the Tintle Mining District. The road has since been known as the Tintle branch of the main Utah line.

Before this time, about 1876, another road, the Utah & Nevada (begun 1872), was completed by the Union Pacific, from Salt Lake City to a terminus near the then flourishing mining camp. This road, which was narrow-gage, ran westerly to the south shore of Great Salt Lake, reaching Garfield Beach, 18 miles out, and at two miles further on it left the lake and ran southerly through the Tooele Valley to the station called Terminus, a distance of 37 miles. This road was also projected as a through line to southern California. All three of these lines were long controlled by the Union Pacific R. R., and with the segregation of the Oregon Short Line R. R. Lines in 1887 they became parts of the latter system.

The extension of the Utah Central line, from Milford (221 miles from Salt Lake City) to the coast in southern California, has long been contemplated, and in 1889-90 over 240 miles of grade were constructed, leading from Milford on to Pioche, Nevada. During the past two or three years renewed attention has been drawn to the desirability of a line from Salt Lake City to southern California, and the accounts of the rivalry between the San Pedro, Los Angeles & Salt Lake and the Oregon Short Line railways for possession of rights of way through Nevada are still fresh in the public mind. A part of the latter company's plans for the through line was a radical change of a large part of its line from Salt Lake City to Milford. The old operated lines from Salt Lake City to Leavittsburg, a point on a high mesa in Millard County, 135 miles distant, was not suitable for a through line, on account of excessive grades and distance. It was decided to connect these points by a totally different route.

The new line, called the Leamington cut-off (Fig. 1), has been constructed during the past year. It runs westerly from Salt Lake City for 20 miles, rounding the north end of the Oquirrh range of mountains where they break off toward the south shore of Great Salt Lake. Then, at Lake Point, the new line turns southerly, running through the Tooele valley, then through the Bush valley, both on the west side of the Oquirrh ranges, and finally through the Tintle valley, west of the Tintle range of mountains. The distance is 117 miles, as against 133 miles by the old line. For 38 miles the road runs very close to the Utah & Nevada road (the track of which has been torn up), and for 7 or 8 miles it lies near the Tintle branch of the main line, but outside of this it runs through an entirely new country.

The guiding principle in location and construction was to furnish a roadbed in every way suited to form a part of a transcontinental route, and the standards and limits employed in the rebuilding of the Union Pacific R. R. in Wyoming have been throughout. The maximum grade is 0.05% (22 ft. per mile), compensated on curves up to 1 degree at the rate of 0.50% per degree; for 3° 30' curves and sharper, at 0.60% per degree. The maximum curvature is 4°. All curves over 2° and over are spiraled. The spiral used is an adaptation of Bear's, using a constant chord length of 30 ft. For 2° curves there are 7 chords; for the latter case the roadbed proper is made 16 ft. wide, and for former material they vary to suit the case.

All covered openings for drainage are either cast-iron pipe or concrete arch culverts, and for a few small drainage dams near grade wooden box culverts are used. The provision for drainage is most complete, although the line runs through an arid region. The Jordan River, in Salt Lake City.

The preliminary surveys and nearly all of the location were made by Mr. R. F. House. For construction, the line was divided into two districts. The first district, embracing 63 miles of line out from Salt Lake City, was in charge of Mr. H. G. Taber, and the second one, taking in the 52 miles of line at the south end, was in charge of Mr. House. The entire work was in the general charge of Mr. W. M. Ashton, Resident Engineer for the Oregon Short Line R. R., which office carries with it all the duties of that of a chief engineer. The Leamington cut-off's track and construction were under the general supervision of Mr. W. P. Watson until his resignation on Dec. 1, 1902, after which his former work was conducted directly by Mr. Ashton's office. The line was divided into divisions from 8 to 10 miles in length, each in immediate charge of a division engineer. There were six divisions on each district. The contract for building the cut-off to the Utah Construction Co., of Ogden, Utah.

LOCATION.

Beginning at the Salt Lake City yards (Fig. 1), the line follows that of the old Utah & Nevada, for 5½ miles, the roadbed with improvements, to Buena Vista Station, where material yards were located. It then leaves the old line and heads directly for a point near the center of Buena Vista Station, formerly reached by a detour to the south. The new line here has a tangent 13 miles long. The
grade to Garfield Beach is practically level. Shortly before an ascending grade of about the maximum of 0.6% begins, and it continues to the Stockton cut, a distance of 20 miles. In the first two miles of this occurs about the same really solid rock on the line.

In the Tooele valley the ascending grade takes place in as much as two miles from the old road. The latter keeps on the flatter ground nearer the bottom, with an undulating grade.

Thus, notwithstanding the features that could have been taken advantage of by a narrow-gauge line, or one with the grade formerly permissible for a standard-gauge line, the new line was compelled to use a continuous maximum grade for 20 miles, and then to go through the bar with a cut of 100 ft. in depth, containing 786,000 cu. yds. of material. Former surveys have shown that a half mile will reach the top of the bar in 18 miles, starting at the north end of the Tooele valley.

The Stockton bar is a remarkable bench or dyke, presumably all composed of sand, gravel and other material deposited by the action of the waters in Lake Bonneville, the ancient body of water which once occupied the basin of Great Salt Lake. The bar connects the Oquirrh range with the Wasatch range, to the west, and forms a divide between Tooele valley and Rush valley, to the south. These valleys once formed only a single valley and the bar occurs at its most compressed part, about 1½ miles in width.

A profile of the bar, from east to west, shows it to be nearly level. The top corresponds with the high-water level of Lake Bonneville, and is a little over 1,000 ft. higher than the present surface of the lake. Being deposited across the wide, trough-shaped basins of the two valleys which it separates, the result is that each valley abruptly terminates. From these basins the natural slope of the sides of the bar (at angles of 20° to 35°) lead directly to the top, over 300 ft. higher. At the highest part of this natural embankment, near its west end, the width is much less than toward the east end, forming a narrow neck of land.

When the Utah & Nevada R. R. ceased building at Terminus Station, on the north side of the bar, the survey for a continuation of the road through the bar called for a line following closely the hillside till the narrow part of the bar was reached, and then reverting to the left and passing through this on a tangent with a tunnel not over 800 ft. long, with shallow approach cuts. At the south end the line curved to the eastward, running along a lower level of the bench and passing on to the slopes of the Rush valley. Ten degree curves were required at each end of the tunnel.

A line enabled to pass through the bar at the low level of this survey would have the advantages of easier grades, shortened distance and easier ground to build through for a distance of nearly 25 miles. But the curve limits of the new line would not allow of the dotter and the turn required, and the deep V-shaped basins adjacent to the neck of the bar afforded no supporting ground for approaching it head-on or directly.

A tunnel, of about 2,000 ft. length, was at first contemplated, but test pits, sunk to a depth of 75 ft., showed that only sand and gravel would be encountered, which of course meant very expensive work for supporting the ground.

The cut (Fig. 2), is 3,500 ft. in extreme length, of which over 3,000 ft. is through cutting. For 700 ft. the cut on the center line runs 95 ft., and it is nowhere less than 85 ft. for 1,150 ft. The transverse slope of the ground is nearly level except at the north end, where there is some side-hill work. The cut is 220 ft. wide on top at the deepest part. A vertical curve 2,300 ft. long is used to join the grades on opposite sides of the summit. The north end is on a 4° curve, and there is a 1° 20' curve at the south end. The deepest cutting is near the north end, through the highest bench level, which continues out to the narrow neck before spoken of. The surface then breaks off to another bench to the south, the cut being reduced from 95 ft. at 45 ft. inside of 250 ft., after which it gradually tapers out. The bottom was made only 20 ft. wide, the intention being to widen it by additional excavation for ballast material. Side slopes are 1½ to 1.

The cut was excavated by the Flick & Johnson Construction Co., who took the subcontract for this work alone. The excavation was made with steam shovels, loading on to dump cars that were hauled by "dinky" engines out of dumping grounds and wasted. A 40-ton Bucyrus shovel was used at either end. These shovels, which have dippers of about 2½ cu. yds. capacity, did excellent work. With a 14-ft. reach, the limit of width cut by one is 24 ft. They averaged about 25 ft. width of cutting, with a depth of usually 12 to 15 ft. at each passage of the shovel. Much time was lost in shovel work on account of moving the dump car tracks.

FIG. 2. EXCAVATING STOCKTON BAR CUT, LEAMINGTON CUT-OFF.
Gravel pits will be opened in the Stockton bar cut, using the material for ballasting the track. This material ranges from sand to cobble stones as large as a grape cup, which latter will have to be separated in spreading the ballast.

Just how deep it is to solid rock at the Stockton bar is not known. It seems probable that acomb or crest must have projected above the general surface originally, in order to start the excavation of sand and gravel at the site.

Just north of the bar, at Terminus Station, a 7,000-ft. drain tunnel is being built, to drain the famous Honoree and other mines on the slope of the mountains to the eastward. This tunnel, which will serve both for drainage and in place of shafts for operation, starts well toward the bottom of the basin. As the road approaches the basin, the tunnel extends over nearly 1/5 mile, to avoid too heavy a cut of the mountains to the eastward. This tunnel, with a maximum height of 22 ft., has a maximum depth of 53 ft. from the mouth. No solid rock at all is encountered, the material varying from a mixture of sand and clay to heavy cobble stones. Hard material was run into only after the tunnel was bored to a point even with the slope of the mountains, at a depth of 250 to 300 ft.

LOCATION FROM STOCKTON SOUTHWARD.

Going south from the Stockton bar the grade descends into the Rush valley, a rate of 0.05% (34 ft. per mile) serving to reach the bottom in about three miles distance. The line runs by the town of Stockton, just beyond the bar. Rush valley is an arid basin draining into Rush lake at its north end, which has no outlet.

Then follow between 12 and 13 miles of light grades, except for one stretch of 3/4% of the maximum ascending, with comparatively light work. There is also one tangent of 10 miles length through this valley.

In mile 45 an ascending grade of 0.7% to the south begins, the line keeping on the west slope of the basin. This is increased at the end of two miles to the maximum of 0.8%, which is unbroken. The compensation on curves, for the distance of nearly 22 miles to Boulder summit, which separates Rush valley from Tintle valley on the south. On miles 55 and 20 a long grade has to be crossed, which is the principal feature in controlling the elevation of the line from here to the summit, 20 miles distant. The grade is adjusted to make a fill averaging from 12 to 18 ft. for a distance of 3,800 ft. across the valley. This fill has a maximum height of 22 ft., and contains 100,000 cu. yds.

On mile 70 is a cut (Fig. 3) with a maximum of 50 ft. on the center line, which, though only 500 ft. long, contains nearly 57,000 cu. yds. On mile 71 is another cut containing 42,000 cu. yds., and on mile 76 is a cut 1,600 ft. long and containing 105,000 cu. yds. This has a maximum depth of 53 ft. on the center.

The Boulder summit, at the end of mile 70, is crossed with a cut 1,500 ft. in length and containing 40,000 cu. yds. The maximum depth here is 52 ft.

From Boulder summit going south an almost continuous descending grade of the maximum of 0.8% is required for a distance of 20 miles to reach the bottom of the Tintle valley. The line lies on the east side of the valley. A grade rate of 1 1/2% would reach the bottom in a much shorter distance, and by adopting a maximum of about 1 1/2% for the first few miles the bottom of the valley could then be followed with a grade of not over 1 1/2% at the start and gradually reducing to almost zero.

There is only comparatively light work beyond mile 102. In mile 106 the end of the supported grade of 0.8% is reached. Back of this point, on mile 109, there is a reduction to a grade of 0.5%, extending over 1/2 mile, to avoid too heavy a cut in crossing a ridge. Beyond mile 106 the grade is undulating, with short lengths of light adverse grade. The drainage from the valley soon disappears in sinks beyond this point, and the country opens out onto the broad Sevier River Desert. There is one tangent of 4 miles in length shortly before joining the old line at a siding on Leamington Hill.

Gravel pits will be opened in the Stockton bar cut, in order to start the excavation of sand and gravel at the site. Just how deep it is to solid rock at all is encountered, the material varying from a mixture of sand and clay to heavy cobble stones. Hard material was run into only after the tunnel was bored to a point even with the slope of the mountains, at a depth of 250 to 300 ft.

FIG. 4. STANDARD 30-FT. CAST-IRON PIPE CULVERT.

There are no curves shorter than 50 ft. on the south side of Boulder summit, ranging from that down to as light as 6° 20'. On the second district north of the summit there are but four curves as sharp as 4°, and on the first district there are but two.

The Leamington cut-off crosses the spur from Ironron in mile 85, at about two miles above Ironron. Trains were formerly backed up this spur from Ironron (the terminus of the main branch) to the towns of the Tintle Mining District, a distance of five miles. From the station of Tintle Junction, near here, a 3-track spur connects with the old system. The mining camp is reached by stock trains from this point. A climb of over 1,000 ft. is required to reach the station at Eureka.

The elevation of the road above the road level varies from a little over 4,200 ft. near Great Salt Lake to nearly 6,100 on Boulder summit. It is over 5,100 in mile 60, and about 5,500 at the north end of Rush Valley. At Salt Lake City it is about 4,250, and 4,800 on Leamington Hill.

The continuous supported grades used to ascend the summit on this line are unusually long. The grade line being rigidly fixed beforehand, and the limits of curves and connecting spirals and tangents calling for an alignment that can be made to follow only the general features of the country, the matter of a location becomes one involving much skill and judgment as well as labor. By following along near the bottom of the three valleys traversed, on drainage grade lines, the material to be moved would have been nearly all earth. The amount of grading would have been vastly less and the alignment much more direct, but all of this would have been impossible without using grades ranging from 1 to 2%. As built, the maximum grade on any one cut is 800 ft. in mile 106, and the limit of haul 2,000 ft.

Graders, loading directly onto dump wagons, were in several parts used for long hauls, some of which amounted to nearly 2,000 ft. The contractors often preferred to waste from cuts and to borrow for fills in place of making any considerable haul with wheel scrapers, getting pay for the calculated overhaul from the cut. It was sometimes necessary to extend the borrow pits as much as 300 ft. from the center line, as they generally had to be shallower. Pits were usually made wider at the top than at the bottom so that they would be of the proper width for the addition given to bring them to the true grade after they quit settling. No additional height was given in the first place. A bench cut was left between fills and borrow pits. Wheel scrapers were also used to dump through traps into dump wagons, and in some cases tongue scrapers were used to dump through a trap into 3-hp. dump cars, which were hauled by horses. Steam shovels were used on most of the heavier cuts. No shovels over the 45-ton size were used, except on the Stockton bar cut, and the light shovels as a rule did not seem to be as satisfactory as the large ones. Some of the light ones, under favorable conditions, would move as much as 800 to 1,000 cu. yds. per day, and in these were of 1 1/2 to 1 1/4 cu. yds. capacity. Some of the cuts taken out by steam shovels were made

GRADING.

A considerable portion of the grading was done, and all the structures built, by the Utah Construction Co. with its own force, aided by firms let in subcontracts covering from one to nine miles. The different methods of handling it, by scrapers, graders and steam shovels, were all used on construction. The free haul was 500 ft., and limited to 2,000 ft. The wheel scrapers were not used for actual hauls much exceeding 500 ft.

Graders, loading directly onto dump wagons, were in several parts used for long hauls, some of which amounted to nearly 2,000 ft. The contractors often preferred to waste from cuts and to borrow for fills in place of making any considerable haul with wheel scrapers, getting pay for the calculated overhaul from the cut. It was sometimes necessary to extend the borrow pits as much as 300 ft. from the center line, as they generally had to be shallower. Pits were usually made wider at the top than at the bottom so that they would be of the proper width for the addition given to bring them to the true grade after they quit settling. No additional height was given in the first place. A bench cut was left between fills and borrow pits. Wheel scrapers were also used to dump through traps into dump wagons, and in some cases tongue scrapers were used to dump through a trap into 3-hp. dump cars, which were hauled by horses. Steam shovels were used on most of the heavier cuts. No shovels over the 45-ton size were used, except on the Stockton bar cut, and the light shovels as a rule did not seem to be as satisfactory as the large ones. Some of the light ones, under favorable conditions, would move as much as 800 to 1,000 cu. yds. per day, and in these were of 1 1/2 to 1 1/4 cu. yds. capacity. Some of the cuts taken out by steam shovels were made
wider than required, in order to obtain needed material for adjacent fills, this method of borrowing being peculiarly adapted to steam shovels.

**DRAINAGE**

The entire line is well provided with drainage ways. Crossing the wet alkaline flats west of Salt Lake City, extensive drain ditches were excavated on each side of the roadbed, on the right-of-way. At long intervals an outlet ditch is run from these to the northward, to discharge onto lower ground. Irrigation ditch crossings are made usually by use of a box culvert, but in some cases, by a concrete culvert with a top made of old rails embedded in concrete. A form of culvert permitting a very near approach to grade is usually necessary for irrigation ditches. As the rule is to keep the grade above the natural surface wherever practicable, in open flat country the line is in fill averaging 3 to 4 ft. Through the Salt Lake Valley it ranges from 1½ to 7 or 8 ft.

Where the line lies on the slope of the mountains, at Lake Point and beyond, the rush of waters that take place from the gulches and canons after a cloud-burst is provided for by building a short diversion ditch at the mouth of such canyons and carrying the water over into a drainage basin. This is because of the fact the floods have brought down boulders, etc., and piled them into long moraines reaching out towards the valley, the water channels remaining on the moraines, and where the roadbed cuts through the latter it is subject to floods pouring down into the cut unless the water is diverted. Such channels have been treated, where they issue from the base of the mountains, at distances of 1½ mile or even 3½ mile from the line.

Drainage water is often conveyed in ditches across the drainage lines for ½ mile or more alongside the roadbed, in order to concentrate it at one opening and so make the one take the place of several. The drain ditches are usually out a safe distance from the roadbed. This sometimes required deep cuts through the ridges, and where these would be too deep for the cut for the roadbed is made 4 to 6 ft. wider on the upper side, so as to make room for a ditch of sufficient size alongside the track. Often where the drainage is divided on a ridge through which the road is cut, a dyke of the waste material is made instead of a ditch.

The openings for drainage are nearly all cast-iron pipe or concrete-arch culverts, of the Oregon Short Line standards, Figs. 4 and 5. The former are of three sizes, 24, 36 and 48 ins. The culvert is made of full sections of 12-ft. pipe and a part length of 3 ft. or some multiple of 3 ft., as required. The length is put together without capping or cementing. An concrete cross-wall, with a good footing, is built at each end of the pipe. The pipe between these rests on the ground, which is well tamped. A slight silt is added to allow for settlement due to the weight of the fill on top.

On the first district these are 29 of the 24-in., 10 of the 36-in., and 16 of the 48-in. Culverts. Concrete culverts (Figs. 5 to 7) are used for the larger openings. They are of either 6-ft. or 8-ft. span. On the first district there is one of each size.

On the second district there are nine of the first size and two of the latter. The 8-ft. arch has side walls 9½ ft. high, making a clear height of 9½ ft. Under each wall is a footing course, 6 ft. wide and 3½ ft. deep. The walls batter from 4 ft. at the top to 3 ft. at the springing, and the arch tapers to 14 ins. thickness at the crown. Heavy spandrel walls and wing walls rest on footing courses, are at each end. The bottom is paved with stones 12 ins. deep, on a sand and gravel foundation. Connecting the outer end of the wing walls, at each end of the culvert, is another course of the same depth as a footing, which prevents undercutting the pavement. In long culverts, at intervals of about 50 ft., the footing courses are also connected by a wall across the bottom, which also helps hold the paving in place. The slope of the fill catches just behind the parapet wall at each end.

Outside of the pile-trestle bridge across the Jordan River there are but four of such bridges on the entire line. The standard pile bridges have been spaced 15 ft., with five piles in each bent.

**TRACK**

The ties used are 7 x 8-in. x 8-ft. Oregon 80, 3000 ft. to the mile. The rails at present used are 60-lb. rails that have been released in the laying of heavier rails on the operated lines. They will doubtless be replaced by much heavier steel when the line is completed to southern California. Tie-piles are used on curves, and 36-in. 4-hole angle bars are used. So far only the line from Bula to Visalia across the wet clay ground to near Garfield has been ballasted. The entire ballast here used, which came from Point Mountain on the old line, is placed 7 in. under and between rails to 1 ft. behind their ends. The remaining ballast will be obtained from the Stockton shale.

The track on curves is elevated for a 40-mile speed for the present, though the system of curves and spirals was designed for a 50-mile speed.