azimuth, and figure a fix, ending "a day's work of navigation." But there was no end to the other work of navigation, seamanship, and steaming.

That night (because of the dog watches) the starboard watch would stand the first watch. Under a clear and starry sky as the men worked the tanker would steam against the wind across the Tropic of Cancer and about the same time over the deepest bottom of her run, along the western slope of the Sigsbee Deep, nearly 2,100 fathoms down. Neither of these events would be remarked in the log, although a sight or an azimuth would.

So cold and windy, so routinely, and so recorded the next seven watches would to, only to move the tanker ever true north on 94º 25' at 10 knots. At the next sunrise, again gray, the latitude would be 24º 52' N. At noon it would be 25º 07’ N., making since noon the day before “a day’s run” of about 240 miles and the distance from departure some 244 miles. AT sunset, again red, it would be 26º 39’ N. At about midnight it would be 27º 48’ No, the tanker by then having steamed some 575 miles north of Puerto México, within a few miles of the Gulf’s northern 100-fathom line. But during the middle watch that night the mate would log a notable change: the wind falling to moderate and shifting to the northeast. It was as cold as before, but the norther was blowing out, the sea subsiding into small waves and long swells. As the mate ordered the helmsman, the assistant engineer, and the fireman would make the due adjustments to hold the course at 10 knots.

The third morning at sea, the last of that urn, Wednesday, December 8, officers and men would do the morning routines and begin the first work of arriving. By four bells through the dark on the morning watch the lookout would be smelling the Texas coast. At 6:42 a.m. he would see the sun rise, cold and white. And at about 7:00 he would see at four points off the starboard bow the lights from Heald Bank, which he would call to the bridge. The mate would record the time and the bearing, which made the latitude 28º 59’ N. By the chart the tanker would be shoaling her water to less than 10 fathoms, but Heald Bank lay a safe 10 miles east of her course. On the forenoon watch by 8:35 the lookout would have lost the Heald Bank lights. But here and there he would see gulls. At about 9:20 he would make land. It would be due north about 12 miles, High Island, on the coast about 22 miles up from Galveston.

Hearing the lookout call the landfall, the master would go to the bridge. AT once too the mate would record the time, the land’s bearing, and the patent-log reading, maybe 708 miles, and correct it to 670. By the chart they would be shoaling to seven fathoms. of the hands would haul down the S flag, hoist the H flag, and go stand by at the stream anchor and chain. The carpenter and the other hand would be standing by at the windlass.

Then as the pilot ordered and the men worked the San Cristóbal would steam ahead, leaving a red gas buoy on the starboard hand, and enter the channel midway between the jetties. Soon at the ordered six knots, followed by the pilot’s launch, she would head up the channel in the middle of the pass, leaving red spar buoys on the starboard hand, past the life-saving station on the west side, whistling once and hauling handsomely to the starboard if she met a vessel coming down the pass, slow, and at about 2:30, opposite the town up on the west bank, Sabine, Texas, below Brant Point and the white, 75-ft. lighthouse up on the east bank, in Louisiana, stop stream-anchored in four or five fathoms; out the fireman would hold the steam at full pressure.

The master would call all bands to muster. It was cold there, in the 40's. From the Texas state quarantine station in town a health officer would come aboard, see the Puerto México bill of health, look over the *25* men present, and give the master pratique. The boatswain would haul down and stow the yellow Q, and as soon as the health officer left haul up and stow the pilot ladder.

On the master's order and the first mate's commands the afternoon watch would return to duty and weigh anchor. The pilot would take charge again. As he conned, the mates stood lookout, anti the men worked on deck and below the tanker would steam ahead up the channel, followed again by the pilot's launch, past Brant Point, past the red nun buoy on the starboard, at six knots again past the Security and Sun Oil tank farms and the Sabine docks on the west side, past any vessels coming down on the port hand past red spar buoys Nos. 18A and 20 on the starboard, and toward 3:30 swing left into the Port Arthur canal. By then the carpenter would have the winches turned over and warming; below the assistant engineer would have the auxiliary pumps likewise readied. Up the canal toward Port Arthur visible in the distance the tanker would continue at the posted limit of 7 mph., hauling to the starboard for vessels coming down, but between them favoring the west bank, Sabine Lake all along the outside of the east **b**ank, Keith Lake, everglades, brackish wetlands, cheniers, and salt marshes in a green wilderness beyond the west bank. At 4:00 as on the master's orders the first mate ordered the boatswain would break the watch. The port watch would remain on duty, but the starboard watch deck hands would join them, and the boatswain would direct all five hands on deck to make up the heaving lines, chafing gear, and mooring hawsers. Meanwhile the commissary idlers would be starting supper.

At about 4:15 the San Cristóbal would reach the head of the canal. Slowed to bare steerageway, whistling long, doubled left around the point of Texas Company Island, swung to starboard, the mouth of Taylor's Bayou on her port beam, she would come slowly into the Port Arthur turning basin a place of much traffic. The master out on the bridge, the mates keeping a sharp lookout at stem and stern, the boatswain and four hands would be making ready at port-side chocks, the carpenter and a hand at the by then live after winch.The master would resume command. As he ordered and the helmsman, an assistant engineer, and a fireman worked the tanker would come very slowly up the island's west side, past any vessels moored along the wharf there, toward her assigned and signaled berth. Seeing that she was beyond tight quarters, practically para11el with the wharf, maybe 100 feet off it, about a length from her berth, the waster would order, “Helm amidships…,” astern full..., stand by to let go.” The tanker would move ahead ever more slowly, her stern working off to port, In maybe 13 minutes, by then canted to maybe 20º with the wharf, but her bow still maybe 80 feet off it, she would have come to rest practically even with her berth. The master would order, “Port helm hard over..., ahead full....” The helmsman, the assistant engineer, and the fireman, and the boilers and machinery responding, the stern would swing to port ever faster as the tanker gathered headway. Before she had gone a length ahead the master would order, “Starboard helm hard over..., astern full....” the stern would continue swinging to port, and the tanker gather sternway. So after two or three more turns she would be heading very slowly down the island’s west side, ever nearer parallel with the wharf, in a few minutes but a length from her berth, within heavin$_6$ distance of the string-piece. The master would order, “Port helm hard over…, astern full…, stand by to dock.”

On the first mate’s order to heave the lines and at the boatswain’s command the hand at the quarter chocks would heave the line for “five,” the forward quarter spring. As he did, the hand at the bow chocks would heave the line for “two,” the forward bow spring, and the hand at the inshore stem chock would heave the line for “one,” the head line. The tanker moving ahead ever more slowly, her stern working off to starboard, the wharfmen along the fendered stringpiece would haul the hawsers through the chocks and walk them forward. In maybe three minutes, again canted to maybe 20º with the wharf, her screw churning 100-odd feet offshore, the tanker would stop, and her port bow come lightly to the stringpiece.

Immediately the master would ring off the engine and order, “make fast.”’ At once below the assistant engineer would answer, center the engine’s links, close its throttle, open its drain cocks, and close its lubricating valves; the oiler would pull its lubricator wicks; the wiper would start wiping its coolest parts; and the fireman would turn down the heaters, fuel, and air, and open the circulating valve past the midship and the port boilers, banking their fires. At once on deck as the first mate commanded, the boatswain directed, and the wharfmen secured “five,” “two,” and “one” on the proper bollards, the hand at “five” would take it to the after winch, the hand there would bend it to the winch head, the carpenter on the winch would take in the line’s slack, and the hands at “two” and “one” would take in their slack.

There ensued maybe a half an hour of work to shut down and actually make fast. Below it would be numerous separate operations. The chief engineer would examine and tighten the gland on the stern tube, examine the main bearings, and go examine and disengage the steering engine. The assistant engineer would switch power and motion to the auxiliaries, disconnect the main engine's revolution-counter and indicators, lift its cylinder- and valve-chest covers a little, and pump the bilge. The oiler would stow the wicks, empty the main machinery's drip pans, and retank the oil. As each part of the main machinery cooled the wiper would wipe it down. The fireman would blow off the boilers, change the burners in starboard boiler's furnaces to No. 12's, close the stop valves on the midship and port boilers, close the master valves on their fuel lines, stop their blowers, turn down further the heaters and the fuel close the midship and the port boilers distributing valves, let their burners die, shut their air doors, close dead burners, put buckets under them, uncouple their supply pipes, rack them, take out the burners, and clean and rack them.

ls and the boatswain's directions the work would be maneuvers in constant and intense cooperation. The carpenter on the winch would take a strain on "five," slowly heave round and round on it, slowly turning the tanker around its center of gravity, the hands "two" and "one" steadily slacking them until the stem was almost 110 feet offshore and the stern came to the stringpiece. The hand at the inshore stern chock would heave the line for "eight " the stern line, to a wharfman, who would secure it on the bollard for it. The hand at the quarter chocks would heave the line for "six," the quarter breast, to another wharfman. On deck and on the wharf they would secure this line on the bitts and bollard for it. Then the hand on "two" would take it to the forward winch and bend it to the head, and the carpenter having done there too would take a strain on it and slowly heave round and round on it, slowly dragging the tanker around the quarter breast bitts, the hand on "eight" steadily slacking it, the hand on "one" steadily taking in its slack, until the sternport was about 45 feet offshore and the bow again at the stringpiece. Then the carpenter on the after winch again would heave on "five" again and turn the tanker again around its center of gravity, the hands at the forward winch and the stern slacking "two" and "one," the hand on "eight" taking in its slack, until the stem was was almot 50 feet offshore and the stern again at the stringpiece. The hand on "six' would take in the slack on it and resecure it. So after another heave on "two," another on "five,' and one more on 'two" they would have the tanker berthed. The hands on "one" and "eight" would take enough turns on the bitts for them to hold them, the hands at the forward and after winches would unbend "two" and "five" and take enough turns on the bitts for them to hold them, a hand at the bow chocks would heave the lines for "three" and "four," the bow breast and the bow after spring, a hand at the quarter would heave the line for "seven," the quarter after spring, and when, the wharfmen had secured these hawsers on the bollards for them, take enough turns on the bitts for them to bold them. Finally the first mate would order, “Double up and secure.” As the boatswain directed the hands and maybe the carpenter on one or the other winch would even slacks and strains on the lines, double them, and secure all eight on the bitts.

So about 5 p.m. just before sundown at Port Arthur, the western sky pink again, the temperature in the 30º’s the run would end.

But the work would only change. The master would set watches in port to start at 6 p.m. The wharf lights would go on. The second mate would turn on the riding lights, erase the marks on the charts, put them away, lock the chart room, and still on duty update the log. The boatswain would have the hands lower the gangway, clear the deck, and retrim the ventilators, and himself haul down and stow the pilot flag and the ensigns. The carpenter, expecting a freeze that night, would leave easy steam on the deck machines and go sound the bilge and the tanks. The pilot and the master would go ashore, the pilot to return to his launch, the master for his arrival duties, to the Kansas City Southern station to mail a copy of the ship’s manifest to the U.S. Treasury and telegraph Pearsons in Mexico City that he had landed in Port Arthur, back to the Texas Company terminal superintendent’s office to see the time scheduled for him to take delivery of the cargo. At 5:30 the steward and the boys would serve the cook’s first supper to the fellows not on watch, at 6:00 the second supper to the master reboarded and the men relieved on deck and below. The time to take delivery would be sunrise tomorrow. The night watch in port would require some extra duty. The chief engineer would order the deck boilers relit, to inspect the pumps room, and open it for ventilation.

As the master ordered the mate on watch would begin preparations to discharge ballast. Under the wharf’s cold electric lights the boatswain would station the three hands on watch port-side at the bitts. The carpenter would open all 16 tank vents and sounding holes, set the flame screens, and go plug the scuppers. In the pump room the assistant engineer would open the after cross-over valve. There and in the other rooms below the oiler and wiper would make their rounds. In the boiler room the fireman would relight a furnace in the midship and port boilers, bank their fires, but adjust the heaters, fuel, and air to hold their steam for the night. About 6:30 the mate would set on open the red and the green deck cargo valves to Tank No. 8’s port and starboard compartments, signal below to discharge, and open one after another cargo valves to tanks No. 6,4, and 2.

At the mate’s signal the assistant engineer would open the pump room’s starboard sea valves, and shortly some 475,000 gallons of oily, stinking Coatzacoalcos River water would have commenced flowing into Port Arthur's basin. The tanker rising from the bow aft five or six inches in half an hour, the boatswain, the carpenter, and the deck hands would continually check the lines. The commissary idlers would finish cleaning, and turn in. By 9:15 all the water that could run out, some 255,000 gallons, would have run out. The tanker would be drawing under 12 ft., and the ballast pump would be warm. The mate would go close all the cargo valves except to Tank No. 8's starboard compartment. On his signal the assistant engineer would start the ballast pump, which in 35-40 minutes would force practically all the rest of that compartment's water into the basin. When the pump began sucking, the mate would open No. 8 port-side and close it starboard-side. So, as in trimming at Minititlán four days before, the fellows on deck and the fellows below would discharge the ballast. It was freezing that night in Port Arthur. They could nap in turns, on deck around the funnel or a machine or on the engine-room hatch, but on deck and below there would always be at least a couple of fellows keeping each other awake and the work going. And by 3 a.m. they would have all the even compartments empty, their valves closed, the pump stopped and draining, the pump room's sea valves closed and lashed, the starboard boiler's power reduced, the funnel guys tightened, the mooring lines again even and secure, and the tanker again upright and still, as high as she could be in fresh water, drawing but 9 ft. The boatswain would station the hands as guards, one on the gangway, one for the liens, and one at the boats, see that the deck was clear, and turn in. Having sounded the bilge and the tanks, the carpenter would turn in too.

Below the watch would turn to overhauls, refittings, and maintenance. The assistant engineer, the oiler, and the wiper would work on the engine, mainly resetting the eccentric sheaves to restore due lead to the slide valves. Between his studies of fuel, water, heat, and pressure gauges, looking and listening for leaks, the fireman would change and work dirty filters, polish burners, and clean diaphragms.

At 5:30 a.m. on December 9 the commissary fellows would serve the first breakfast to everyone not on watch. At 6:00 they would serve the second to the men relieved, and under the thin crescent moon, the stars, the riding lights, and the wharf lights the day watch would begin. The master, informed by the terminal agent that his pumping crew was making ready, would order the mate to prepare to load. The mater would order the carpenter and the boatswain to make the connections to shore. The carpenter would oil the after winch, close its cocks, oil the after derricks' goosenecks, shut down the forward winch and the windlass, and go sound the bilge and tanks, making sure that the vents and holes were still open and the flame screens secure. The boatswain would exchange signals with the head wharfman, call the hands to the port quarter, and have them break out the after derricks, rig their head blocks and tackles, and bend one derrick's topping-lift fall to the winch head. Back at the winch the carpenter would put it in gear, start it, and top that derrick. As the boatswain commanded a hand would secure it by chain. So the other derrick would be topped and secured. Leaving easy steam on the winch, the carpenter would go shut down the other deck machines, then see that the scuppers were still plugged. And as the boatswain commanded and directed the hands would train the derricks inshore, guy them, haul in from the wharfmen the cargo-hose lengths, and connect them into two delivery hoses. Strop them from the tackle at the flanges, and set buckets under the joints. AT 6:45 the sun rose. The mate would turn off the riding lights. The wharf light too would go off. The boatswain would hoist the ensigns, haul up a red warning flag on the fore-mast, hang a warning sign across the gangway, open the locker of gun-metal tools and emergency equipment, and have the hands flange up at the deck delivery lines. The mate would order all fires out. The steward would kill any fire in the galley, and the assistant engineer, ordering the fireman to kill the two idle boilers, would log all fires out and sea valves tight (a lie). The fireman would kill the banked fires, shut the midship and the port boilers tight, turn down the fuel and its heat and the air from the starboard boiler, and refocus on the gauges. Meanwhile on deck the mate would be opening all 16 cargo valves, and the master and chief engineer would be inspecting the deck, the boiler room, and the pump room. There the chief would stay with the assistant engineer, see in detail that the sea, pump, air, and steam valves were on closed, the cross-over valves on open, and stand by.

At 7:00 the work of loading would begin. With the master on the bridge the mate would hear and answer the head wharfman's questions: "yes, valves are open,…pipes connected, …all tanks empty, …fires out [which the haze over the funnel and the overboard discharge would belie], …ready to take in cargo, …stand by!" In about five minutes he would call, "Commence pumping slowly! The head wharfman would open the wharf manifold's oil delivery valve. A big terminal pump would start, the hoses would swell and steam in the cold, the deck valves would warm, below hot crude oil would pour into the tanks, and up through the bents would come the stink. There being no knocks in the main or leaks in the hoses or in the pump room, the mate would call again, "Stand by!," and in another five minutes, "Fast!" Soon the pump would have doubled its speed or more, the hoses would have stiffened, and the oil would be pouring as fast as the system could take it, some 225 gallons a minute into each compartment. From the bridge the mate would keep a sharp lookout on the derricks, their guys, stays, and spans, the tackle, and the hoses. Below the chief engineer would see that the fireman could instantly kill the fire in the starboard boiler and that the assistant engineer had correctly refit the main engine. There too the carpenter would examine the main machinery's stuffing boxes and repack leaky glands. On deck as the tanker very slowly drew deeper water the boatswain, and the three hands would move fore an aft port-side altering the moorings. By about 11:00 the tanks would be nearly 90% full, the tanker drawing over 16 feet. The mate would call to the head wharfman, "Stand by!" About five minutes later he would call, "Slow!," and go close all the cargo valves but the four to Tank No. 1. In a few minutes he would have its compartments full up almost to the top of the trunk. Then he would open No. 2's valves, and close No. 1's. And so every few minutes he would proceed forward, topping off tank by tank, closing the valves behind him. As he went, the carpenter would come forward too, removing flame screens, closing the vents, taking each compartment's alley, temperature, and specific gravity, recording them, continually observing aft the topped tanks' levels at the sounding holes, to see that their valves were not leaking. On opening No. 8's valves the mate would call again, "Stand by!' And before these last compartments had filled, he would call, "Stop pumping…, tanks full…, ship loaded!" The terminal pump would stop. The head wharfman would close the wharf manifold oil delivery valve. The hoses would go limp; the oil draining from them would fill the last tank up. The mate would close its valves. On his signal the assistant engineer would close the cross-over valves. The tanker would be down to her fresh-water line, drawing 16 ft. 8 in. As the mate ordered the boatswain and the hands would disconnect the hoses from the deck delivery lines, close the lines tight, and start taking the hoses apart and lowering their lengths to the wharf; and the carpenter would record the last gaugings, report them to the mate, and go close all the sounding holes. Below the chief engineer would inspect the pump room and close it, and the assistant engineer would inspect the pump room and close it, and the assistant engineer would have the fireman light off the dead but still hot boilers and commence raising steam. From the carpenter's gauging the mate would figure the load, the <u>San Cristóbal</u>'s biggest so far, 21,747 barrels, and enter its volume, heat, and density in the tank log. By then it would be about noon.

On the bridge the master would at once set sea watches to start at noon and order "secure for sea" for the run home. As per S. Pearson and Son's standard instructions he would then give the Texas Company agent bills of exchange to Pearsons for a copy of the run ticket and a bill of sale to Pearsons. Quickly he would write up the exporter's invoice and the shipper's and the ship's manifests. And with the shipping and ship's papers in hand he would hurry back ashore, toe the Mexican consulate for a consular invoice and a certified bill of health, to customs for clearance outward, and to Kansas City Southern again to telegraph Pearsons that the San Cristobál had her cargo and would depart that afternoon.

Smartly on the master's order the starboard watch would have taken the afternoon watch. The second mate would order preparations for getting underway, update the Binnacle Book, test the ship's lights, and turn to his other preparatory duties on the bridge and in the chart room. The chief engineer would order a steaming watch, slacken the funnel guys, update the Machinery Book, and go examine the steering engine and gear. The boatswain would order the deck cleared and the derricks unrigged, haul down and stow the warning flag and sign, hoist the ensigns, the blue peter, and the S flag, and go examine masts, rigging, ventilators, and ground tackle. The carpenter would sound the bilge and some tanks, and as soon as the derricks were free, turn the hands and the winch to rig them in. The steward and the cook would inspect the pantry. AS soon as they could the boy would start cleaning the galley and messes. Within an hour the carpenter would have shut down the after winch, sounded al tanks and the cofferdams, opened the scuppers, and examined the sideports; the hands would have cleared the cargo hoist and then peripherals, overhauled and stowed the tackle, made the derricks fast in the crutches, secured the deck, and swabbed it where oil had spilled; and the fellows below would have raised the steam in all three boilers to 180 psi, made the switches from auxiliary to main machinery, slackened the gland on the stern tube, jacked the main engine over, drained and warmed it, connected and filled lubricators, connected the revolution-counter, set the indicators, and tested the siren and whistle. Then on the double the boatswain and carpenter would inspect the storerooms and boats, after which the mate, the chief engineer, and the carpenter would test and reconnect the wheel, steering engine, and rudder, after which on the double the mate, the boatswain, and the carpenter would make a final inspection on deck, and the chief engineer would do like wise in the boiler and engine rooms. Then there would be a double-quick boat drill. And that secured, with all the deck hands on deck, the boatswain would have them take in the mooring hawsers, leaving only slip ropes.

About 1:45 the master and a pilot would board. The first mate would go to the bow. The second mate would station a helmsman at the wheel, and go tot the stern. As the boatswain ordered the five other hands would haul up and stow the gangway and stand by at the lines. The boatswain would haul down and stow the blue peter and the S flag, hoist the H flag, and stand by at the anchor. The carpenter would take the draft fore and aft, report it to the bridge, lubricate and begin warming the windlass, stand by. Below the assistant engineer would start the engine, test it, report it ready, and stand by.

At 2 p.m. the master would blast the whistle long and order, “Cast off.” As the first mate commanded and the hands let go and took in the liens the pilot would take the conn. The last line in, the pilot would order the helmsman and the assistant engineer so that as they worked and the machinery responded the tanker would swing her stern momentarily to starboard, clear the wharf, and gain steerageway ahead into the basin. Past Taylor’s Bayou on the starboard the pilot, the helmsman, the assistant engineer, and the fireman working together would swing the tanker to port beyond the island’s point and into the canal, in a few minutes making 7 mph. Down the west bank. The boatswain would oil the log and examine its line. At about 3 p.m. the tanker would leave the canal and enter the pass. Down its channel she would steam, the pilot’s launch following, past the spar buoys on the port hand, the Sabine docks and tank farms, the nun buoy on the port, Brant Point, the town of Sabine, the dredging and life-saving stations, more spar buoys on the port, out of the pass and between the jetties (where the port watch would take the dog watch), out of the jetties, past the gas buoy on the port, and out to the whistling buoy, where at about 4:30, the sun sinking low and red southwest across the Gulf, she would slow to bare steerageway. The master would resume command. The pilot would leave. The boatswain would haul down and stow ensigns and flags. And on the various orders then executed the <u>San Cristobal</u> would turn into international waters, headed sunward, S.W. by W. 38 W. Her boilers burning maybe 2 ¾ gallons of fuel and evaporating maybe 40 gallons of water a minute into steam at 180 psi., her engine duly cycling at 90 rpm., using 1,250 horsepower, ? maybe 650 into the sea, she would soon be making 10 knots good. The boatswain would stream the log. The mate would take a departure from the Brant Point light, 29º 43’ 43” N., 93º 51’ 00” W.

As yesterday morning the tanker had steamed up the coast, so this evening she would steam down it, but 2 ft. 4 in. deeper in the water. The gulls would wing inland. The sun set. The mate would turn on the maps and the running lights. For another hour he would pilot by bearings from the Brant Point light, then, losing it, depend on the compass. At about 8:15 through the clear, moonless night the lookout would make dead ahead the Bolivar Point light from Galveston, which the mate would take for a fix at 29º 27’ N., 94º 28’ W. As he ordered and the first watch worked the tanker would turn to port. By 9:00 about 104º off Bolivar Point she would be at 29º 29’ N.

headed due south before a northeasterly wind on 94º 30' W., her route home, as before at 10 knots. Soon after three bells Bolivar Point would be gone in the dark, but Pollus and Castor, Procyon, and Sirius would twinkle in the east, Markab and Alpheratz in the west.

Through the same routines as outward-bound and light the watches would succeed each other homeward-bound and laden, to keep the tanker on course, secure, and at 10 knots. So at sunrise on Friday, clear and warm, she would have steamed to 27º 43', at noon to 26º 50', at sunset to 25º 27', by a star shot at midnight to 24º 50', ever south on 94º 30' W. On Saturday, again clear and warm, the work would be practically the same, sunrise at 23º 44', noon at 22º 50', sunset at 21º 57', midnight at 20º 50'. Likewise on Sunday, December 12, the Day of Our Lady of Guadalupe, the middle and morning watches would be the regular gravey-eye and morning duties at sea, the headway the same, the sunrise fix at 19º 46', the position in the 8 o'clock report 19º 30' on 94º 30' W.

It would be the forenoon watch that day when the first landmark appeared. On time at about one bell the lookout would make at about 4 points off the starboard bow the volcano San Martín, 75 miles southwest in the Sierra de Tuxtla. By the non sight San Martín would bear about 108º west, and the <u>San Cristóbal</u> would be at 18º 50' N., 94º 30' W. That would be the last celestial shot. Shortly after five bells on the afternoon watch, having already seen gulls, the lookout would make at not quite 2 points off the port bow Puerto Mexico's Coatzacoalcos light. That would figure into a position of 18º 24' N. on course. On the lookout's call the master would begin preparing papers for arrival, the mate would order starboard helm for a course S. 18º E., the helmsman would turn the wheel round to port, the boatswain would go examine the ground tackle, the carpenter would go uncover the windlass, to warm and lubricate it, and below the assistant engineer would have the oiler and wiper turn over and begin warming the auxiliary machinery. Shortly before six bells the lookout would make the hills east of the Coatzacoalcos River and a few minutes later the first red light leading to the port. Just after the bells he would make the hills west of the port and several minutes later the second leading lights. The mate would command the helmsman rudder-right or –left to bring the tanker into line with the lights. In another 15 minutes the dunes along the coast would be clear. About 3"45 as the mate ordered the boatswain and a hand would haul in the patent log, clean, oil, and stow it. The mate would record its last reading out of Port Arthur, maybe 750 miles, and correct it to 710. As he ordered below the assistant engineer and fireman would begin turning down the power and motion. By then in Mexican waters the boatswain would hoist the Mexican ensign and the Q and H flags. At eight bells the watch would change, but on the boatswain's command the relieved hands would stay on deck for extra duty. By 4:30 the tanker would have slowed to bare steerage-way just off the jetties, and the pilot would come aboard.

The master and the pilot would take the bridge, the pilot the conn, and the mates the lookouts fore and aft. The boatswain would haul down and stow the H flag, and hoist the S flag. Ahead the tanker would steam between the jetties, the launch after her, up the channel past the red buoys on the starboard and the black buoys on the port, in line with the lights. Since as the pilot advised the master another norther had hit the Texas coast early that morning and was to hit Puerto México early next morning, the tanker would steam past the anchorage off the town, up past the wharves, and under the lee of the hills west of town slow, stop, and drop her stream anchor. In excellent holding ground the boatswain, the carpenter, and a couple of hands would veer the stream chain to maybe 4-1/2 shackles, unlock the windlass's starboard-side wildcat, slack off that side's brake, knock loose the stopper on the bower chain, drop the starboard bower under foot, veer a few fathoms, brake both wildcats, lash down the brakes, and stopper both chains. The chief engineer would order below to keep the steam up and the main engine warm. By sunset, 5:26, under a hot southern wind, the tanker would be riding properly lit and ready for a gale. The master would set anchor watches to start at 6:0, and leave with the pilot for town, to report to Pearsons. The commissary idlers would serve the suppers. Later the master would return in a Pearson launch with the weather forecast and instructions: wait…

The earth nearly in its perihelion, under a new moon, the norther would hit Puerto México in the wee hours Monday morning and bring a very high tide. Normally the rise was a foot, but that night it would stand at maybe four feet. Under the wind across the river, the flood, and the ebb the San Cristóbal would ride uneasy, but safe.

Monday dawned clear, windy, and cold, in the 50º's. On his instructions the master would keep the tanker anchored where she was, and the day watch would do the routines of the day at anchor, on the bridge, on deck, and below. No one would come aboard or disembark. The night watch on the bridge and on deck would also be routine. The night watch below, however, would prepare to steam the next morning.

This voyage ended on Tuesday, December 15, 1909. In the dark at 6 a.m. the master would set river watches, from anchors-aweigh to noon to Minatitlán, and the chief engineer would order below to prepare to set on. At sunrise the boatswain would hoist the ensign and the H flag. A Pearson launch would come alongside. The master would go back down to Wharf No. 1, receive pratique, report to the port authority and customs, and receive entry inward, then return to the San Cristóbal, with a pilot, a Pearsons' agent, and a customs officer, hear the 8 o'clock report, and order the tanker opened for inspection and taking ullage. The H and the Q flags would be stowed, the S flag hoisted. The ullage read only 20,880 barrels: in the cold the cargo had shrunk, but it weighed the same. By 9:00 the agent and the officer would leave. AS the master ordered and the mates commanded and the boatswain, the carpenter, and the men on watch worked the bower anchor would be weighed, then the stream anchor, and the main engine would start turning the screw. The pilot would take the conn, the officers and the men on watch their stations, and as they worked and the engine thumpity-thump-thumped up to 90 rpm. The tanker would slowly gain headway against the current. The same channel she had taken downriver nine days before, she would now take upriver, but more powerfully, unsteadily, and slowly. Passing Diablo Island starboardside about 11:00, she would come to Yeguero Island portside about 11:30, finally haul to port along the right bank around the last bend west, steam past the Uxpanapa, over the last bar upriver, and soon come in clear sight of its destination. Nearing the refinery and its familiar stink, she would haul across the river, steam ever more slowly, her engine in reverse, past the company's wharf and the wharfmen there, stop, and drop her stream anchor. As the stream chain veered she would on the master's commands be backed and steered in the easy water until her stern touched the wharf. At once her engine would be stopped, her windlass braked, and her mooring lines heaved onto the wharf. In short order she would be made fast at the stern and breasted in at the bow. By 1:30 she would be moored on all eight lines, doubled up and secured, her engine cooling down, home.

Usually there was some delay in discharging the cargo. After most of the previous voyages it had happened on the following day or even later, and not only the master, the chief engineer, and the idlers but also other officers and men off watch had gone ashore, some of the idlers and men not to return. But this time it was urgent. Only the master would go ashore, in a hurry to the refinery office, and he would quickly reboard and order preparations to discharge as soon as possible.

The mate on watch and the head wharfman would set the time to discharge. Probably by 2 p.m. the mate, the boatswain, the carpenter, hands, wharfmen, and a steaming watch would have the equipment rigged as they had to take in cargo, but the power and machinery ready to deliver it, on the tanker's steam and by her cargo pumps. All deck cargo valves, tank vents, and sounding holes open and flame screens set, the red and green valves below open, the assistant engineer would start the pumps, and the oil in all 16 compartments would begin pulling through the suctions and main lines into the pumps, pushing up the delivery lines into the cargo hoses, and through them and the wharf manifold oil discharge valve into a pipe line to a refinery storage tank. Both pumps delivering over 2,000 gallons a minute, they would lower the cargo's level below the trunk within 40 minutes and reduce the deadweight by over 400 tons an hour. As the tanker rode evenly and ever higher in the river the boatswain, the hands, and the wharfmen would continually alter the stream chain's scope and the mooring lines. By sunset she would have only about 13-1/2 feet underwater. The riding lights and the wharf lights would go on, and so would the work. At 6:00 the watch would change, but the work would stay the same, except the mate and the assistant engineer would close the valves to Tank No. 1, to begin trimming by the stern. By about 8:30 the oil in Tank No. 8 would be down nearly to the suction lines. The mate would reopen the valves on No. 1 a crack, and go close all the valves forward but the No. 8's starboard compartment. And as the ballast had been pumped, from forward aft, compartment by compartment, list by list, so the last oil would be pumped from Nos. 8-2, and finally from No. 1. By 9:30 p.m. the delivery would be done and the San Cristóbal empty.

If the next voyage had been to carry refined products from Minatitlán, there would then have been another job, cleaning the tanks. Like cleaning field-storage tanks, but more thorough and less terrible, this meant closing the compartments, steaming them, opening them, rigging and putting down windsails, unrigging them, hosing down the sides with hot water, pumping out the water, sweeping sludge toward the suctions, bailing refuse, taking one compartment full of kerosene, pumping the kerosene from compartment to compartment, pumping it out, rigging stages in the tanks, wiping down all their surfaces, unrigging the stages, pumping clean kerosene around the main lines and the pumps, and pumping it out, which took a mate, a boatswain, a carpenter, a pump man, a fireman, and some helpers, ordinarily casual laborers, two or three days to do. It would also mean more time for officers and men ashore.

But the San Cristóbal was no longer carrying any cargo from Minatitlán. The only cleaning she then underwent was overflowing the tanks. And as ordered this time it too would happen as soon as possible. So after the delivery the mate, the boatswain, the carpenter, the hands, the assistant engineer, and the wharfmen would continue working, reopening all the deck valves, raising all the hatch covers, changing the cargo hoses for water hoses, otherwise clearing the deck, making sure all scuppers were open, changing the valves in the pump room as if to take in cargo, and changing to the water line at the wharf manifold. It would be very stinky and maybe 11 p.m.

before the boatswain and the carpenter turned in, leaving a night watch on deck, a donkey watch below. About 2:30 a.m., down from the refinery's water-storage tank, water would begin rushing into the tanks, over 3,600 gallons a minute, cutting the sludge, raising the stink. Soon the hands on watch and the wharfmen would begin altering scope and lines. Not long afterward they would hear a big pump at the refinery's water plant a few hundred yards up the Coatzacoalcos begin working, to suck the river's water up to storage to keep the head. By the change of watch at 6 a.m. the tanks would be nearly 90% full and the air foul. By sunrise the filth in the tanks would be almost up the trunk, and the air awful. The rise to the hatches would slow. About 7:00 the filth would overflow onto the harbor decks and begin running off through the scuppers down into the river. The head wharfman would close the manifold water valve. The mate on deck and the assistant engineer below would close the tanks' valves. The flow would stop. The stink would spread, heavy but breathable.

There followed on the master's orders and the mate's commands the work of remaking the San Cristóbal ship-shape and resecuring her for sea. At the boatswain's directions the deck hands on watch would wash, sweep, scrub, squilgee, and swab the deck. The steward, cook, and messboys, besides making and serving meals and duly cleaning the galley and messes, would receive provisions from shore and replenish the pantry. The boatswain and the carpenter would receive supplies from shore and restock the storerooms. The chief engineer and some helpers from shore would make the connections for fueling from the wharf manifold and refill the fuel tanks. The carpenter would overhaul deck machinery. The assistant engineer, oiler, wiper, and fireman would overhaul and refit the machinery and equipment below. As soon as the mate could claim the assistant engineer he would have him drain the tanker's even tanks, then start pumping them. That night below would be a steaming watch.

As on December 5, so on December 16, 1909, the San Cristóbal would steam from Minatitlán down to Puerto México and depart northward on 94º 25'W. On this voyage and by the same sorts of work as before she arrived in Port Arthur on December 19, the temperature there down into the 20º's, departed with a cargo of crude oil on December 21, arrived in Puerto México on December 24, and delivered another 20,000 barrels in Minatitlán on December 28.

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In Veracruz the manufacture of crude oil into useful products first happened in Papantla around 1870, to make kerosene. "Fractionation," the primary process in refining, the initial separation of the crude into light and heavy portions, “the most important art in the whole scope of refining,” the refiner did by the batch in a little pot still. At the bigger refineries later established in the state the process remained technically the same for another 30-odd years. The Waters-Pierce refinery as it stood on the western outskirts of the port of Veracruz after 1887 was a “complete refinery,” capable of distilling 500 barrels of crude a day into stocks for making gasoline, kerosene, lubricating oils, grease, and paraffin. But it too operated on the batch system, three 500-barrel crude stills, each separately charged, run through the fractions to coke, cooled down, emptied, cleaned, and recharged, batch after batch, 54 hours a run. This was still the Waters-Pierce system in 1910. It happened around the clock, but in tasks with variable intervals between them. And to average 500 barrels a day and package and ship the refined products, it took some 200 workers.

In contrast the S. Pearson and Son installations as they opened on the eastern outskirts of Minatitlán in May, 1908, made a complete refinery not only on a much larger scale but also on a continuous system of fractionation. They could distill 2,000 barrels of crude a day (that being only one-third of projected capacity) in a Russian Nobel battery of 11 1,000-barrel stills. Connected in series, the stills were each to distill continuously around the clock a certain fraction of the crude, in simultaneous succession to yield stocks for gasoline, kerosene, lubricants, fuel oils, and asphalt. At the start the refinery ran only 1,500 barrels of crude a day, and although complete in equipment, was only “stripping” the oil; it did not then do lubricants or asphalt. Nevertheless, to process three times as much crude as the Waters-Pierce refinery, and to package and ship final products, it took only some 250 workers.

It was ordinarily very hot in Minatitlán, often 100o or more in the rainy season, hot enough to boil summer gasoline. Only the Coatzacoalcos River gave any relief. The Pearson grounds east of town, just beyond the first swamp downriver, then made a rough parallelogram nearly 1,000 yards north-south, 1,300 yards northwest-southeast, about 250 acres. The refinery rose from the company wharf at riverside up the naked Riberas Coloradas hill to its heights some 85 feet above the river. From the wharf the smell of sulfurous “sour” oil would gag any newcomer, but pleased and reassured veterans of the place.

In daylight the refinery was clearly several different kinds of places. Some 60 yards north up from the wharf stood loading docks, a loading rack, the shipping, casing, and filling houses, a filling shed, the box and can factories, warehouses, and back to the west the repair shops. Farther up the hill and in the broad gully eastward were several 45,000-barrel and 5,000- and 10,000-barrel tanks. From the heights some 350 yards north of the wharf rose two 50-ft.-high, 3,000-barrel forewarming tanks. Behind them, northward, along the heights where the smell was strongest, stretched a great shed, nearly 150 feet wide, more than 1,000 feet long, three stories high, with three chimneys that high again rising from it about midway. Under the shed, crosswise, all facing east, lay 40 big shell stills--from south to north 17 200-barrel tar stills, each about the shape and size of a locomotive boiler, the 11 2,000-barrel crude stills, each nearly 50 feet long, over 13 feet in diameter, five 1,000-barrel re-run stills, and some 325 feet beyond them seven 500-barrel lubricating oil stills, every still with its big condenser behind it on the west side. [[[My note in the margin on the manuscript: “Not all that was there then. No tar or lube stills.” This’d mean only 16 shell stills, ll for crude and five for re-run. Or was it there, but not yet in use?]]] Down the hill from the condensers were 70-odd distillate and storage tanks. On the east side in front of the re-run stills was a great boiler house; just north of it, a pipe-fitting shop. Along the heights farther east were an acid plant, agitators to treat the distillates, three for 1,000 barrels, nearly 20 feet in diameter, 35 feet high, eight for 500 barrels, and more tanks. On a rise beyond a gully north of them were yet more tanks and five 1,000-barrel steam stills, to redistill crude naphtha into gasoline and kerosene. Here and there around the plants were many other buildings--offices, living quarters, more warehouses and storage, a hospital, an electric power plant, pump houses.

The place also had various means of communication and transportation. The wharf (the only one in Minatitlán) allowed entries and departures by boat and ship on the Coatzacoalcos, the river access from and to the Gulf. Not 200 yards northwest of the wharf was the Minatitlán Railroad’s eastern terminal. The railroad ran eastward past the repair shops and around between the shipping house and the wharf, curved north and continued up the gully, curved northwest toward the great shed, near the lube stills [[[not there then???]]] curved north again, sending a spur straight back along the front of the stills to the shed’s south end, sending another spur off to the right back to the acid plant, and finally curved northeast around the steam stills and out into the country, toward El Carmen, its western terminal and junction with the Tehuantepec Railroad. Not 150 yards downriver from the wharf was the terminal of the Pearson pipeline from the San Cristóbal field. At the general offices not 100 yards southeast of the wharf there were telephone and telegraph connections to San Cristóbal, El Carmen, and from there to the rest of the world.

As a manufacturing center, however, the refinery's most distinctive feature was its means of internal transfers. One appeared obviously between plants and tanks--miles of level, graded, and curved, 2-, 3-, 4-, 6-, 8-, 10, 12-, 15-, 21-, and 27-inch pipe, above ground, out in the open, and underground, and all on a system, for the coordinated movement of crude oil, vapors, water, distillates, residues, acids, air, steam, and refined products. Equally obvious but less conspicuous was another complex of connections, electric lines from the refinery's power plant, down near the railroad terminal, to all the other buildings, among them 15 pump houses, where the power turned the motors that drove the pumps that moved oil, water, acids, crude and refined gasoline and kerosene, and fuel oils.

At night, while Minatitlán lay dark but for a few dim bulbs in the main square, the jail, and some homes, the refinery was all lit up like a town in celebration. The pattern of its electric lights then revealed the essential connections between power plant, pump houses, tanks, stills, and condensers. For so much light, it was oddly quiet there. The only sounds were the steady clatter of heavy Diesel engines and a medley of rumbling from pumps. But these alone indicated the place was in operation, "on stream."

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The full transformation of the raw material into its final products occurred through continuous and intermittent mechanical and chemical processes and manual operations. As in other manufactures, these required particular adjustments depending on the volume and nature of the raw material actually supplied and the program of products planned. The 1,500 barrels a day that at the start the refinery was running was San Cristóbal crude. Its flow in the field then was over 1,650 barrels a day and increasing; in storage there and at the refinery were some 175,000 barrels. Naturally 22o B., this oil showed experimentally 12% gasoline, 30% kerosene, 20% "gas oil," 20% "intermediate oil," 13% tar, 5% sulfur. The program for the rest of the year was 16-17,000 barrels of gasoline, 30-40,000 barrels of plain kerosene, 15-20,000 barrels of premium kerosene, at least 220,000 barrels of fuel oil, all as sulfurless as possible.

So the daily run proceeded. Periodically pipelined from San Cristóbal's storage and pumped from the riverside station up to one or another of the four or five big storage tanks then used for crude, continuously pumped from one or another of them up to the forewarming tanks just south of the stills, heated there to maybe 165o F., crude oil continuously flowed from these tanks under its own head at 40-45 gallons a minute north through the 6-

inch crude feed line to the first crude still and then by gravity in declining volume and mounting density back south through it and five more. In these six stills six successively heavier fractions of the crude were continuously vaporizing, in each still a fraction at a successively higher temperature, in the first at maybe 235o, in the second at 300o, in the third at 360o, in the fourth at 430o, in the fifth at 625o, in the sixth at 680o F. Pouring up from the stills through dephlegmators and goose-neck vapor pipes, the vapors were continuously cooling and liquefying in their respective condensers, turning into a series of "tops," precipitating in the first condenser into light "crude spirit" at maybe 90o F., more than 2-l/2 gallons a minute, in the second to heavy crude spirit, in a little more volume, in the third to light crude kerosene at maybe 100o F., nearly 3 gpm, in the fourth to heavy crude kerosene, more than 3 gpm, in the fifth to gas oil at 10 or 11 gpm, in the sixth to furnace oil at maybe 110o F., more than 5 gpm, each distillate continuously flowing through its running line to the "tail house," streaming there through its particular *farol*, "lantern," or "look box," and on into its particular 1,000-barrel run-down tank just down the hill west. And always from the sixth still the residue tar, the "bottoms," or "tailings," at 680o, was continually flowing back into the forewarmers' heating coils, more than 16 gpm, exchanging its heat with the crude in the forewarmers and so cooled flowing from them just west into a 45,000-barrel storage tank.

When the crude spirits and kerosenes had filled their respective tanks, they went pumped up batch by batch to the agitators for their treatment. A batch went first into one of the big apparatuses for a wash with sulfuric acid and water, then into a pair of the smaller ones for a wash with caustic soda and water. Once these distillates were somewhat clean of tar and sulfur, which ordinarily took a good 36 hours, they sooner or later went through a redistillation, a "rectification," to define and strengthen each fraction. From the agitators where they had lost some of their stink light and heavy spirits flowed north down into separate 20,000-barrel "treated crude spirit tanks," to await rectification, or went separately pumped north directly over into a steam still. When one of these stills was full of 1,000 barrels of treated light crude spirit and under steam pressure and heat slowly reached 235o, nearly all the charge would gradually over the course of 48 hours vaporize, waft through two dephlegmators, condense into *gasolina*, "motor spirit," run through the steam-still tail house and a look box, and stream down to one of the 1,000-barrel spirit tanks just southwest. The bottoms, maybe only 50-100 barrels, would run down through one of the pair of coolers just west, then back into storage with the heavy crude spirit. From the tanks of motor spirit sooner or later batches went pumped back up to the agitators for another treatment or two, to become refined motor spirit, as which it streamed back down southeast to storage in a 10,000-barrel tank on the slope toward the next swamp eastward. Once or twice a week 500 barrels of refined spirit would run from its distant storage through a line down to a filling tank just west of the filling house. Under its own head from the filling tank for some hours every working day it would flow in measures of 100 or 60 gallons a draw through a filling line around to the filling shed and there pass through hoses into 100-gallon iron drums, or into a filling machine and down into 12 5-gallon tin cans, which, full, closed, and boxed two by two, would make a "case." These were final products, drums and cases of automobile or motor-boat fuel, trademarked as Pearson's *Nafta*, ready for shipment, as many as 50 drums or 500 cases a day.

The rectification of treated heavy crude spirit happened at the other end of the fraction. When a steam still stood full of this spirit and under pressure and heat slowly reached 235o, only a few barrels would soon come over, clear a look box, and stream down to a treated crude spirit tank. The bottoms would eventually run down through a cooler to storage, go pumped back to the agitators for another treatment or two, and return to storage.

Likewise light crude kerosene would lose its tops. From the agitators where it left some of its foul qualities, it either flowed batch by batch north down into a 10,000-barrel "straight kerosene distillate tank," or went pumped over to a steam still. There under pressure and heat at 300o a very little, maybe only 50 barrels, would quickly vaporize, condense into spirit, stream through a look box, and run to storage with the refined heavy spirit. The bottoms, that much less explosive light kerosene, would run down to storage in a 45,000-barrel tank toward the swamp eastward. After another treatment or two, batches of refined light kerosene would then stream down south as "water-white high-test kerosene" into their filling tanks beside the filling house. Under its own head for some hours every working day the kerosene would flow in regular 60-gallon draws through a line into the filling house, into the filling machine there, and down into 12 5-gallon cans that when full, closed, and boxed in two's would be ready for shipment as "case oil." As the final product superior kerosene-lamp oil, trademarked *Excelsior*, it amounted on the average to nearly 500 cases a day.

Treated heavy crude kerosene followed a different course. From storage or directly it went pumped in 1,000-barrel batches to one or another re-run still. There at 430o nearly all the charge would gradually vaporize, condense into heavy kerosene, stream through a look box, and run down to storage; the bottoms, once cooled, would run to storage with gas oil. After another treatment or two, the re-run kerosene would run to storage with refined heavy spirit, and so blended eventually stream down south as "standard-white 110-test kerosene" into other filling tanks beside the filling house. Like the water-white the standard-white kerosene for some hours every working day would flow in draws through the filling machine, filling 12 5-gallon cans for six cases of the final product ordinary kerosene lamp-oil, *Aurora*, on the average nearly 1,000 cases a day.

The other distillates, gas oil and furnace oil, received no rectification. When they filled their respective run-down tanks, they went pumped up to agitators, usually for only one treatment, and then went pumped to their particular storage tanks on the heights beyond the gully eastward. Daily gas oil at 33.4o Beaume flowed through a 6-inch fuel line down to a Diesel tank above the power plant, to fuel the Diesel engines there, and as ordered down to the loading rack along the railroad, into tank cars for shipment to the port of Veracruz, to fuel the engines in the port's light and power plant. Likewise furnace oil went pumped over to the refinery's boiler house, or ran down to the railroad fuel tank to fill a Minatitlán locomotive fuel tender, or to the loading rack to fill tank cars for shipment as fuel for boilers at Pearson drilling rigs and pumping stations out in the fields, at the Puerto México light and power plant, and on the Tehuantepec and Mexican Railways. And daily in anticipation of need various batches of gas oil would go pumped to mix with tar in storage to make more furnace oil, or to make bunker oil, which as needed would run down to the wharf to fill the bunkers of Pearson and other tugs and tankers.

The volume and the nature of the refinery's raw material changed several times during the next couple of years. The refinery's program for production changed too. It was only a few months after operations began at Minatitlán that production from San Cristóbal began falling, and fast. Pearsons nevertheless expanded the refinery's capacity to 4,000 barrels a day, started drawing down storage and importing from Texas, and by November, 1908, had doubled the daily run to 3,000 barrels. The supply from Port Arthur then was "Gulf crude." It had around the same specific gravity as San Cristóbal crude, usually between 20 and 25o B. But in the laboratory even the lightest such oil would not boil below 210o F.; most of it would not begin to vaporize until it was over 300 or 400o. It showed very little gasoline, 12-20% kerosene, 80% or more fuel oil, 1-2% sulfur. Since it would ill go through fractionation with the local crude, it would sit in separate storage and under the new program go through separate processing, to "skim" only the little gasoline and kerosene there was, and leave all the rest as residual fuel. By December plans appeared for yet another tremendous expansion, in construction of a new, 300-hp pumping station and a new, 8-inch pipeline 14 miles to Puerto México, capable of transporting 24,000 barrels a day to the port. Then the refinery suddenly lost capacity. On December 8, 1908, in a fire at the steam-distilling plant, four of the five steam stills exploded, and 16 tanks burned down to junk, including a 45,000-barrel tank full of fuel oil.

In two months the refinery was back on steam, San Cristóbal crude storage refilled, the daily run again 3,000 barrels, the new pumping station and pipeline open. But production from San Cristóbal was in steady decline; by mid-1909 it was under 1,000 barrels a day, by October under 900, and crude stocks down to nearly half a big tank. Only because of heavy imports, at least 18 shipments in 1909 amounting to 337,000 barrels, on the average some 1,100 barrels a day, could the refinery then operate at more than half capacity. And beginning in October, 1909, the raw material was no longer from Texas but from Oklahoma, Glenn Pool crude, pipelined to Port Arthur and for a while shipped two or three times a month, at 20-30,000 barrels a shipment, to Puerto México and Minatitlán. From October, 1909, through 1910, as San Cristóbal production dwindled to 150 barrels a day, at least 20 shipments of Glenn Pool crude totaling 428,000 barrels arrived at the refinery. This was much lighter oil, in the laboratory around 39o B., 20% gasoline, 20% kerosene, 60% fuel oils, only 0.15% sulfur, and it too went through separate processing. Besides these shipments, beginning in May, 1910, the refinery also began receiving the Furbero crude from Tuxpan, an oil almost as heavy as San Cristóbal or Gulf crude, around 26o B., but showing 10-20% gasoline, 30% kerosene, 30-35% fuel oils, 25-35% lubricant stock [[[remember the question of when they begin producing lubricants]]], 1-1.5% sulfur. Pearsons resumed its program for 3,000 barrels a day, in order to produce through the remainder of the year 30,000 barrels of gasoline, 165,000 barrels of kerosene, 5,000 barrels of lubricants, and 500,000 barrels of fuel oils.

The adjustments at the refinery were consequently frequent. In January and February, 1910, for example they were for only around 1,600 barrels a day, of which around 500 came from San Cristóbal crude pipelined from the field, 1,100 from Glen Pool crude offloaded from the *San Cristóbal* and other tankers. From their separate storage tanks the two crudes moved to fractionation in parallel and through the stills in tandem. Continuously pumped up to one of the forewarmers, heated as before, only 14-15 gallons a minute of the San Cristóbal crude flowed through the feed line into the first of only four stills now on the line. The fuel pump, burners, drafts, and steam valves on them were all set lower than before, to vaporize less oil at the same temperatures, 230o in the first, 300o in the second, 360o in the third, 430o in the fourth. Correspondingly on the condensers the water-inlet valves were set tighter, there being less heat to take. Now the vapors pouring through the goosenecks were continuously reliquefying into light crude spirit at only three-quarter of a gallon to a gallon a minute, heavy crude spirit about the same, light crude kerosene at about a gallon, and heavy crude kerosene at a little more than a gallon a minute, to stream through the tail house and the look boxes to their rundown tanks. And from the last still the tailings, but 10-1/2-11 gallons a minute, flowed back through the San Cristóbal forewarmer to storage, maybe a quarter of it for use as the refinery's fuel, which was why the place still stank to high heaven. At the same time, continuously pumped from its storage through the other forewarmer, heated to about 180o, some 32 gallons a minute of the Glenn Pool crude flowed through a new feed line running alongside the old one into the first of six of the other seven stills. The burners, drafts, and steam valves on them and the water-inlet valves on their condensers were all set differently from before too, for vaporizations at maybe 220o, 270o, 350o, 425o, 575o, and 645o, condensations of light crude spirit at 1-1-1/2 gallons a minute, of heavy crude spirit at about 2 gallons a minute, of light crude kerosene at 3-3-1/2 gallons, of heavy crude kerosene about the same, of light fuel oil at around 5-1/2, of Diesel fuel at 3-3-1/2 gallons a minute, all streaming through the tail house and their look boxes to their rundown tanks, and tailings of 13-14 gallons a minute flowing back through the Glenn Pool forewarmer to storage.

The agitation of San Cristóbal distillates remained the same, in 1,000- and 500-barrel batches. But provisions for Glenn Pool were again different. For these gasoline and kerosene distillates, already clean and sweet compared to San Cristóbal's, the agitators carried much less of a chemical charge and took much less time for a treatment, only about 12 hours. The Glenn Pool fuel oil distillates did not even receive treatment, but went directly to storage and shipment.

Rectification also remained the same for San Cristóbal gasoline and kerosenes, but the batches of Glenn Pool distillates had new settings. The burners and steam valves on the steam and re-run stills and the water-inlet valves on their condensers were for the lower temperatures at which these oils passed from crudely cut lliquid to vapor to nicely cut liquid.

There was a change as well in the filling house. Not two weeks after the refinery began receiving Glenn Pool crude, it had also received from the Texas Company's refinery in Port Arthur a shipment of over 31,000 barrels of "refined products." Stored until the San Cristóbal crude stocks ran out, these products allowed Pearsons to maintain final production at least at half capacity--as it happened until the Furbero crude began arriving--by blending its own products with the imports. This did not require any mechanical or chemical readjustment. After agitation the refined San Cristóbal spirit and its Glenn Pool replica simply ran together in storage with the Texas Company spirit, and so mingled as one essence flowed to the gasoline filling tanks, filled the drums and cans, and went shipped away as if it were the same good old, yet also better, *Nafta*. Likewise the refined San Cristóbal and Glenn Pool water-white and standard-white kerosenes respectively united in storage with the Texas Company kerosenes, and so went canned, cased, and shipped away as the good old, yet also new and improved, *Excelsior* and *Aurora*. This program did, however, require a new operation: canning, casing, and shipping imported lubricants [[[then these were the first SPS sold, actually other companies'???]]] as one of the refinery's final products.

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But whatever the adjustments work at the refinery remained much the same. From the general manager's point of view it happened on his orders in five separate divisions organized in some 20 departments. His secretary supervised "general administration," the accounting, purchasing and materials, and security departments, and the railroad agencies. The refinery superintendent directed "operations," or "processing," which meant the laboratory, distillation, treatment, the box and can factory, and shipping. Another superintendent controlled the "acid plant," organized into "manufacture" and "concentrating." The chief engineer was in charge of the "engineering" division, the most extensive, comprising the electrical, steam, maintenance, projects, construction, tanks and pipelines, and railroad operations departments, and the repair shops. The medical officer headed the smallest division, only one department, the hospital. In practice, in professions, crafts, trades, and processes of various tasks, the refinery's 250 workers were doing more than 100 different kinds of work. The simplest division of their labor was by the clock, between work that happened continuously in successive 12-hour *guardias*, "watches," or shifts, and "daily" work, done ordinarily from 6 a.m. to 6 p.m., six days a week.

Since the refinery could not run without pumping oil and water, its most important subdivision was the electrical department. Under the chief engineer the electrical superintendent and his nightly assistant managed the work of ordinarily 13 men. The department's most important installation was in the powerhouse, where during the day every day five men worked, at night every night, only three. From the outside the plant even looked powerful. Down the hill southwest from the continuous stills, just below the electrical superintendent's living quarters, some 130 yards up from the river, a good 25 feet above flood level, it attracted attention from town and from the river. It was the solidest building between the Tehuantepec railroad shops in Rincón Antonio and the powerhouse at Puerto

México. Cement-floored, iron-framed, brick-walled, with seven windows on its long south side and a “Marseillaise” roof (“French tiles”) with skylight, it measured about 40 feet by 120 feet and 40 feet high, as fireproof and brightly lit as it could be. There inside it was so loud the windows always shook, and men had to yell to make themselves understood. Under a traveling cane and heavy chain tackle, in a row back to front, stood the refinery’s prime movers, five identical 4-cycle, 2-cylinder, 120-brake-horsepower, vertical Augsburg, DM 60 Diesel engines, each about 12 feet from back to front, 14 feet from side to side, over 10 feet high, with a 10-foot flywheel, and direct-coupled to a 40-pole, 80-kw AAEG alternating-current generator. In the beginning, in 1908, again in early 1910, when the refinery runs were only 1,500-1,600 barrels a day, only one of the engines would be running all the time, presumably at 180 rpm, driving its flywheel and generator to produce under a full load some 135 amps of 3-phase, 60-cycle current at nearly 600 volts. The power for 2,000 barrels a day or more took two engines to make. And whenever in 1909-10 the pumps went on for a pipeline run to Puerto México, two more engines would be in operation. But one or another of the five would always be in reserve, or down for the regular overhaul and maintenance every two weeks. Unlike the great, cursed Augsburg and Sulzer Diesels in the port of Veracruz, these engines, property erected and brought into service, gave no particular trouble. Whichever one was in service any week in early 1910, driving its own air compressors, fuel pumps, circulating pump, and lubricating pumps, besides the flywheel and generator, it ran smoothly hour after hour, compressors drumming 180 times a minute (more or less), five pumps clicking and six cams and valves clattering 90 times a minute (more or less), exhaust pipes singing the same song for 336 hours on end, while the wheeling generator at its side sent the kilowatts as demanded along the conductors to the switchboard, up into the bus-bars, through the air circuit breaker, fuses, meters, [[[instrument transformer???,]]] and switches on one of the board’s five machine panels, through the meters on the totalizing panel, through the meters and air circuit breakers on all the feeder panels, and from them along the 16 feeder lines, one inside the powerhouse, to the motor for its crane, the others to the water plant, the compressed-air plant, the riverside pump house, the crude-still pump house, the rerun-still pump house, the steam-still pump house, the mixing-tank pump house, the pipeline pumping station, the acid plant, the agitator pump house, the plumbing shop, the repair shops, the box and can factory, and the fire pump house, for all these places’ 50-odd various motors, and to the transformer house for reduction to 110 volts and distribution to all the refinery’s inside and outside lights. [[[OJO: See notes on Yellow 8g for PP 228; there may not be 16 feeder lines, but only these: to the water plant, to the Coatzacoalcos pumping station, and to the compressed air plant, and one inside the power house itself, and the transformer house, and others are distributing lines???]]]

Only three of the five men the superintendent had daily in the powerhouse worked continuously and directly in the production of power. *Guardieros*, shift men in "constant vigilance," they were a *jefe de la guardia*, or shift foreman (or watch engineer), a *maquinista*, the Diesel engine operator, and his helper. The other two, for maintenance and minor adjustments and repairs, were *diarios*, day men, a mechanic and his helper.

The foreman had to watch the Diesel operator and the mechanic, to make sure they did their work right, but mostly he concentrated on his own duties, which were many and various. An experienced engine operator and mechanic himself, versed in the process of elimination, he was also an "electrical artisan," a fellow of the fraternity of "the electrical sense," able to imagine the force unknown, invisible, impalpable [[[???]]], but evidently live and flowing under pressure, and able as well to control the force at the switchboard and in the wiring. He had become therefore a devotee of details and precision, keenly aware that where he worked the littlest mistake or the slightest neglect could suddenly cause a jolting, frying death.

For him the entire shift was details, a host of minute matters in intricate and dynamic relations to keep in the right balance. As soon as he arrived in the powerhouse, usually by 5:45 a.m., he would read the night foreman's entries in its log, on fuel- and lubricating oil-tank levels, the operating unit's revolutions per minute (180, more or less), the temperature of the cooling-water discharges (ordinarily around 140o), the pressure in the starting-air tank (not over 710 psi), the pressure in the injection-air tank (between 540 and 640 psi, depending on the load), the pressure in the reserve-air tank (as a rule around 800 psi), and the pressure in the operating compressors' first stages (around 25 psi) and in the lube pumps (35 psi), the amps, volts, and watts on all the closed circuits, and the totalizing watt-hour meter. He would study the superintendent's schedule of the day's due maintenance and repairs, in particular to see if today he was to test run the next stand-by unit. [[[Check the previous stuff: Yellow Notes, PP 231. How many lube pumps were there on a unit? One, or more?]]] He would write his shift's first details into the log, the date and time, the weather and the temperature outside, the number of the unit in operation, all the live ammeter, voltmeter, and wattmeter readings, and anything wrong or odd about the house or the equipment. Then he would methodically examine the unit. He smelled the engine's main bearings for the stink of burned lubricant, touched their housings to feel if they were too hot. He put his ear to the great cast-iron frame and listened for any knocking or pounding or a cylinder misfiring. Up on the starting platform he opened the test cock on one of the exhaust pipes, to see the exhaust's color, clear or faintly bluish if the tuning was still good, black or white if trouble, shut the cock, opened its twin on the other exhaust pipe, saw the exhaust's color there, shut that cock. He listened to the valve gear right and left for any clattering louder than usual, telling of a few hairs too much clearance between one or some of the cams and their rocker-arm rollers. He listened to the air intake and along the exhaust pipes for any whistling. He listened close to the cylinder heads for air leaking and felt for hot spots on the cylinder covers. Likewise he looked over the fuel pumps and the compressors, smelled and felt them, listened to them. Back down on the floor he listened close to the pistons, to hear if either was leaking, hissing as if in tiny sneezes. He looked at the pistons' lower ends, where they overran their cylinders at low dead center, to see if they were still bright, or blackening with burned fuel. And he looked over the lubricating-oil pumps and the cooling-water pump, smelled and felt them, listened to them. Around the great whirling flywheel at the generator he saw whether it was still shiny and clean, dry, and with full lubricator cups, felt if it was hot, listened if it was more than barely humming, and looked to see if its exciter was still clean and dry, not sparking, smelled for its hint of paraffin, felt if it was hot, and heard if it was singing or humming. [[Knowing that things not running right would not run for long, but]] having sensed no trouble, he stepped over to the switchboard, looked in back to see if it was clean and dry, and in front, on the totalizing wattmeter, to see how much of a load the system at that moment was carrying. One by one he studied the feeder-panel switches, saw that all the right circuits were properly closed, the others (for example, the pipeline pumping station) open, and pulled out any synchronizing plug still in its socket.

At 6:30 it would be time for the foreman's second entry in the log. Again he would record all the ammeter, voltmeter, and wattmeter readings on the closed circuits. While he was at the log, in January or February, the morning sun would flare through the east windows, and he would open thee circuit feeding the refinery's outside lights. Then he would return to the mechanical side of the house, find the trash the superintendent wanted thrown out, order the mechanic to get rid of it, review the inventory of supplies and spare parts in the stock room, look over the idle units for broken or missing thermometers or gauges, and make sure that the engine operator was paying due attention to the engine and that the mechanic was doing the job due on the right idle unit. At 7:00 he would yet again record the live ammeter, voltmeter, and wattmeter readings, as every half hour he would do to the end of the shift. Between his commitments at the switchboard he would continually revisit the unit in operation, up on the engine's starting platform, down around its crankshaft, over at the generator's exciter, smelling here and there, feeling, listening, looking. At noon, before he took his half hour to eat, he recorded fuel- and lubricating oil-tank levels, rpm, the temperature of both the cooling water discharges, and psi in the starting-air tank, the injection-air tank, the reserve-air tank, the compressors' first stages, and the lube pumps. Through the afternoon, back and forth from the switchboard to the machinery, he followed the same routine, smelling, feeling, listening, and looking for trouble. And whenever he found it, he figured its cause and ordered its correction.

This might be simple. If, for example, he eventually heard a cylinder misfiring and noticed the ammeter needle jumping, went up on the platform, listened closer to the engine, head the other cylinder missing, and looked and saw both exhausts puffing black, stinky smoke, he would first see if the engine operator had unwisely fiddled with the engine's cooling or fuel system--was running too much cold water on the missing cylinder, or had tightened its fuel pump's suction-valve lifting mechanism. If so, having cursed the operator's mother, he would simply turn the water back down, or reset the mechanism's screw back as far as the engine's load required. But if not, if he found the water and the fuel suction lift properly adjusted, he faced a complication--to determine quickly, before the engine stalled, the presence or absence of the symptoms from which he could deduce the trouble's cause, so that he could explain taking the engine out of service before schedule and prescribe the right correction for maintenance. Ordering the operator to keep the engine running, he would go for the likeliest fault, glancing to see if the air gauges were reading too high and feeling the missing cylinder's fuel-valve casing, if it was too warm, from the valve being clogged. Finding no fault there, he would feel the fuel line back of the check valve, if it was too warm, air-bound from a leak in the check valve. Nothing faulty there either, he would feel the exhaust-valve casing if it was too warm and listen close to it for the faint whistle of a leak, and listen to the air-intake valve for a whistle there. Nothing defective again and again, he would regardless of the air gauges feel the compressor's high-pressure discharge pipe near where it entered the cooler, if it was not so hot as usual, from a leaky discharge valve, feel the high-pressure discharge- and suction-valve cages, if they were warmer than usual, likewise feel the low-pressure discharge and suction valves for too much heat, the sign of a leaky valve or piston. If he still found nothing wrong he would climb down for his last try, smell around the crank, and listen as close as he could to the missing cylinder's piston for the faintest whiff of a leak. If there was only cast iron and Siemens-Martin forged steel, duly lubricated, driving and revolving, no hint of lost compression, he knew where the trouble was, in the only other place it could be, that cylinder's fuel pump, its suction or its discharge valve hung up, and would order the operator to start the designated stand-by engine.

The change from one unit to the other would not take the jefe long. Within a minute the operator had the stand-by engine running at its rated speed. At its panel on the switchboard the foreman had meanwhile turned the field rheostats up for maximum resistance, thrown the field switch into its clips, and stuck the synchronizing plug in its socket. Within the next minute he turned the rheostats down, adjusted them for a good long beat to the flicker of the synchronizing lamps, counted his time, glanced at the voltmeter, precisely at the instant of the reddest glow lamps' [[[???]]] closed the circuit breaker, bringing the incoming generator into the circuit in parallel with the other, turned his face away from the board (in case of a short circuit), and threw the main switch in, stepped to the outgoing generator's panel, tripped the circuit breaker there, opened the main switch, turned the rheostats up to maximum, pulled the field switch out of contact, and ordered the operator to shut the missing engine down and the mechanic to tag its faulty pump for cleaning and repair. It would take him longer to log the change, the reason, and the new unit's rpm, temperatures, and pressures.

But since the engines and the generators ran well, he did not often find trouble. All he could ordinarily record were the numbers that marked the fluctuations of the electrical load. Finally, to end his shift, he recorded again the fuel- and lubricating oil-tank levels, the rpm, the temperature of the fooling water, the pressures in the starting tank, the injection tank, the reserve tank, the compressors' first stages, the lubricating-oil pumps, and while he was at it, sunset coming just then in January and February, closed the circuit-breaker and the switch for the refinery's outside lights.

Given the character of the Diesel, running right or not at all, "it is a simple matter to operate the engine…." Beginning his shift at 6 a.m., the maquinista took charge of an already running machine, in good condition, revolving at due speed, its fuel, air, and water properly adjusted for its load, and which for the rest of the day he ordinarily did not so much operate as attend. Under the foreman he had learned to attend to the right parts in the right ways. Concentrating (unlike the foreman) exclusively on the engine, he would down below go continually smelling around the crankshaft, listening to the frame, feeling the main bearings, seeing that the lubricating pressure gauges read as always, the oil pots' gauges showed plenty of oil, the drip feeds held the correct setting and were feeding, the cooling-water thermometers indicated no overheating; every half hour he would blow down the air lines. Up on the platform he would move back and forth, feeling and listening to valves, pipes, and the cylinders, taking a look at exhausts, and forever glancing over to see that the air-pressure gauges read in the allowable ranges. Whenever he heard the engine knocking and saw on the gauges and at the exhaust cocks the signs of a heavier load, he would open the compressor throttles accordingly; whenever he heard the engine missing and saw the lighter load on the gauges and in the exhaust, he would screw down the valves until the pressure and temperature held steady and the white smoke cleared. Once a day, usually to begin the afternoon, he would take a wrench to the intake, fuel, and exhaust valves and gently give each a quarter turn.

Ordinarily the day's only actual operation happened toward the end of the shift, when the operator started and ran the stand-by unit for a little while, to make sure it would run. It took some minutes to prepare the engine for the test. First up on the platform, seeing that the control lever was in neutral, he took out one of the fuel valves, carefully inserted a brass wire up into its nozzle-plate, extracted it, saw no trace on it of gum or dirt, oiled the valve's packing and guide, carefully replaced the valve in the cylinder head, then did the same on the other cylinder. One by one he opened by hand and let spring close the intake, fuel, starting, and exhaust valves, to see that none was sticking or hanging up. He gauged the play between the cams and the rollers, still as the manufacturer prescribed, "no more and no less than 1/10 mm," except on the exhaust valves, half a millimeter. Likewise he examined the governor, to feel that it worked freely and with the proper adjustment. He opened the cam shaft's grease cups, and saw they were full. He brushed heavy oil on the cam rollers and rockers. He set the levers to hold open the intake valves. Then he went below. Seeing that the engine's starting tank showed maybe 700 psi and the injection tank at least 540, that all nuts and bolts were tight, and that no tools or oil can lay within the engine's or the motor's motion, he racked the flywheel around by hand so that the crank under the cylinder next to the wheel stopped just past top dead center, so opening the cylinder's starting valve. He shifted the bar out of gear, locked it, looked and saw lubricating oil in the crank pit up to the mark, the cylinder oil pots full, and the drip feeds set. He turned the lubricating pumps' gear-wheels around by hand a few times, to feel that they worked freely, opened the taps in the lubricating supply and discharge pipes, and oiled pins and links by hand. Back up on the platform in a performance of precise, fluent gesticulations, as if at a great musical instrument or in a dance or an exercise, he released the levers on the intake valves, opened the taps on the fuel lines, turned the cut-off bar on one fuel pump to horizontal, turned the other the same, releasing fuel into the pumps, opened the taps on the water lines, and opened just a crack the compressors' throttles. Now he was ready, and the start as such a matter of seconds. Below again, he opened the receiving valves and the supply valves on the injection tank, then the supply valves on the starting tank. Back on the platform he listened closely. Hearing no leaks, sure that all stuffing boxes and pipes were tight, he shifted the control lever from neutral down to start, putting the starting valves and the intake and exhaust valves into gear. Instantly the starting air at 700 psi drove the starting piston down, cranking the shaft and turning the flywheel half around, at 695 psi drove the other piston down, turning the flywheel another half around, then all around again, faster, yet again faster, until usually on the fifth or sixth revolution, cams clacking, the wheel spinning nearly 100 feet a second, the operator shifted the control lever straight up to the running position, putting the fuel valves in gear, pulling the starting valves out. Both cylinders began firing; the engine picked up on the fuel and began running, as smoothly as yesterday, as smoothly as it should if it were needed tonight or tomorrow.

The trial run would last only 30 minutes or so. The operator felt behind the starting valves, along the starting-air supply pipes, for any heat from the valves leaking back into the pipes. He went below, closed the starting tanks supply valves, climbed back up and opened the compressors' throttle wide. While the engine was still cold and the injection tank was refilling, he listened intently to the frame and the cylinders for secrets they might not tell when they were warm. As soon as the compressors had rebuilt 640 psi in the injection tank, he opened their throttles a little wider, and opened the starting tank's receiving valves. When the compressors had refilled the starting tank to 700 psi, he closed its valves and throttled the air down to hold the injection tank at 640. The engine having warmed up, he gave it a quick general examination, smelling, feeling, listening, looking all around it for any sign of trouble. Satisfied there was none, he raised the fuel pumps' bars to cut off the fuel, closed the injection tank's supply valves, closed the taps on the fuel lines, and watching the flywheel run down, just before its last revolution, set the levers to hold open the intakes. The engine stopped. In another of his performances the operator shifted the control lever down to neutral, closed the drip feeds, the taps on the lubricating pumps' pipes, and the compressors' throttles, and turned off the cooling water. Finally he felt all the bearings, could tell they were not too warm, and went back to his regular place.

There he would tend to the engine's last need on his shift, bleeding the day's accumulated water of its air tanks.

The operator's helper was a greaser and a wiper. From the commands the operator gave him through the day he might well have assumed that his work was simply not to fiddle with the engine, not to break its thermometers or gauges, and not to leave wrenches anywhere but hanging on the wrench board. As he was told, so he did, usually. But without being told, usually, he also moved as his job otherwise required continually around the engine, looking into the crankpit, smelling the crankshaft, feeling the main bearings, refilling the oil pots, eyeing the drip feeds, resetting them if they fed too fast or too slow, refilling oil cans, screwing down a touch the camshaft's grease cups, and on every round wiped and wiped the engine's stationary surfaces clean of dust, dirt, fuel, water, oil, and grease--and threw the dirty wiping rags into the proper barrel. Besides, when the operator needed it, knowing which it was, the helper would bring him the right wrench. And when the operator left his place, at mid-day to eat, toward the end of the shift for the stand-by's trial run, the helper would stand as his relief.

The mechanic worked almost always according to a schedule. That [[[besides the fact that the millright had erected it properly in the first place]] was why the machinery ran smoothly: because as the jefe ordered and directed, he followed the Augsburg rules on maintenance. If now and then he had to remedy some trouble, a fuel pump's suction valve hung up, a fuel valve clogged, a connection worked slack, on the other days, almost every day, he only had a series of prescribed duties, the performance of which increased the already very high probability that he (or his successor) would not have anything but such prescribed duties to do in the future; maintenance on Diesel engines and alternating-current generators tended to be pure routine.

But it was not a simple routine. Since different parts of the plant's mechanical and electrical equipment deteriorated differently, running dry, wanting cleaning, wearing down, working loose or out of alignment at different rates, the daily duties varied from week to week. The mechanic's first round on any working day (except in an emergency) was always the same, to see the running engine's crankpit had oil and that the generator and its exciter were clean and dry and their bearings lubricated, to feel, smell, and listen to the engine and the electrical machines for any sign of trouble in them, and to make sure the lightning arresters were all still there, and wasps were not building a nest in any of them [[[or did the wireman do this last job?]]]. But during the rest of the day the duties were a sequence of differently periodic tasks, weekly and as they fell due biweekly, monthly, bimonthly, quarterly, triannual, semiannual, and annual jobs. The routine happened then in the repetition of combinations of cycles of altogether nine different lengths. Moreover it proceeded according to two different calendars, one for continuously used equipment, the other for the engines and generators. By early 1910 the plant had been in continuous operation (even during the awful fire) for some 90 weeks, but the five engines and generators, operated in turn, only one unit at a time for some months, had each by then run only about 33 weeks. By late January, 1910, on schedule, the weekly change of an element in the oil filter and inspection of switch contacts on the feeder panels would therefore have occurred 91 times, the monthly cleaning of the switchboard 22 times, the bimonthly cleaning of the dirty-oil tanks 11 times, the quarterly calibration of the watt-hour meters seven times, the semiannual cleaning of the clean-oil tanks, calibration of ammeters, voltmeters, and wattmeters, and inspection of feeder-panel circuit breakers three times, and the annual test of distribution lines, transformers, and lightning arresters once, the previous May. In contrast, for each of the three leading units, the weekly addition of oil to its crankpit, change of its compressors' air filters, and inspection of switch contacts on its generator panel would have occurred only 34 times, the biweekly cleaning of the engine's air-intake, change of its cylinder oil, overhaul of its exhaust valves, cleaning and readjustment of its governor, and testing and tuning only 17 times, the monthly cleaning of the generator and exciter and overhaul of fuel valves and compressor valves only seven times, the bimonthly overhaul of fuel pumps only three times, the quarterly refilling of grease cups only twice, and the triannual cleaning of oil pots and semiannual cleaning of the fuel filter, oil-filter pipes, inspection of main bearings and generator-panel circuit breakers, change of crankpit oil, and overhaul of intake valves, main pistons, and compressor pistons only once. At that rate the first annual cleaning of an engine's oil lines, overhaul of its starting valves, and change of oil in its generator's bearings would not occur until next October.

Of these various duties the mechanic himself did the complicated and the delicate, which were also the cleanest jobs. It was he, multiply skilled as he was, who inspected switches, circuit breakers, and bearings, and made any necessary adjustments, repair, or realignment; he who overhauled valves, pumps, pistons, and ran the annual electrical test; and he who cleaned and adjusted governors, tested the engines, tuned them, and calibrated electric meters. It was only on his orders and subject to his review that the other work happened, as his helper, not yet skilled at machines or electricity, still learning both, did the simple and dirty jobs, seeing if lightning had blown out any arrester, discouraging wasps, changing the oil filter, adding oil, changing the oil, regreasing cups, and cleaning the switchboard, tanks, filters, pipes, pots, idle machines, and the consequent sludge, muck, trash, and grime off the floor.

Because of the schedule incumbent on them, the mechanic and his helper had more work some weeks than others. In December, 1909, on top of the regular daily, weekly, and biweekly duties, two units the same week would have come due for their monthly, bimonthly, and triannual overhauls, doubling this combination of six cycles of jobs, then two more units would have come due for the same jobs, then the last week of the month the fifth unit the same. But even while two units at a time had been in service, and every two or three weeks, two more for a day or so, for the pipeline, the mechanic would ordinarily pass one week in three at only daily and weekly rounds. His helper, for all the periodic cleaning jobs he did, would find himself maybe one week in four doing only daily and weekly chores.

Since on schedule the refinery's production had declined, and again only one unit was running, January, 1910, would have been the lightest month for maintenance in a year. The only biweekly work due the second half of the month would be on Unit No. 3. Accordingly during the week of January 17 the mechanic would start every shift with a look into Engine No. 4's crankpit, a careful look, feel, smell, and listen around the engine and Generator No. 4 (and its exciter), and a word to his helper about the lightning arresters. Through the week, as the jefe day after day arranged brief stoppages of power elsewhere, at one place of distribution after another [[[remember the question of distribution and feeder lines, which are which]]], the mechanic at the switchboard as ordered would trip the right feeder-panel's circuit breaker [[[are they all feeders, or only some, the rest distribution lines?]]], disconnect it, see that the breakers's fixed and movable copper and carbon contacts were clean and still made good contact, see that the circuit switch's blades and jaws were clean and straight, showed no rust or burn, and did not cut or bind or grind when they made or broke their contact, try the feel of them a few times, and once sure of them, leaving the switch open, reconnect the breaker, close its contacts, and then close the circuit switch. Doing two or three panels a day, he had them all [[[all feeders, only some, distribution???]]] done by the end of the week. Otherwise he would ordinarily stay more or less busy at Engine No. 3.

First he overhauled the exhaust valves. This job did not take much skill, but it always took extraordinary care and patience. As soon as he could after the engine went out of service, once he could touch the hot, cast-iron valve cages, he would slack back the set-bolts holding the valve-rockers' front ends over them, lay the front ends aside, gauge the clearances between the cages' flanges and their seatings on the cylinder heads, unbolt the flanges from the heads, lift one cage out, nearly 4 inches in diameter, some 8 inches across at the flange, 15 inches long, carry it over to the grinding box, and so too bring the other. There while they were still warm he would first on one, then on the other, unscrew the locknuts on top, withdraw the spring cap and the valve spring from the top, withdraw the valve from the bottom, look to see if a gum of oil and carbon had collected between the valve stem and the guide, put cages and valve parts to soak in a pan of kerosene, and order his helper to clean them.

He could then leave the job at any time, as demands on him arose elsewhere, and come back to it, on and off, as other duties allowed. But he could not without ugly consequences involving the jefe simply take the kerosene-washed valves and put them back. Not only according to the rules but obviously in fact they wanted close attention. In no other operation anywhere on earth then did valves take the pressure, strain, and cutting effects they took in Diesel engines, and no other valve in a Diesel engine suffered as intensely as the exhaust valve, here, for instance, 90 times a minute instantly blowtorched by internal combustion at its head and seat to maybe 3000o F. (hot enough to turn them white), cammed open not a quarter of a second for gases and the debris of combustion still as hot as 1800o F. to blow out as fast as 2,500 feet a second through a 5/8 inch of lift between the head's 3/16-inch-wide face and seat, then, as the exhaust slowed and cooled to 900o F., sprung closed like a trap, hammering the debris caught between face and seat into them. Once therefore his helper had done the cleaning in kerosene, the mechanic would when the time came carefully wash and rinse each part in gasoline, and study every one. He would see that the cages showed no buckling up around the flanges, or heat cracks at the bottom, where the seat was, that the valve stems had not worn or bent, that the valve heads had not warped or cracked, and he would feel the valve faces and seats, again as usually faintly rough from tiny pits and grooves in them. The harm might not be enough to matter through another run or two of service. But since it could (and certainly sooner or later would, as it inevitably worsened) prevent the valve from seating tight, which would reduce the cylinder's compression and force a shutdown, he would as usual that day or tomorrow grind the valves in.

The helper would bring the grinding paste and the grinding tool. The mechanic would bolt one of the cages upside down through its flanges onto the box, set a light spring inside on the guide, smear the paste (emery and oil) evenly around the seat, and insert the stem into the spring, so that a slight pressure down on the head would put the face on the seat. With the tool ready, a forked key fixed in a bit-stock, he would insert the key's two prongs into the two little holes in the top of the head and, apply barely more pressure than the weight of the tool, gently and evenly crank the tool around about a quarter of a turn, back and forth, 25-30 times, put the tool down, take the valve out and see that the paste had not gummed up around the edges, reseat the valve and turn it 90o, put the tool back on it, gently and evenly crank more quarter-turns, back and forth, and so on, adding paste as necessary, until he had ground the face all around the seat, two or three times. Wiping the paste off them, washing them again with gasoline, he could feel the face and the seat smooth again. To tell how they fit together, he would smear Prussian blue around the seat, press the valve's face into it, give it an eighth turn, and take it out. If the face showed any blue ring in a full circle, the joint would be tight. If not, he would wipe and wash away the blue, smear more paste on the seat, and keep grinding and testing until he had a complete fit, a closed blue line maybe only 1/16 or 1/32 inch wide, but all around. To improve the joint he would grind the valve in with fine grinding paste (emery flour and oil) around another four quarters, two or three times. To confirm the fit he would grind the face without any paste directly into the seat, cast iron on cast iron, around yet another four quarters, two or three times, leaving the narrow rings of contact as smooth and silvery as mirrors. In relief he would take the cage off the box, give it and the valve parts a last wash, reassemble the valve in the cage, and bolt the cage back on the cylinder head, down to precisely the same clearance as before. Then, or later, resummoning his patience, he would do the same with the other cage and valve until he had the same signs of a seal between their face and seat. Finally, once he had that valve back in its cage, and that cage back on its cylinder, he would reattach the valve rockers' front ends and bolt them tight in alignment and adjustment for the due clearance between the rollers and the cams.

If, however, he had seen gummy oil up between one of the valve stems and its guide, he would have to change the valve's clearance. He knew that if he left it as it was, the gum might collect enough on the next run to make the stem stick in the guide, making the valve leak. He would turn the rocker-arm's adjusting screw just a touch, to cut the play just a few hairs.

That week, after finishing the valve job, he would also take care of the governor. This job too he could do on and off, but it required real craft. It was simple for him, despite the governor's "fearful and wonderful" design, to remove its brass casing and flyballs and steel collar and sleeve from its shaft, to unkey its case-hardened steel linkages from the camshaft eccentrics, unfasten them from the fuel pumps, and disassemble its dash pots and linkages, levers, and springs; and as he ordered his helper would wash everything for him, including nuts, bolts, washers, screws, pins, and bearings, clean in kerosene. But it took fine skill to reassemble all the parts in exactly their prior balance. For once he had the linkages rekeyed to the eccentrics, fitted and pinned back together, refastened to the pumps, and relinked to the sleeves, once he had the dash pots screwed back just as tight as before, but no tighter, once he had the flyballs and their bell-crank levers and springs, collar, and sleeve repositioned and reconnected, once he had every part lubricated, and once he had reset the adjusting screws just as they had been, he had to make sure that it all worked at least as well as before. He would give the exposed governor a whirl. It moved easily, smoothly, sensitive in all its parts, twirling, lifting, pressing down, graceful in all its motions. But until he had it running warm, he could not tell if he had it right. Sooner or later therefore he would prepare the engine, start it, let it run some 30 minutes, then focus eyes and ears on its controls. “The governor’s parts and the governor,” so Augsburg ruled, “must have a light play; on this depends the engine’s running regularly.” That was what he wanted, to see the flyballs whirling on their bearings freely and without friction, a brass pendulum revolving at 90 rpm “with perfect smoothness and freedom from jar,” a light play in all the mechanism, and to hear nothing but the cams clacking, nothing rattling around the balls or rubbing in the linkages. On the first try he rarely succeeded. For no evident reason the governor would begin hunting, speeding up, then slowing down, the balls leaning out, then drawing in. Something would be rattling. A screw here or a pin there was too light or too loose. The engine stopped, he could feel where the linkage was binding, where it was slack. Through more adjustments and more trials he eventually reestablished the exactly right balance--and put the brass casing back on to exhibit it.

Meanwhile, between his daily drudgery and occasional use to the mechanic, preparing jobs for him, fetching tools, cleaning up after him, the mechanic’s helper did his weekly chores and as much as he could of the biweekly round. Of all his periodic duties the most important and therefore on orders the first was the worst, changing the oil filters. He preferred to do it last, on the principle that maybe this once it might not finally be necessary. But when the mechanic ordered it, he did it. The only allowable delay was for a preliminary, related nastiness, to drain sludge and water from the filtering system’s primary settling tank and dump it down the hill west. Try as the helper might, he could not help getting slop on himself. The filter, a clarifying filter, which took already twice-settled oil, contained only the last “impurities,” but he could not change it without a bigger mess. Standing in a back corner, a horizontal plate press, like a frame-and-chamber press, it accumulated the oil’s remaining dirt on four successive elements, decreasing in dirtiness from the inlet to the outlet end. Resigned, the helper would open its air cocks, close its inlet, unlock and wheel open that end, see that the asbestos gasket had not torn, take the element there out, the dirtiest of the four, dripping oil and sludge, pull the dark, slimy cotton-ply-on-asbestos-wool pad off the element's screen, dump the pad in a barrel of kerosene, wash the element in gasoline, let it dry (as it quickly would), screw the packing clamp onto it, fit a clean, dry pad on the screen, tighten the clamp until the screen went back into the element, take the clamp off, open the outlet end, see that the asbestos gasket there had not torn, push the remaining dirty, dirtier, and dirtiest elements forward to the inlet end, run graphite over its gasket, wheel the inlet end closed and lock it, put the clean element in front at the outlet end, run graphite over its gasket, and close that end. Then, still as a matter of changing the filter, he would pull out the thread holding the cotton and the asbestos together around their edges, wash the cotton in clean kerosene, wash the asbestos in clean kerosene, rinse them in gasoline, and hang them up to dry. He got himself clean too in the kerosene and gasoline, but he could not get rid of the itching rashes, the pimples, and the scaly, flaking sores on his hands and arms. Having let all the air that would escape the filter escape, he would close its air cocks. Later, when the cotton and asbestos were dry, he would darn them back together again for a clean pad for the next change.

Second on the mechanic's agenda for him was changing No. 3's oil. Accordingly, sooner or later, he would fill from the clean-cylinder-oil tank a five-gallon can, carry it (nearly 40 lbs.) to the engine, if possible without spilling any, drain the engine's oil pots into another can, refill them with the clean oil, and go dump the dirty oil, with inevitable drips and spills, but if he could without slopping it on himself, into the primary settling tank. Again he would clean up with kerosene.

Pending by then would be an order to fill No. 3's and No. 4's crankpits. From the clean-crankpit-oil tank the helper would fill a couple of 5-gallon cans, carry them to the engines, struggling not to spill, and add one can to No. 3's pit, the other to No. 4's. Yet again he would clean up with kerosene.

Next as ordered he sooner or later would look after No. 3's and No. 4's compressors. This was a dry duty. He would only remove the screen-and-muslin filters on No. 3's suction pipes, clean the dust from them (outside), remove the identical parts from No. 4, replace them with No. 3's, clean No. 4's, and put them on No. 3.

Finally, that week or the next, the mechanic would tell him to see to No. 3's air intake. When he got around to it, the helper actually got to use a tool. With a rag and a shop-cut, sheet-metal blade thin enough to go into the intake pipe's 1/32-inch-wide muffling slots, he would try to scrape the slots clean of the oily grime that had collected in them. And once more, when he figured his effort on the pipe would pass the mechanic's inspection, he would clean up with kerosene, cleaning his own sores with it, aching for relief.

The engine having run right before maintenance would almost always run right again afterwards. But the rules required a test to demonstrate its condition, and sometimes therefore allowed the mechanic to turn his work into play. To him, any test of an engine always suggested finer adjustment or tuning that he could do. If no other duty prevented him, he would make the adjustment. Working ahead of schedule, he and his helper would have the entire week of January 24 free of all but unpredictable calls and daily and weekly routines to test and tune No. 3. They did not need so much time. But all they had, they took, in long trial runs and various, successive adjustments, each of which, in the mechanic's judgment, entailed more runs to prove its accuracy.

Consequently, as soon as he could, even without an order, the mechanic would start preparing the test, gauging all cam roller clearances, leveling all valve settings, making any imprecision precise. As soon as they could, he and his helper would rig Unit No. 2's panel for No. 2 to take power from No. 3, eventually to serve as the test's load. Then they would prepare both units to run, No. 3 as a Diesel-powered generator, No. 2 (on No. 3's power) as a synchronous motor driving a dead Diesel engine. Once they had them ready to run, leaving the circuit between them open, they would outfit Engine No. 3 to record its run. As the helper brought the instruments he ordered the mechanic would fix them where they belonged, a special thermometer in a receptacle in the exhaust pipe just next to each cylinder, a tachometer on the crankshaft. He himself would go bring the forms of record, a pencil, and the two Diesel indicators, like steam-engine indicators, but smaller, steel, made to measure hundreds of psi in tens of millimeters, but as delicate as sextants, each carefully stowed in its case. Carefully he would take them out, screw one into the indicator cock on one cylinder, the other into the cock on the other, give them a drop of oil, and hook their drum cords each to its gear off the bottom of the main piston below it.

At some point early in the week, ready to record, going through the operator's starting motions, the mechanic would get No. 3 started and running. Like the operator's helper, the mechanic's helper would keep moving around the engine, seeing to its oil and wiping it clean and dry. While it ran warming up, the mechanic would go listening, smelling, feeling, looking for trouble, finding none. his helper tailing him, trying to learn. After a good hour, when the engine and the generator were holding a constant heat, the mechanic would begin recording the trial under no load. Bored, he would write down as fast as he could the obvious conditions, the time, the level of the fuel in the tank, the rpm, the temperature of the cooling water at the inlets and the outlets, the temperature of both exhausts, and the high and low pressures in both compressors. What interested him were the events taking place inside the cylinders, which he could not see but which purportedly the indicators would tell him in a graphic story. Positioning himself at one cylinder, with one hand on the indicator cock there, his helper at the other cylinder, one hand on the indicator cock there, he would count down, so that they could act simultaneously, and on his signal, as fast as either of them could say abracadabra, they would open and close the cocks. In the same 2/3-3/4 of a second the story would have appeared in practically identical little line drawings on the cards around the indicator drums. The mechanic would remove the cards, date and time them, note the engine and cylinder numbers. Each an outline as if of a miniature banana, or a tiny machete or scythe, the drawings together told of the 180o-overlapping cycles of suction, compression, expansion, and exhaustion that in 2/3 of a second had driven both cylinders' pistons through four strokes and the crankshaft through two revolutions. [[[What are the distances driven???]]] Separately, ahead or behind 180o did not matter, each drawing in its details of line and area told for its cylinder just when the intake valve had opened, how low the pressure and the volume had been as the piston rose to top dead center, expelling the last exhaust, then the instant when the piston had begun pulling back, then when the exhaust valve had closed, air sucking through the intake into the deepening hollow, then just when the piston had reached bottom dead center, then when the intake valve had closed, the piston rising and compressing the air, how high the pressure had soared in the shallowing hollow, the instant when the fuel valve had opened and combustion had begun, the very next instant when the contained expansion, the piston having reached top dead center again, had begun driving it back down again, then just when the fuel valve had closed, how far the pressure had fallen and the volume of burnt gas had expanded, then when the exhaust valve opened, when the piston had reached bottom again and begun driving up again, expelling the exhaust, and maybe just when the intake valve had opened again, and maybe a bit more, until the cock had been closed and the line ended. Since this was a trial under no load, the cylinders were responding a little differently, which the drawings seemed to indicate in differences in their details.

When the jefe interrupted the test, ordering some other duty done, the mechanic would not shut the engine down. If the duty was his, he would go do it, but leave the engine running and his helper standing relief. If he had to send his helper to change the oil filter or fill up No. 4's crank pit, he would, but would also keep the engine running, if on no other pretext than seeing how much fuel it burned.

Without interruptions or after them he and his helper every 15 minutes would do more indicatings. When he had taken as many cards as he could justify on no load, running light, idling, three or four pairs in all, he would record the time, stop the engine, feel its bearings, have his helper refill its fuel tank, and record how much fuel the tank took.

Then he would prepare for the trials under a load. He himself would go throw the switch for Unit No. 3 to feed No. 2, but cut enough resistance into the circuit so that No. 3 would be under only one-quarter load. Once he had No. 3 set to run again, he would record the time and restart the engine. In no more than 10 minutes he would have it running fully warm again, its injection pressure at 565 psi, its meters on the switchboard reading maybe a bit over 20 kw. He would commence looking for trouble again. Finding none, he would record the rpm, temperatures, and pressures. And he and his helper would do another indicating, just as before, but under the load. At first glance the cards were the same as before, but in detail, to the mechanic's practiced eye, they showed telling changes; mainly they were more like each other. Every 15 minutes unless interrupted the mechanic and his helper would do another indicating. When he had taken four or five pairs of cards, the usual number at that load, he would again record the time, stop, and record the amount of fuel the tank took in refilling. Likewise, without interruptions or after them, he would run trials at one-half load, three-quarters, and full load, at maybe a bit over 40, a little under 60, and almost exactly 80 kw, the trial at this load lasting for two or three hours, and finally at overload, over 90 kw, which would bring Engine No. 2 into motion and up to speed, but not for long, only for a couple of pair of cards, at most half an hour. On none of the runs would the mechanic find any trouble except as he expected on overload, when both cylinders' exhaust smoked. To his eye the cards were increasingly alike the closer the load was to full, and there virtually the same, just as they should be, indicating equal work done in both cylinders. After the trial on overload, the mechanic would unhook the drum cards, reset the load at full, restart the engine, and in 10-15 minutes with his helper take cards pulling the cords by hand, which drew a bigger picture of the events of fuel admission, ignition, and combustion, again virtually the same for both cylinders. Finally he and his helper would take a pair of compression cards, briefly cutting out the fuel and compressed air, running only on the flywheel, and pulling the cords by hand, for lines that told only how tight the cylinders' pistons had squeezed the air in them, yet again evidently the same.

The first trials done, the mechanic would disconnect No. 2 from No. 3, shut the live engine down, feel its bearings, carefully remove, clean, and oil the indicators, and replace them in their cases. At once then, or as soon as he could, that day or the next, he would review the records. At least he needed all the numbers for the jefe to figure each cylinder's indicated horsepower under different loads, the fuel consumed per horsepower-hour under different loads, and so on. But most keenly he would seek reasons to make adjustments to the engine, to tune it better in order to take more trial runs. Some possibilities were not worth trying. Differences in rpm between running light and running at full load, for instance, were almost always too small to justify resetting the governor's adjusting screws, which anyway was so easy that it would not warrant another trial. The most numerous and tenable excuses for new adjustments and runs were on the indicator cards. In their tiniest details these little pictures supposedly showed whether the fuel admission was just right, or too early, or too late, whether the air pressure in the fuel admission was just right, or too low, or too high, whether compression was actually the same in both cylinders or not, whether the valve settings and timing were actually right or not. The jefe, the engine operator, and the mechanic all knew how imperfect and often deceptive or confusing the cards in fact were, often indicating, without any indication of their error, as much about the indicators as about the cylinders indicated. But precisely therefore the mechanic could read the cards straight, or on a hunch, or as he pleased, and follow his interest and curiosity in continual tune-ups and trials. Whatever the cards seemed to tell, whether the engine was already nicely tuned and running smooth or not, he could always find a reason for another adjustment--which gave him a reason to run the engine again. The second trials would yield their batch of cards, and lead to the third round. A week as otherwise slow as that of January 24, 1910, [[[or as January 24, 1910, may have been,]]] allowed trial runs every day, the mechanic ever in search of the perfect tune-up, the engine running absolutely smooth. And on every run his helper not only learned more, but stood another chance himself of taking charge of the big, wonderful, powerful, clattering thing.

The night shift in the powerhouse was cooler, quieter. Only one unit would be running, except for the stand-by toward the end of the shift, and there would be only the *guardieros*, the night foreman, operator, and operator's helper.[1] But the shift duties did not change. As the day shift had worked, each fellow at his particular details, the night shift worked at the same details, in the continuous, direct production of power. The work differed only in being simpler and easier. At night the load on the engine increased and tended to stabilize; although some departments closed, while the load from the various pumps fluctuated as ever, the lights on all night took more

[1] García Lozano, *op. cit*., 236, 257; Viriato da Silveira Pérez and Raúl Salinas Aragón, *Minatitlán de ayer* (Minatitlán, 1993), 12 ???.

power than the closed departments had taken, and drew it constantly.[2] The engine therefore burned fuel at a more even rate, wanted adjustments of air pressure and cooling water less often, and ran more cleanly. Whenever the operator heard a heavier load on the engine and saw it in the dimming lights, on the gauges, and at the exhausts, he would open the compressor throttles accordingly; whenever he sensed a lighter load, he would screw down the valves until the lights and pressure held steady and the exhaust cleared.[3] But this happened only a few times a night, when some big pump went on.

The five other fellows in the electrical department worked inside and outside. All of them were *diarios*, a wireman, his helper, a motor cleaner, and a couple of lampmen.[4] After the department's superintendent and his assistant, the wireman was the third electrician, like them always on call, but six days a week on general detail for the refinery's electrical transmission and distribution, usually every day also on particular assignments. No less than his superiors did he belong to the electrical fraternity. Like his brothers everywhere the scion of telegraphers, motormen, and motor mechanics, he had spent years at motors, switches, conductors, and insulators, and gained intimacy with magnetism, magnetic induction, forces, domains, fields and their strength, lines of force, flux and its density, electric charges and discharges, fields and their intensity, potential and its differences, currents direct and alternating, circuits, resistance, reluctance, capacitance, reactance, impedance, inductance, and resonance. Scion of physicists too, practically an electrical engineer, he read his craft's manuals and magazines, knew Coulomb's, Ohm's, Laplace's, Ampère's, Faraday's, Joule's, and Lenz's Laws, the right-hand rule, and Fleming's rule, and could think by vectors and in dynes, gausses, maxwells, ergs, amps, coulombs, volts, ohms, joules, watts, farads, and henrys, and in sines and cosines, amplitude and declination, series and parallel. And proud of the modern codes he knew, he carried his own tools on the job: everywhere his pocket knife, screw driver, and pliers; outside, his leather gloves and receiver, and if he knew he would need it, his safety belt hanging crossdraw.[5] The company's equipment

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[2] "Minatitlán Refinery, Estimated Expenditures, January-June 1916, Light and Power Service," Schedule L, CP, C45/3, 23; Meares, *op. cit*., 116-117, 296-299, 301.
[3] Maschinenfabrik Augsberg-Nürnberg, A.G., *M.A.N.-Diesel-Motoren* (???, 1909), 5, 12; Clark, or Clerk, "The Diesel Engine," ???*PIME*, Part 3, (1903), 449-451; David L. Jones, *Diesel Engines: Marine-Locomotive-Stationary* (New York, 1926), 78, 91, 124, 190-191, 194-195, 201; Lacey H. Morrison, *Diesel Engines* (New York, 1923), 312-316, 350-352, 548; Giorgio Supino, *Land and Marine Diesel Engines*, 2nd ed., rev. (London, 1917), 132, 226, 233, 297-298.
[4] García Lozano, *op. cit*., 257; "Minatitlán Refinery," 23.
[5] Elmer E. Warner, "Practical Suggestions to Electric Light Wiremen," *Electrical World*, January 31, 1891, 78; Electrical Supply Co., *Illustrated Catalogue of Electric Light and Power Supplies*, 3rd ed. (Chicago, 1892), 318-319, 404; C.P. Cummins, "Technical Training of Electrical Artisans," *The Electrician*, May 24, 1907, 224-226; Harry S.

he used, his helper carried: inside, maybe a ladder; outside, when they had to go pole-climbing, a hammer, a handline, spurs, tackle, and hot sticks.[6]

These two kept the refinery's electricity under control, and they had plenty to do for it. As in other industrial installations then most of the interior wiring was open, on cleats, exposed to ever damp air and corrosive vapors; even wiring on knobs and through tubes or in conduits deteriorated fast. Outside, the power lines were bare under summer rains and heavy lightning, the glass insulators wet every morning with sulfuric condensation, then baking in the sun, the poles inviting to termites, ants, and wasps, the transformer tank inevitably accessible to birds, therefore to snakes.[7] The wireman and his helper would start easy, in the power house every working day at 6 a.m., for the wireman's study of the house log and quick look at the meter boxes, the conduit to the crane's motor, its switch box, and the lightning arresters on the east, west, and north walls, and the helper to stand by.[8] But they were soon outside. In clear light, before 7 a.m. on the year's shortest day, the wireman would watch the helper fill the weed sprayer with Diesel fuel. He would check his receiver's connections and battery, tasting its leads' clips. The helper, the grunt, would shoulder the sprayer. Together they would head out on patrol.

Coyle, "The Training of the Wireman," *Electrical Worker*, October 1907, 48-49; Terrell Croft, ed., *American Electricians' Handbook* (New York, 1913), 39-40; N. Hawkins, *Hawkins' Electrical Dictionary* (New York, 1915), 444-445; U.S. Department of Labor, *Descriptions of Occupations: Electrical Distribution, Manufacturing, and Maintenance* (Washington, 1918), ???; William W. Haines, *Slim* (Boston, 1934), 120, 122; idem, *High Tension* (Boston, 1938), 40; José Serrat y Bonastre, *Tecnología mecánica* (Barcelona, ???), ???; A. Michal McMahon, *The Making of a Profession: A Century of Electrical Engineering in America* (New York, 1984), 36-50; Robert Rosenberg, "Test Men, Experts, Brother Engineers, and Members of the Fraternity: Whence the Early Electrical Work Force," *Institute of Electrical and Electronics Engineers, Transactions on Education*, E-17, 4 (November 1984), 103-110. Cf. Carolyn Marvin, *When Old Technologies Were New* (New York, 1988), 12-62; Grace Palladino, "Forging a National Union: Electrical Workers Confront Issues of Craft, Race, and Gender, 1890-1902," *Labor's Heritage*, III, 4 (October 1991), cover, 4-6, 10-11; Tom Dalzell, "Linemen's Lingo: The Colloquial Speech of Electrical Power Line Workers," *ibid*., VIII, 2 (Fall 1996), 26-33, 48-55.

[6] Haines, *Slim*, 16-17, 19, 23, 44, 133; Bill Alexander, *The Rebel Apprentice* (London, 1990), 11-37, 73, 90; Palladino, *op. cit*., 17; Dalzell, *op. cit*., 50; Electrical Supply Co., *op. cit*., 293, 318; *Electrical Worker*, May 1905, 70-71, 75, 78; American School of Correspondence, *Cyclopedia of Applied Electricity*, 5 vols. (Chicago, 1905), V, 322, 327; Hawkins, *Electrical Dictionary*, 269; Edwin Kurtz, *The Lineman's Handbook* (New York, 1928), 251-252, 406-408, 493-494, 517, 519, 529-530.

[7] "Lista de maquinaria, materiales, etc., exentos de derechos de importación conforme a la concesión otorgada por el Supremo Gobierno a los Sres. S. Pearson & Son Ltd.," January 18, February 1, 1906, Archivo General de la Nación, Ramo Fomento, Minas y Petróleo, Vol. L, Leg. 9, Exps. 137-139, 3-7; *Cyclopedia*, V, 303; Croft, *op. cit*., 354; Harold Pender, ed., *Handbook for Electrical Engineers: A Reference Book for Practicing Engineers and Students of Engineering* (New York, 1914), 818, 825, 1608, 1627, 1952-1953, 1955; N. Hawkins et al., *Hawkins Electrical Guide*, 10 vols. (New York, 1914-16), IV, 802, 811-812; J.W. Meares and R.E. Neale, *Electrical Engineering Practice*, 3rd ed., rev. (London, 1917), 559, 569-570; Kurtz, *op. cit*., 212-216, 250, 385-388.

[8] García Lozano, *op. cit*., 255-257; Minatitlán Refinery," 23; *Cyclopedia*, I, 158, III, 109; Croft, *op. cit*., 38; Pender, *op. cit.*, 360-361, 869-870, 872, 1069-1070; Hawkins et al., *op. cit*., IV, 887-892; Meares and Neale, *op. cit*., 559;

First they walked the feeder for the system's heaviest load, the three overhead hot wires running current at 550 volts down the steep slope west 50 yards to the water plant, which alone used almost two-thirds of the refinery's power. At each pole, the power house's terminal, the pole half way down the slope, and the water plant's terminal, the wireman looked for damage to it, a shift in its rake, a loose guy, or much change in the conductors' sag ahead, or in their ground wire's sag, or in the main (for lights) wired below, or in the telephone wire. And each pole he tested for defective insulation, fitting the receiver's earphone to his ear, holding the positive clip to the pole's ground pipe, touching the negative higher on the pipe, two or three times, to hear the sharp click every time, proof the pole's insulators were good, the line's circuit closed, or to hear faint, fading clicks, an insulator's resistance low, the circuit leaking current to earth.[9] Any fault he found, he would log to put right later. And if he saw a faded patch on the pole's butt, or weeds around it, he would have the grunt spray it. From the water plant the two would hike back up to the power house.

From another terminal there they would follow a feeder and main east, the wireman looking for trouble, listening to the poles, the grunt by him looking to learn the wires, hating the weeds. Along the way about 100 yards out they would walk a sub-feeder and main 40 yards south to the terminal at the repair shop, trudge back to the feeder, walk it another 100 yards out, then walk another sub-feeder and main 80 yards south to the terminal at the case and can factory, trudge back to the feeder, and head east again, the wireman eyeing the poles and lines, tuning his ear at every pole, the grunt always by him, sweating under his burden, spraying any little weed just to lighten the load. Another 70 yards, down a slope, and they reached Pump House No. 7, which served the great shed's continuous stills. From there they would walk a sub-feeder and main another 50 yards east to the terminal at the pumping station for the pipeline to Coatzacoalcos, spray weeds, and trudge back. Again from No. 7, they would

H.E. Stafford, *Troubles of Electrical Equipment: Their Symptoms, Causes, and Remedies*, 2nd ed. (New York, 1940), 281.

[9] García Lozano, *op. cit*., 253-255, 257; "Minatitlán Refinery," 23-24; Croft, *op. cit*., 39-40, 109-115, 330, 379-391; International Correspondence Schools, *Telephone and Telegraph Engineers' Pocketbook: A Handy Reference Book for All Persons Interested in Telephone and Telegraph Systems, Location of Faults, Electricity, Magnetism, Electrical Measurements, and Batteries* (Scranton: International Textbook, 1908), 233-234; Donald McNicol, *American Telegraph Practice* (New York, 1913), 153, 195-196; Pender, *op. cit*., 1692-1695; ???Swingle et al., *Standard American Electrician: A Complete Encyclopedia of Electricity*, 3rd ed., 3 parts (Chicago: Sears, Roebuck, 1914), II, 84-85; Hawkins, *Electrical Dictionary*, 189-190, 356, 379; Kurtz, *op. cit*., 401-403.

walk another sub-feeder and main southeast 230 yards to the terminal at the crude-oil pump house, then hike across the grounds down along the railroad track some 300 yards south-southwest to the riverside pump house.[10]

From its terminal they would turn north, looking for trouble on this sub-feeder and main around past the refinery's general offices and quarters back up 380 yards along the slope and the hill yet again to No. 7. Along the main continuing due north they hiked 320 yards more uphill, the great shed, its wall, and a sidetrack over on their left, to Boiler House No. 1. From its terminal they walked another sub-feeder and the main just 30 yards north to the transformer substation, practically the refinery's geographic center and the source of all its mains. The wireman went into the little brick building, listened to the hum, saw that the primary and secondary lightning arresters were whole and clean, no scorching, saw too that the screens were still all tight (no birds since the last time), took the three single-phase, air-cooled transformers' temperatures, almost always found them normal for that hour (maybe 8 a.m.), felt no hotter air by their tank's vents, and logged the temperature and the time.[11] Meanwhile, weeds or not, the grunt sprayed all he could around the building. Back outside the wireman would eye the power, light, and telephone lines over next door northwest to the pipe shop. Leading the grunt, he would then walk another sub-feeder and main east 125 yards to the terminal at the acid plant, as before, studying the line pole by pole. From there they would hike 300 yards uphill north-northwest to Pump House No. 38, where the pumps were for the steam stills higher up the hill over to the northeast. No. 38 was the farthest north and the highest point they went on patrol, about two-thirds done; by there the grunt's load was light.[12]

From this terminal they walked the sub-feeder and main straight south 150 yards to the compressed-air plant, which alone used one-sixth of the refinery's power. The same lines they walked 50 yards farther south to the pump house for the agitators, and then 130 yards southwest to Pump House No. 4, for pumping distillates. From there they walked the sub-feeder and main east toward the transformer substation, but only some 50 yards, to Pump House No. 2, for moving the asphalt and gas-oil for fuel oil. From No. 2 they trudged back to No. 4, then turned

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[10] García Lozano, *op. cit*., ???map, plus 222, 257, 259-261. 263-265; "Minatitlán Refinery," 23???, map, ???

[11] García Lozano, *op. cit*., map, 261; "Minatitlán Refinery," map, latter showing the substation; "Transformers," *Westinghouse Electric & Manufacturing Co., Catalogue* No. 93, *Circular* No. 4 (September 1895), 1-7; "OD Transformers," *ibid.,* No. 1057 (June 1904), 1-22; "Westinghouse Types S and SA Distributing Transformers," *ibid*., No. 1157 (May 1909), 2-19; Croft, *op. cit*., 599, 604-605, 635; ???William S. Franklin and William Esty, *The Elements of Electrical Engineering: A Textbook for Technical Schools and Colleges*, 2nd ed. (New York, 1909), 218, 221-222; Pender, *op. cit*., 1616, 1618, 1626-1627; Swingle et al., *op. cit*., III, 99, 115, 237, 293, 371; Hawkins et al., *op. cit*., VI, 1405-1406; Stafford, *op. cit.*, 97-104, 107, 281; V.M. Montsinger and Walter M. Dann, "Transformers," in Knowlton, *op. cit*., 566, 622-623; Harry B. Gear, "Power Distribution," *ibid*., 1343-1345.

south-southwest to walk the third outside feeder and main 280 yards to the fire-pump house.[13] These were the lines they walked another 120 yards south-southwest, down a steep hill, past the refinery superintendent's house, back to the north-side terminal at the power house, arriving maybe as late as 10 a.m.

Any trouble logged or otherwise reported, the wireman would review to decide quickly on priorities. In the ever damp and corrosive air the commonest trouble was faulty insulators, and as soon as he decided on the shortest route for repair, he would head right out again, wearing his receiver and his safety belt, the grunt with him, carrying new insulators, a canvas bag with the necessary tools, and the hot sticks. It did not take long to replace an insulator. At a pole leaking current the wireman would hammer its butt to hear the deep thump of solid wood, move to its high side, loop the handline on his belt, strap on the spurs, see that his safety was not twisted, slip on his gloves, lay hold of the pole with both hands, set a spur into it toward one side, lift himself up, lock that knee, at a right angle to the first spur set the second maybe six inches higher on the other side, lift himself again, shifting his hold higher, lock that knee, break the first spur out of the pole and set it again maybe a foot higher, and so climb up to the highest crossarm, maybe 19 feet up, making sure there not to touch a crossarm brace, which if hot would knock him off the pole. Setting the spurs on both sides about even, on locked knees, holding the pole from behind with his knife hand, he would reach down with his other hand, unsnap his safety's single keeper from the D-ring on that side, pass the single end around behind the pole to his knife hand, hold the pole with his other hand, bring the single end in his knife hand down to the D-ring with the double keeper on that side, snap it on the ring, and lean back, trusting the belt, both hands free. To tell which insulator was faulty, he would press his receiver's positive clip on the crossarm's through bolt and press the negative clip out on the arm near each insulator; the loudest static indicated which wanted replacing. He needed only a few minutes to rig his position. He would hitch his end of the handline to the arm, haul up a pulley and fall, hitch the pulley on the arm near the trouble, send the fall down to the grunt, run the handline in hitches on the arm to hold the tools as he had the grunt pull them up, unhitch the tie stick when it came up, nine feet long, with a double-horned steel hook out near the end, hand it under the arm away from the trouble, send the fall down again, take the bag holding a new insulator when it came up, lay the insulator, a new tie wire already on it, on the arm away from the trouble, throw down the empty bag and send the fall down again, take the jew claw when it

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[12] García Lozano, op. cit., map, 240, 257-259, 263, 265-266; "Minatitlán Refinery," ???
[13] García Lozano, *op. cit*., 242-244, 257, 262-264; "Minatitlán Refinery," 23; Smith, *op. cit*., II, 229, 315-319, 405-420.

came up, another nine-foot stick, with a steel hook screwed into its working end and a swivel clevis in its butt end, through which the grunt had run the fall, unhitch the working end, hitch the fall on the arm, send the fall down again, take off his gloves, tuck them in his belt, put the hook on the live wire near the trouble (feeling the light fuzz on the stick), screw the hook like a monkey wrench tight on the wire, and hitch the stick to the arm so that it could move only up or down. He needed no more time for the operation. He would take the tie stick, use its horns (feeling the same fuzz) to undo the tie fastening the conductor to the insulator, unwrap the tie from the conductor, drop it to the ground, and re-hang the stick. As he ordered the grunt would pull on the fall, lifting the claw, raising the live wire maybe a couple of feet above the arm. The wireman would quickly unscrew the bad insulator from its pin, drop it below, feel that the pin was solid and tight, and screw the good insulator onto it. As he ordered the grunt would slack the fall until the conductor hung right by the new insulator. The wireman would take the tie stick again, fasten the conductor by the tie wire to the insulator, wrap the tie backward and forward around the conductor, and re-hang the stick. He needed even less time to clear the pole--to put his gloves back on, unhitch the fall from the arm, unscrew the hook from the conductor, hitch the fall on the claw's working end for the grunt to let it down, likewise send down the tie stick, unhitch the handline, unhitch the pulley from the arm and let it down on the handline, hang the line back on his belt, unclip his safety from around the pole, clip its single end back on the other keeper, and climb back down.[14]

In the dry season he would work up on the poles all day if there was so much work, replacing not only insulators, but maybe a bad crossarm, a down conductor, a loose ground. But once the rainy season came he would not climb a pole after noon if he saw a cloud in the sky. In July, August, and September lightning storms swept in from the Gulf two or three times a week. He and the grunt would work inside.

After the overhead circuits, the wireman concentrated on motor maintenance. For the most part this too was only inspection, and it too took him and the grunt out on rounds along the power lines, but now into the buildings where the power went. All 16 such places (besides the power house), from the water plant to the riverside pump

[14] L.C. Nicholson, "Location of Broken Insulators and Other Transmission Line Troubles," *Transactions, American Institute of Electrical Engineers*, XXVII, Part 2 (1907), 1319-1331, 1359-1362; Croft, *op. cit.*, 39-41, 51, 355, 358-359; ???"Safety Rules …," *Journal of Electrical Workers and Operators*, September 1916, 68, 72, 75-76, 78; Kurtz, *op. cit.*, 251-255, 276-278, 318-324, 401-403, 405-413, 415, 529; W.L. Nelson, *Petroleum Refinery Engineering* (New York, 1936), 296-301. Cf. United States Marine Corps, Utilities Instruction Company, Marine Corps Engineer School, "Student Handout, Power Poles," January 2000,

house to Pump House No. 38, housing altogether nearly 60 motors, all British Westinghouse standard induction motors, simple, sparkless, rugged, constant-speed, 60-cycle, three-phase, for 550 volts, from 15 to 200 h.p., some started manually, others automatically, he visited every day to smell for burnt oil or insulation, see that the lightning arresters were whole and clean, no scorching, birds, or hornets, see on the slate board if every motor's circuit breaker, leads, ground, and starter fuses were all right, feel (if the motor was running) if a bearing or any group of coils or the starter's oil tank was hot, look for bearing oil leaks or improper end play, and log any fault.[15] The grunt would bring a bellows, a brush, and a can of insulating varnish.[16] Always maneuvering if he could to be near the transformer substation around noon and again around 4 p.m., the wireman would then read the transformers' temperatures again, and log them. (If any temperature had lately drifted high, 170o F. or more, he would have to remedy the trouble soon.)[17] At a sixth of all the motors every day, the nine or 10 scheduled for that day, so that every week he would have inspected all 50-odd for these particular troubles, he would also see if any bearing oil was darker than a week before, feel if it was grittier, look for any displacement in the air gap between the stators and the rotors, feel if any circuit breaker's oil tank was hot. At seven or eight of them, motors that started and stopped often, where the starters if neglected would give continual trouble, he would as well have the grunt at each motor draw its starter's insulating oil, then remove the tank, himself see if under the oil (because of water) the switch's contacts had been arcing and burning, and if (as usual) not, have the grunt pour the oil back into the tank and replace it on the starter. At three or four of them, so that every two weeks he would have overhauled all the frequently used starters, he would have the grunt not only drain their oil and remove their tanks, but also remove their cases, and himself see inside each that the cores and their coils, the taps, the cable clamp, and the controller (hand- or magnet-operated)

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www.lejeune.usmc.mil/mces/UIC/BasicElectrician/Power%2520Poles.pdf; Almar Latour, "In This Profession, Everyone Moves Up, Some Fall Down," *Wall Street Journal*, November 17, 2004, A1, A11.

[15] García Lozano, *op. cit*., 253-266; "Tesla Polyphase Induction Motors," *Westinghouse Electric & Manufacturing Co., Catalogue* No. 179, *Circular* No. 44 (June 1897), 1-13; "Oil Switches and Oil Circuit-Breakers," *ibid*., No. 1096 (January 1905), 1-19; "Westinghouse Type CX Polyphase Induction Motors," *ibid*., No. 1112 (April 1905), 1-6; "Westinghouse Type CCL Solid-Frame Polyphase Induction Motors," *ibid*., No. 1118 (July 1905), 1-7; "Westinghouse Type CCL Polyphase Induction Motors," *ibid*., No. 1118 (April 1907), 1-24; Croft, *op. cit*., 186, 233, 237-239, 243, 258-263, 266, 284, 289-296; Pender, *op. cit*., 63-65, 220-226, 277-278, 484, 488, 1366-1370; Hawkins et al., *op. cit*., III, 593, 653-658, 661-662, VI, 1283-1334, VII, 1755-1762; Lionel S. Marks, ed., *Mechanical Engineers' Handbook* (New York, 1916), 1625-1626, 1633, 1637-1639, 1641-1644; Stafford, *op. cit*., 2-3, 14-15, 21-26, 97, 99, 115, 131-133, 135-136, 158-160, 165-166, 209-211, 213-214, 237, 282-283, 317, 319.

[16] Electrical Supply Co., *op. cit*., 310; Pender, *op. cit*., 808; Hawkins et al., *op. cit*., II, 326, III, 624-626, 630.

[17] "OD Transformers," 10-11, 15; [[?Franklin and Esty? Swingle et al.? Pender, *op. cit*., 1633; Stafford, *op. cit*., 107; Montsinger and Dann, *op. cit*., 569-584.

were clean, dry, and tight.[18] About every other day he would likewise do a monthly overhaul of an only once-a-day (or less) used starter, e.g., the one for the motor in the repair shop.[19] Ordinarily every day at two motors, whichever two that day he would have stopped on a monthly schedule for them all, he would inspect their circuit breakers' contacts.[20] At whichever four or five motors a week he would have stopped for their turns on a quarterly schedule, he and the grunt would *pintar el imán*, "paint the magnet," clean, dry, and varnish each motor's primary coils. Each did his characteristic share. In a second the wireman tripped the circuit breaker. In 12-15 minutes, for example, at one of the water plant's 200-h.p. motors, the grunt took off the four bolts on the upper half of the motor frame's outside bell, removed that half, set the inside blocks to support the rotor's shaft between the big pump the motor drove and the frame's inside bell, took off the four bolts on the bottom half of the outside bell, removed that half, set the outside blocks (these on rollers) to support the shaft there, at the other end disconnected the pump from the shaft, carefully, keeping the rotor centered, drew it by the shaft on the outside blocks out as far as the inside blocks allowed, crawled almost into the stator, using the bellows blew its coils as clean as he could, and crawled out. The wireman then shorted the coils, reset the starting taps for a current sufficient only to bake them, reclosed the circuit, threw the switch on, and went off with the grunt to duties elsewhere. The next day when he and the grunt returned, he switched the motor off and again cut it out of circuit, and the grunt painted varnish onto the coils; when a few hours later the varnish had dried, they returned, the grunt put the motor back together and reconnected it to its pump, and the wireman readjusted the taps and reset the circuit breaker in working position.[21]

One motor a week, sometimes two, all on a yearly schedule, they would entirely overhaul. The motor dead, the grunt taking it to pieces, draining the oil from the circuit breaker, the starter, and the bearings, removing the breaker's and the starter's tanks and cases, the wireman looked over the motor's foundation for any crack in the

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[18] " Tesla Polyphase Induction Motors," 4; "Westinghouse Type CX," 6; "Westinghouse Type CCL Solid-Frame," 5-6; "Westinghouse Type CCL Polyphase," 8-9, 17-23; Croft, *op. cit*., 224-225, 232-233, 237-238, 260-267; Pender, *op. cit*., 983-984, 988-989, 993, 1367-1368; Hawkins et al., *op. cit*., VI, 1333-1334, VII, 1757-1762; ???, in Erik Oberg and Franklin D. Jones, eds., *Machinery's Encyclopedia: A Work of Reference Covering Practical Mathematics and Mechanics, Machine Design, Machine Construction and Operation, Electrical, Gas, Hydraulic, and Steam Power Machinery, Metallurgy, and Kindred Subjects in the Engineering Field*, 7 vols. (New York, 1917), II, 188-191; F.W.S. and E.A.L., "Electric Machinery Operation," *ibid*., III, 2-3, 8-9; Stafford, *op. cit*., 21, 23-26, 135, 156, 158-164, 281-282.

[19] *Ibid*., 25, 283.

[20] *Ibid*., 132, 135-137, 283.

[21] García Lozano, *op. cit*., 253-254; "Westinghouse Type CX," 1-2, 4-5; Croft, *op. cit*., 185-186, 218-221, 232-233, 235-237, 239; Pender, *op. cit*., 808, 983-1000; Hawkins et al., *op. cit*., II, 326, III, 624-626, 630, 661-662, VI, 1283, 1290-1297, 1304-1309, VIII, 1998-2001, 2050; Stafford, *op. cit*., 15, 17, 21-23, 104, 283.

concrete or decay in the timbers or bolts rusty or slack, saw if the circuit breaker's toggle showed any tampering (to keep it from tripping), if the breaker's trip was bent, if its blades were out of line, if its contacts or the starter-switch's were badly pitted, saw if either bearing was wearing much or differently from the other, if any of the rotor's bars were coming free, any joints cracked, any windings on the poles loose, the insulation there shrunk, saw if the coils were not tight in their slots, felt if their insulation had gone brittle and weak, tested its resistance on a voltmeter, and with the grunt helping made all indicated replacements and repairs.[22]

About every three weeks on these rounds, in a building to see a motor, a different building each time, he would inspect the lightning arrester there. So through the year he inspected all the arresters, making sure that at least when he saw them they were not only whole and clean, but their line and ground leads tight, insulators sound, and gap settings correct and open.[23]

[[For the paragraph below I need to decide how the lighting system worked, which I do not do here yet: Do they switch it on at the powerhouse every night. Or does someone switch it on at the transformer house every night? As it reads now, it's implicitly the latter. Then this would be the wireman's duty? If it's the former, then he has to leave some other switch on in the transformer house, so that when the powerhouse switch goes on, it makes a circuit through the transformer house.]]

Every four months at the transformers, each in its annual turn (or earlier, if its temperature read over 170o), they would test the one due, so that in the course of the year, they had tested all three. Out to the transformer house those afternoons the wireman would carry the little trunk containing the cased instruments for the test, voltmeter and wattmeter, altogether not 10 pounds; the grunt would bring a wrench, swabs, rust-killer, clean and oily rags, the bellows, the brush, and the can of varnish. It was a simple test, a load test, to tell the transformer's efficiency, how much power it took for its full load, ideally all the refinery's lights shining. Inside the house the wireman would open the transformer's switch for indoors lighting, its only load in the daytime (a faint load, but still a charge), then switch off the power to the transformer, then look for defects in its lightning arrester, see if its cutout fuse was still good, look too for rust on the tank, connectors, or tap changer, dirt or nests or webs in the ventilating louvers, and see particularly that the secondary side had a good ground. Proceeding to the test he clamped the voltmeter's leads,

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[22] Croft, *op. cit.*, 232-239, 284-289; Pender, *op. cit.*, 1119-1120; Hawkins et al., *op. cit.*, II, 327, 394, III, 654, 661-662, VIII, 1950-1953; Stafford, *op. cit.*, 2-3, 14-17, 21-26, 131-133, 135-136, 313-317.

ground lead first (to the dead circuit's ground), across the transformer's secondary leads, and farther out the wattmeter's leads, its current lead in series to take the negative flow, its voltage lead in parallel between the secondary leads, and closed the circuit through the primary. The induced current in the secondary, for no load, showed its pressure on the voltmeter, 110 volts, and its power on the wattmeter, just for the core's losses, maybe 140 watts, and all would be right so far. The wireman would then close the transformer's switch for indoors lighting and all three transformers' switches for outdoors, the entire secondary circuit, throwing practically the full lighting load on the system, and read the tested transformer's voltage and power, maybe almost 107 volts, 22+ kilowatts, 97% efficiency, and all would be right for the log. Right or not, he would switch off the power again, and log the test's results. Then he would undo the tank's lug nuts, and he and the grunt would lift off its iron lid and set it aside. He would look inside, down at the transformer itself, for rust on the terminals, rusty or loose connections, dirt and dust on the windings, any winding turned green or black. The technical faults he found, external or internal, he would correct. Typically they and their corrections were simple, e.g., a loose connection tightened. Rust, dirt, insects' work, the grunt would quickly swab or rub or wipe away. It was the windings that took most time to keep in proper condition. The grunt would blow the dust off them, wipe the tank inside and the terminals clean, carefully rub green or black wire clean, blow the windings clean again, and revarnish them. The wireman and he would put the lid back on the tank (but leave the nuts off). [[The wireman would short the secondary leads, change the tap for enough current to heat the windings to maybe 160o, and switch the power back on to the primary and the secondary. to dry the new, wet insulation overnight. If everything was all right, they put it back on line. The next day, the wireman would then cut the transformer back into the circuit, restore full power for the lights.[24]]]

[[??Some days almost every week the wireman could not remedy all the troubles he found before the whistle at 6 p.m. Maybe from replacing too many cracked insulators, or repairing too many troubled starters, he would barely have time one day to shim a motor's bearing or another day to retighten another's rotor bars.]]

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[23] Stafford, *op. cit*., 240, 282. Cf. "Overvoltage Protection," www.usace.army.mil/inet/usace-docs/armytm/tm5-684/chap9.

[24] "Westinghouse Types S and SA Distributing Transformers," 4-5, 11-12, 16; H.R. Kempe, *A Handbook of Electrical Testing*, 7th ed., rev., enl. (London: E. & F.N. Spon, 1908), 385-391; Croft, *op. cit*., 591-594, 596-597; Pender, *op. cit*., 1628-1631, 1633; Hawkins et al., *op. cit*., VI, 1406, 1426-1428, 1434-1438, 1443-1447, 1456; F.W.S. and E.A.L., *op. cit*., 9; Meares and Neale, *op. cit*., 544-545; Stafford, *op. cit*., 282; Montsinger and Dann, *op. cit*., 626, 629-630, 638. Cf. "Transformers and Regulators," www.usace.army.mil/inet/usace-docs/armytm/tm5-684/chap7; "Navy Electricity and Electronics Training Series, Module 16--Introduction to Test Equipment," www.tscm.com/NEETS-v16-TMDE.

[[Rust-killer: a local product, blended crude oil and molasses.]]