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support in case of derailment. It will be noticed that the parapets are built over the floor-beam gusset plates and the necessary section of concrete provided by heavy fillets on the inside of the parapets. Drain pipes made of old boiler tube or gas pipe, 1½ in. in diameter, are placed five in a row across the floor, three rows to the slab. The deck with track and ballast complete weighs 2,500 lbs. per lineal ft. of single track and the cost is about $5 a foot.

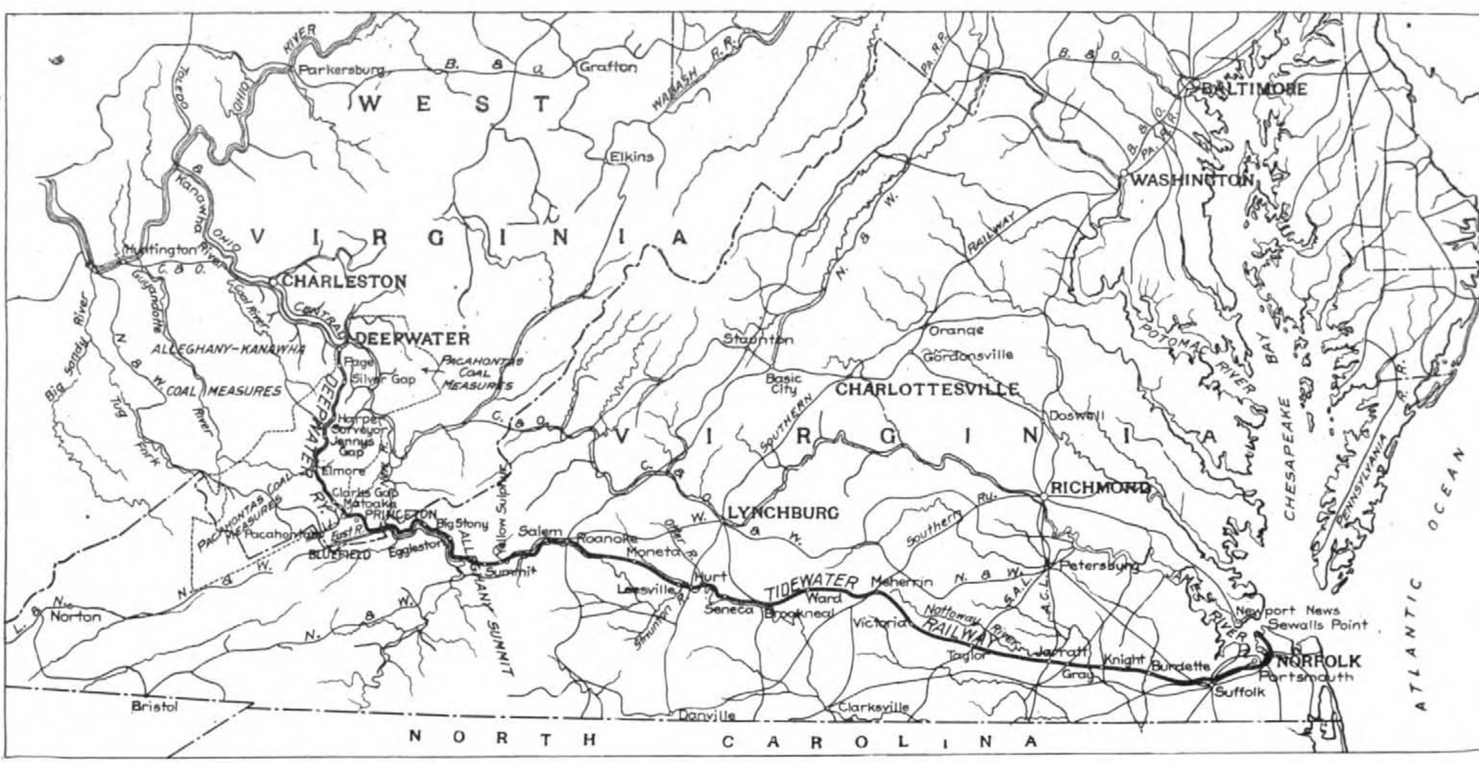
To build the floors under traffic is pretty difficult work, of course, and takes considerable more time than with a new bridge; but once in place, they require no further attention and cost nothing for maintenance. We are indebted to Mr. C. H. Cartlidge, Bridge Engineer of the Burlington, for data for the foregoing.

The Tidewater and the Deepwater Railways.

GENERAL FEATURES.

It is well-known that West Virginia is one of the richest states of the Union in the extent and variety of its mineral deposits and that among the clay, shale, silica and limestone beds with which it abounds coal stands supreme as the product upon which the wealth of the state and the traffic of its railroads chiefly depend. Roughly speaking the coal fields have an extent of from 10,000 to 12,000 square miles of workable territory, and the deposits may be as roughly grouped into the Pocahontas, Kanawha and Pittsburg with branch lines that run as spurs to the north and south in the coal territory, but even with these there is a wide area of this exceedingly rich and productive property that is not reached. Even that already opened is not only taxing the present capacities of the railroads by which it is served to the utmost, but it is capable of a far wider and more extended development, and in this the Tidewater and Deepwater Railways are intended to assist.

Started originally as a spur of the Chesapeake & Ohio Railroad at Deepwater, West Virginia, at the head of navigation of the Kanawha river, but under an independent ownership, and intended primarily to serve the lumber interests of the region, the scheme has been developed until it has come to fruition in the building of a road from Deepwater in the heart of the West Virginia mountains to Tidewater at Norfolk, Va. Although incorporated separately as the Deepwater Railway of West Virginia and the Tidewater Railway of Virginia, the two are being built together by one management and will be operated as a single line of road. They are to be consolidated as the Virginia Railway incorporated this month in Virginia. They are being built for the express purpose of reaching and marketing what will be the products of about 150,000 acres of coal land in the Pocahontas field that have not as yet been touched. In the execution of this project it was decided that after the line escaped from the fastnesses of the West Virginia mountains and emerged into the comparatively open country of Virginia that it should be constructed with a maximum grade of .2 per cent. compensated against east-



Map of Tidewater and Deepwater Railways.

measures. These measures have a general dip to the southwest at the rate of from 30 ft. to 75 ft. to the mile, with the Pocahontas measures the lowest. This Pocahontas coal belongs to the same period as the Pottsville coals of Pennsylvania, and as a steam coal is acknowledged to be unequaled. An approximate analysis of the seam may be taken as:

Fixed carbon	77.0	Moisture	0.4
Volatile matter	16.1		
Ash	6.0		100.0
Sulphur	0.5		

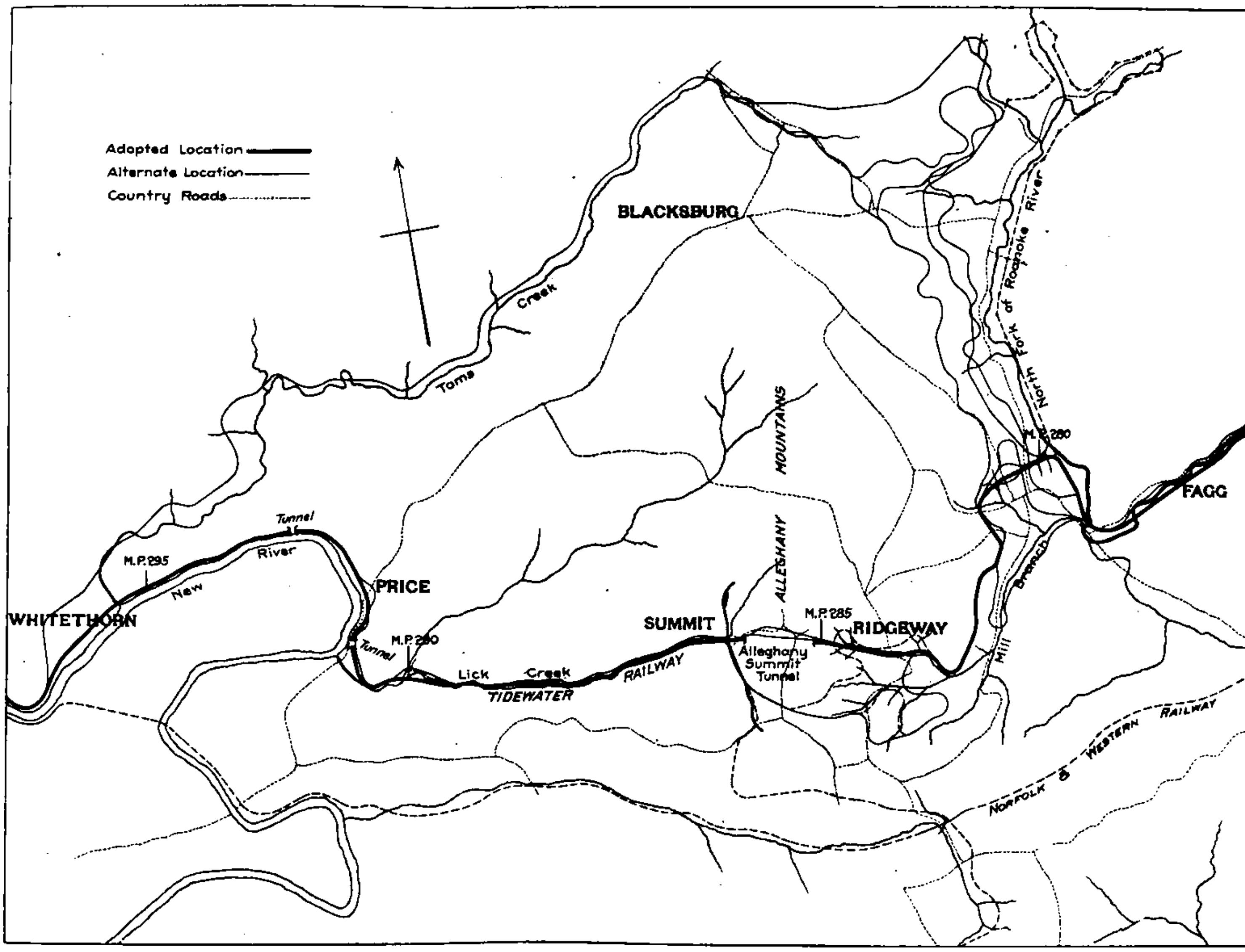
And it is an approximation to this high quality that an attempt is made to reach in the mixture of the anthracites and soft coals for the cheaper steam fuels used in the eastern markets.

These Pocahontas measures lie along the eastern extremity of the state and end in a fault beyond which no coal of importance is found. This line of demarkation is very distinctly marked as shown on the map of the Tidewater-Deepwater Railways. The field itself has a width of about 30 miles and runs from the northeast to southwest. To the west is the Kanawha field ranging in width from 10 to 50 miles. At the present time this great coalfield is crossed by three railroads, the Baltimore & Ohio, the Chesapeake & Ohio and the Norfolk & Western, of which only the two latter touch the Pocahontas measures, and these, at their points of entry on the eastern edge, are about 40 miles apart; the Chesapeake & Ohio coming in with the New river, and the Norfolk & Western further south near the headwaters of the Bluestone river, which flows in a northeasterly direction nearly parallel to the great Pocahontas fault already alluded to. These roads approach each other bound traffic and .6 per cent. compensated against the westbound. With these conditions rigidly adhered to, it will be possible for a single locomotive, such as will be used, to haul a train of 80 loaded cars of 100,000 lbs. capacity from the assembling yard at the edge of the coal fields to tidewater, except in the two cases of mountain climbing where pusher grades will be used, and return with a train of equal length of empties. In passing through the mountains these limitations have been removed, and while heavy work has not been avoided and the line is a remarkable one, both in profile and alinement, the nature of the country through which it passes has necessitated steeper grades. The Deepwater section of the line will, therefore, serve as an originating portion and cars will be hauled from the mines to a general assembling and classification yard at Princeton, W. Va., for arrangement and distribution.

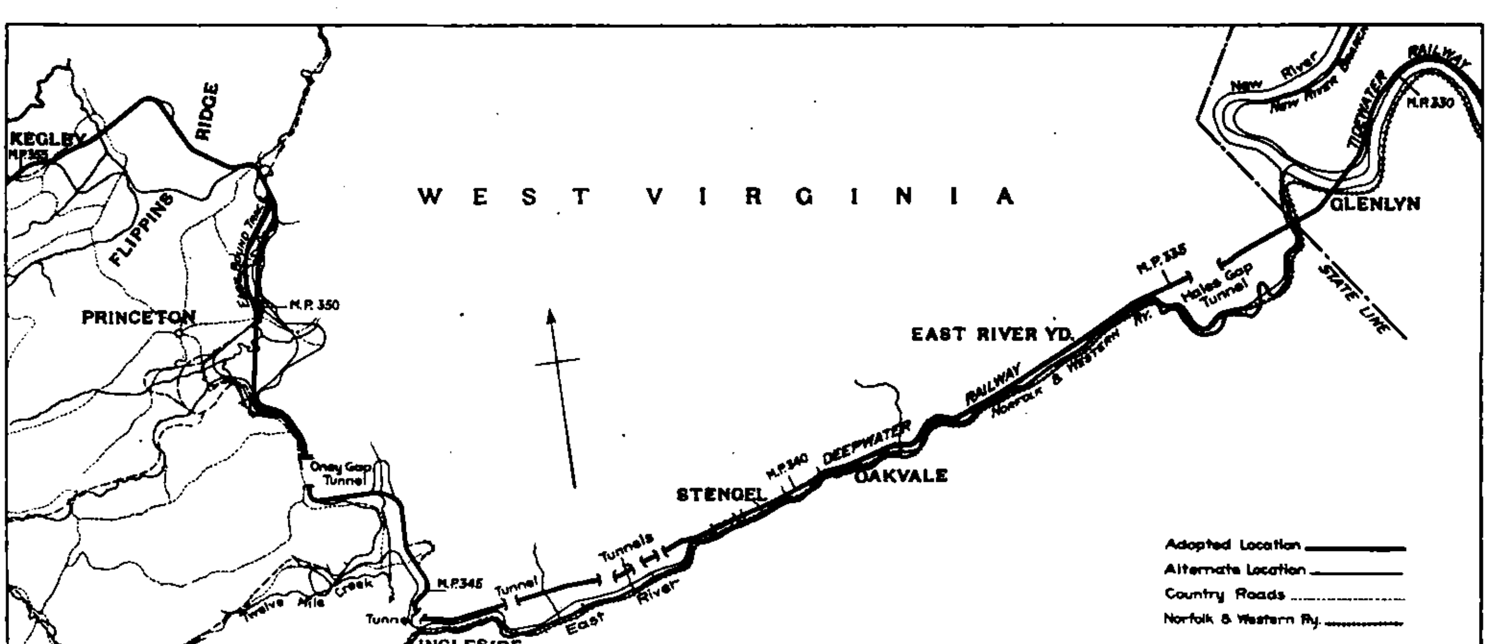
When the character of the country is understood, not only in the mountainous portion covered by the coal fields, but the rolling lands of Virginia as the elevations drop down from the Blueridge mountains to the sea, as well as the space intervening between the Blueridge and the Alleghanies, it will be seen that the construction of such a line as that outlined is not only a task of great magnitude, but one calling for the highest grade of engineering skill.

The alinement and profile vouch for this and to this must be added the willingness of the promoters of the work to sustain the engineers and management, not only in the surveying and location of such a line as had been determined upon, but in constructing it in the best possible way and in accordance with standards that represent the most advanced and thorough conditions of railroad building and operation. In this, bold and extensive works in the form of tunnels, cuts, fills and bridges have been required all along the line, and their execution was naturally preceded by extensive surveys that covered practically the whole state of Virginia south of the James river. In this territory four distinct locations were made with estimates of cost before the final decision was reached. This was for actual work in the field to say nothing of the studies and tentative routes that were made from the topographical maps published by the United States Geological Survey. It may be stated here, as illustrative of the methods used, that throughout the whole of the preliminary work of the surveys these maps were in constant use and served as the basis for the plotting of the general run of the lines before parties were put in the field. They even served to furnish information from which general estimates could be made, and thus avoided the expense of useless reconnaissance or preliminary work that had no chance of success.

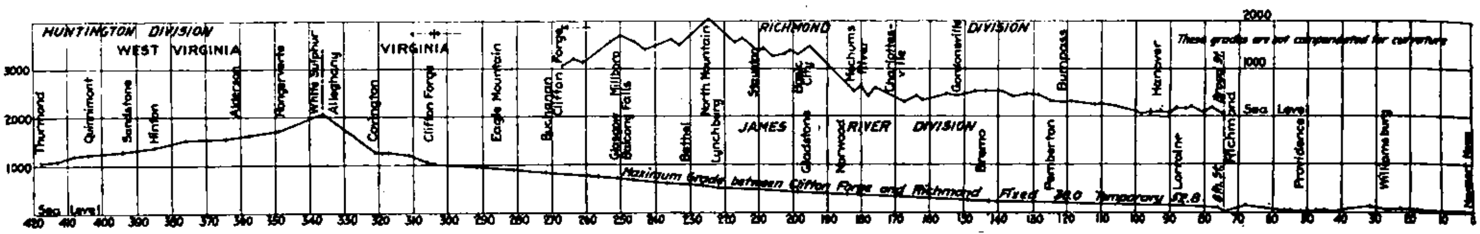
One of the characteristic features of this road, and one which



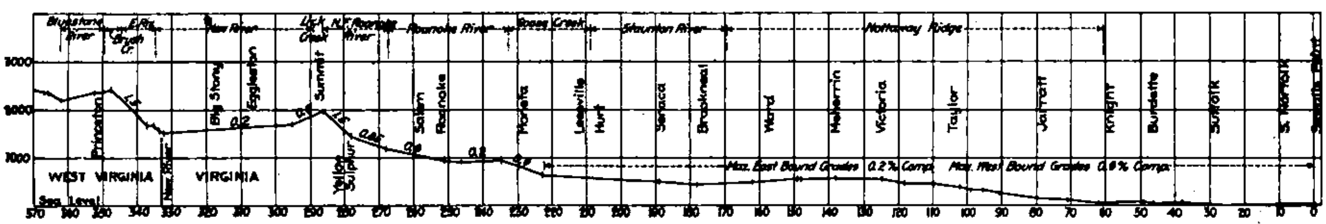
Locations Across Allegheny Mountains; Tidewater Railway.



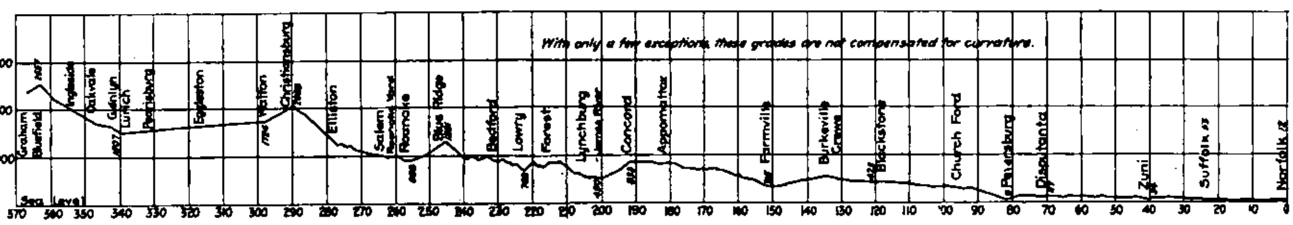
Locations of Deepwater Railway from Princeton to New River.



Profile, Chesapeake & Ohio Railroad.

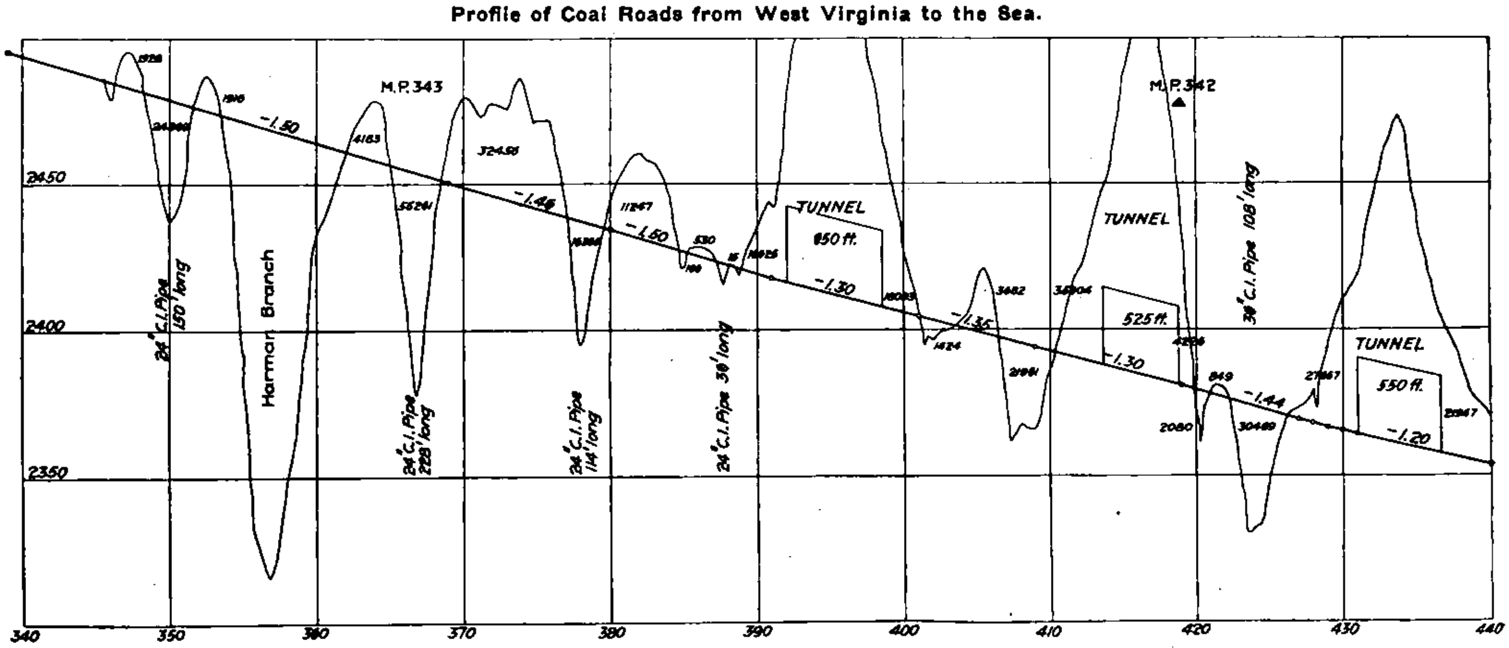


Profile, Norfolk & Western.

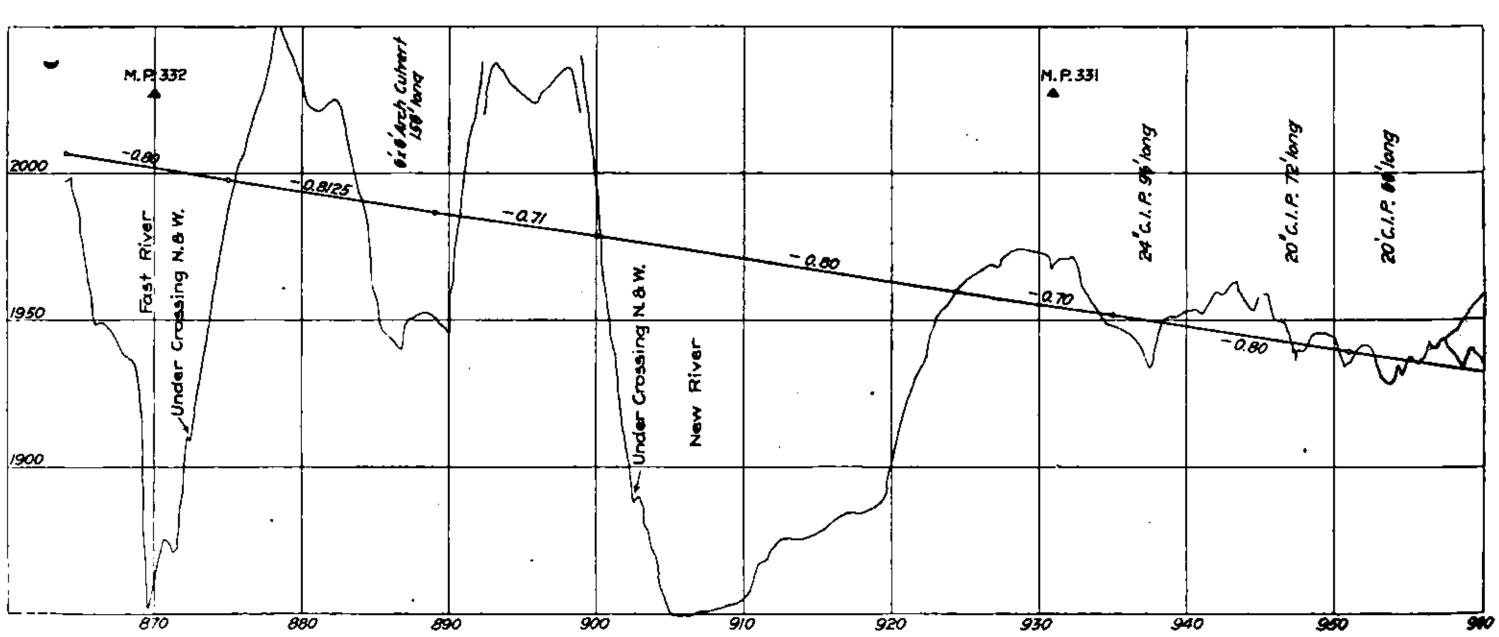


Profile, Tidewater and Deepwater Railways.

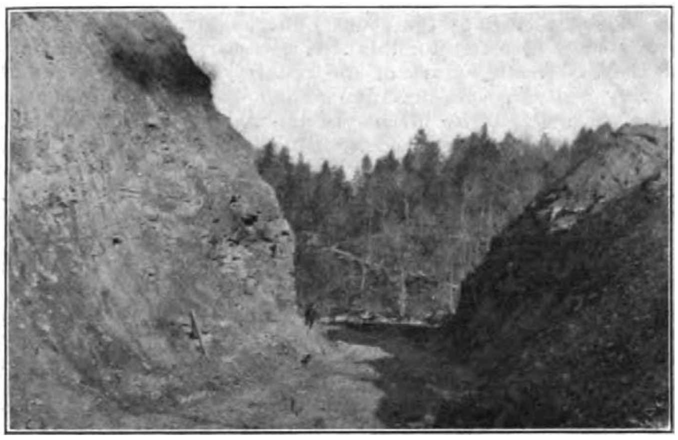
Profile of Coal Roads from West Virginia to the Sea.



Profile of Tidewater Railway, Approaching East River.



Profile of Tidewater Railway at New River Crossing.

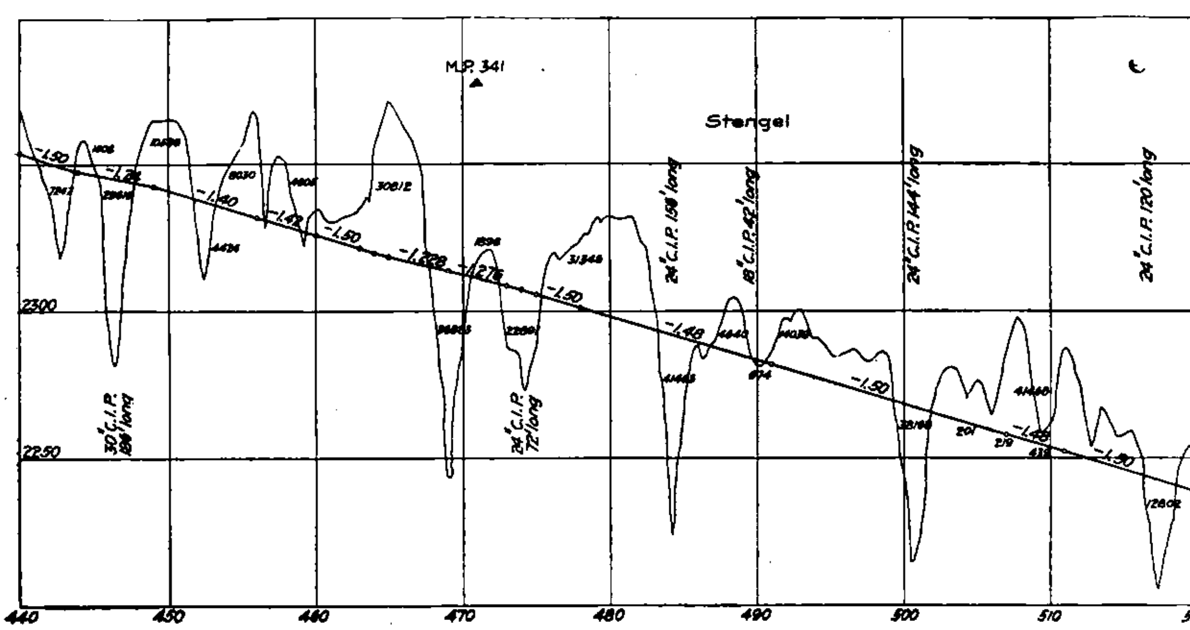


Heavy Cut at Mile Post 83; Deepwater Railway.

is merely indicative of the thoroughness and masterly manner in which all of the work has been done, is that in which the surveys have been conducted. Aside from the general rough character of the country, and the necessity of working a low-grade line with a maximum of .2 per cent. adverse grade from the mountains of West Virginia, there was placed upon the engineering department the duty of laying out the best line that the country afforded. Ordinarily the directors of a piece of line of this kind dictate the details to a greater or less extent; they insist very properly that the towns and villages adjacent to the route shall be reached on account of the immediate traffic which they will afford, and the desire to meet the demands of the public for a convenient and expeditious service. In this case, however, no such lines were laid down. The engineers were simply given two terminals, and told to connect them by a line of the exceedingly low grade specified, and by the shortest and best route that the country afforded. They were not hampered by the needs of reaching a single city or village en route and were given the whole width of the state of Virginia in which to locate the line. While this free hand placed the whole responsibility for the economical location and construction, as well as its subsequent operation, on the shoulders of the chief engineer, and showed in the most marked degree the confidence placed on his department, it added greatly to the work, in that it involved the examination of a much wider belt of territory, not only in reconnaissance and preliminary surveys, but in actual location of alternative lines than would have otherwise been required. It involved also a much heavier expenditure for surveys than would have been incurred under ordinary conditions where, from the necessity of reaching certain definite points, the belt to be examined and surveyed would be much narrower. This is undoubtedly the proper and scientific method of railroad location, and the results in this case seem to have fully justified the elaborateness of the preparation, but unfortunately it is not one that is often permitted either by commercial or operative conditions, to say nothing of the desire on the part of the directors to direct details and their haste to have some tangible results to show in the nature of construction in progress.

However, for once, this broad policy was put in force, and we have a railroad built upon the broad scientific principles of securing the best line that the country affords, regardless of cities, towns or villages adjacent or connecting railroads, and one reaching from one predetermined terminal to another.

With this understanding of the spirit in which the work was undertaken and carried on, we can turn to a review of the details of the alinement and profile and study the manner in which the work of the survey has been conducted and the class of line that has finally been located and put in course of construction.



Profile of Tidewater Railway, Approaching East River.

The nature of the line to be built and the country through which it passes involves continuously heavy work from the start at Deepwater until the level country west of Norfolk is reached.

At the start it is difficult to conceive of a rougher or more unpromising territory in which to build a railroad than the mountain country of West Virginia, through which this road runs from Deepwater to Princeton, a distance of about 95 miles. The mountains are precipitous ridges, true Sierras, saw tooth in section, and the valleys are narrow and tortuous, with little or no arable bottom land, and each carrying a rapid mountain stream of dimensions varying with the season, the amount of immediate rainfall and the area drained. Location here leaves but two courses open; one to follow every bend of the stream, and the other to cut across and work on tangents. The first puts in a road that is full of curves, in fact consists of little else, and the other becomes a mere succession of bridges and tunnels. The first involves the lower first cost, but the higher expense for operation, so that there is usually a compromise between the two, and bridges and tunnels are used where it appears that the saving in cost of operation on the prospective tonnage will warrant the increased original expenditure.

When the first five miles were laid out south from Deepwater in 1894, it was the intention to extend the road eventually down through the coal regions between that point and Princeton, but it was not expected that it would ever develop into a through tidewater line. It was intended merely as a spur tributary to the Chesapeake & Ohio, and reached down to some lumber operations in the neighborhood of Robson. The location was, therefore, made along the banks of Loup creek, a tributary of the Kanawha river at Deepwater, and followed it in all its sinuosities. The idea seemed to have been to get into this territory with a minimum of original outlay, so that we have curves of 16 deg. in abundance while the grade follows that of the fall of the stream and rises 234 ft. in 21,000 ft., or on an average of uncompensated grade of a little more than 1.1 per cent., though for the first 9,000 ft. the rise is continuous at 1.5 or 1.7 per cent. On this section the profile shows

Cut Between East River and Hales' Gap Tunnel; Deepwater Railway.

the selection of a route of minimum excavation, there being but a few heavy cuttings. This was the condition of this nest egg of this present line at the end of October, 1903.

In the meantime surveys had been undertaken for the extension of the line up into the coal fields, but without the expressed intention, at the time, of running on to tidewater. The work was, however, done in a way to somewhat modify the severity of the line already built in that the maximum rate of curvature was reduced and the grade cut down as far as practicable. Consequently immediately after leaving the end of the original line we find the alinement much straighter and the grades against the south or eastbound movement lighter.

With the exception of a tunnel 290 ft. long at station 264, there is little heavy work encountered until Hamilton is passed, about

Rock Ballast Quarries at Surveyor, W. Va.; Deepwater Railway.

11 miles from Deepwater. Then beyond that point there are a succession of heavy cuts and fills with one trestle 60 ft. high. This is on the maximum grade in this portion of the line up to Silver Gap which is turned at an elevation of about 1,850 ft. The line then follows the banks of Mossy creek on a modified grade and about the same class of alinement as before with a continuous succession of rather heavy work. This down grade continues to Lively (24 miles), and in this section there is a trestle 90 ft. high and two tunnels, one of 950 ft. and the other of 300 ft., besides two trestles lower and smaller than the one mentioned.

Again at Lively there is a reversal of the grade with a rise along Paint creek to Harper, on still easier grades, and it is on this section that the two highest trestles so far on the line are found, each about 110 ft. high. At this point the line, as finally located, skirts along the edge of the Flat Top mountain, which is about the only ground in this territory that can be considered at all easy and not set on edge. Unfortunately it was impossible to take any advantage of these conditions, on account of the general trend of the road, which it was necessary to hold. The line, therefore, bends away to the southwest and follows the water course that drops away quite rapidly. It does this running down one branch until a tributary is reached, which is followed up to the dividing ridge, which is crossed in a cut or tunnel, thus forming a rather steeply undulating line to Mullens, 58 miles from Deepwater, situated just above the junction of the Slab Fork and Guyandot rivers. In this section the grading becomes lighter, but the country is exceedingly rough. There is, however, some tunneling.

Mullens is now the head of travel, though the rails are laid for some miles further. One mixed passenger and freight train is run daily between Deepwater and Mullens, and these serve to bring in contractors' supplies and other requirements.

The exceedingly wild and picturesque country continues for 15 miles further on up to Clark's Gap, which is crossed by a 1,200-ft. tunnel. In this distance there are a number of long and high viaducts, all of which are steel of the approved standard designs. Some of them are finished and the grading all done. In this the heaviest work is found of any south of Deepwater.

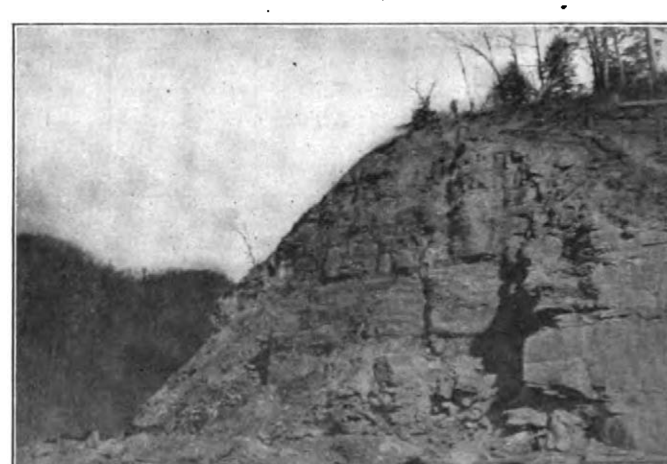
The line, as thus laid out, is an example of high grade work through an exceedingly rough and difficult country, but it must not be thought that the final location was coincident with the only preliminary run. It has been the policy throughout the whole distance from Deepwater to Norfolk to make a broad general study along both sides of the suggested line in order to locate on the best that the country affords. Accordingly the same policy was pursued in this difficult West Virginia country.

Up to Silver Gap summit there apparently seemed to be but one route to be followed and little was done on either side of the line. But on leaving this summit the road strikes into the true Pocahontas coal territory that it is intended to serve, and it became advisable to study the country thoroughly. In order to fully appreciate the necessity for this it is necessary to bear in mind not only the saw tooth nature of the country but also the fact that this very contour, with its innumerable and tortuous hollows or valleys, necessitates the placing of the coal operations upon what would otherwise appear inaccessible heights and locations. Consequently a road to efficiently serve such a country and take care of the traffic that will come when it is developed, must be prepared to reach out-of-the-way and remote places either by its main line or spurs. Hence the necessity, not only for reconnaissance but for the running of preliminaries that it is not expected to build at once, and even for the location of a number of alternate routes. This was done, in the territory under consideration, just as it was done in the more open Virginia country, and lines have consequently been located up and down the hollows leading off the main line all the way from Silver to Clark's Gap. In fact, surveys and location were made for an alternate line to the east of the one adopted, all the way from Silver Gap to the Bluestone river, at a point approximately the same distance from the starting point as the one by way of Clark's Gap. This covers a territory approximately 20 miles wide in places and reaching out into those exceedingly rich mining properties on Dunloup, Piney and Laurel creeks. This would have been a very heavy piece of line to construct and in one place a loop with an approximate diameter of about 3,000 ft. was provided for.

While these lines will not be built, except as spurs to reach operations that may possibly be opened in the future, the fact that they were run and all the data for them obtained enabled the engineers to select the route that they did, which may be considered to be the best that the country affords.

After leaving Clark's Gap there is a drop in the profile in heavy work all the way down to Matoaka, 80 miles from Deepwater. Between this point and Princeton, 350 miles from Norfolk, the territory explored was again widened and careful comparisons made for the best line. The work here is exceedingly heavy, and it is at Rock (361 miles from Norfolk) that the true main line with its easy gradients may be said to begin. The line rises out of Rock on a .5 per cent. compensated grade and there is then a constant succession of heavy cuts and fills for the 10 miles to Princeton. In this distance the cuts vary in depth from 10 ft. to 80 ft., and there is also the highest viaduct on the line with a height of 190 ft. And so Princeton is reached.

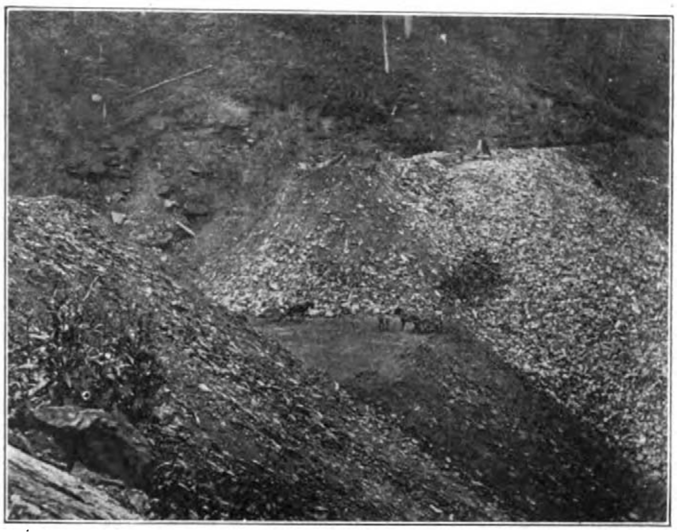
Princeton is to be the gathering point of the coal traffic, and, from this point on, the easy grades and moderate curvature that has been established for the main line will prevail. The country to the north on the Deepwater line is the roughest on the whole route and lies through the West Virginia coal measures. The material to be moved consists of a soft sticky red clay that is treacherous and apt to slide and wash down in the cuts. This overlies,



Disintegrated Rock in Elmore Cut; Deepwater Railway.

to varying depths of from 5 ft. to 40 ft., the true coal measure and rock. This and the coal has a dip to the southwest, and is of a friable nature. It is a soft sandstone that crumbles away easily and is readily broken. It is too hard to cut with a shovel, but a blast shot in it breaks it up badly and develops innumerable fissures, utterly disintegrating the rock and throwing it down in a mass without setting out any very large pieces. It can be rapidly drilled and, with the debris and loose fragments removed after a blast, it will stand well but with a constant flaking off of the surface after the manner of a shale which it closely resembles in places.

Leaving Princeton, the road rises for 2.5 miles on a maximum of .6 per cent. grade to Oney Gap, where the summit occurs in a 1,600-ft. tunnel at an elevation of 2,800 ft. above tidewater. From this there is a rapid drop with a maximum grade of 1.50 per cent. compensated for about 10 miles to the East river. From Princeton to East river the east and westbound grades are pusher grades. The road has now left the coal measures to the north and west and enters on the blue limestone country of the New river district, and at Ingleside is on the opposite side of the East river from the Norfolk & Western, but at a considerably higher elevation. Alternate surveys and locations had been made through all this country, in some of which the curvature was excessive, as must necessarily be the case wherever the natural contour of the ground is followed as shown on the detail maps. But the way was heavy and the demand for low grades imperative, so between Ingleside at milepost 345, and the crossing of the New river at 331, there is some very bold and heavy work. What it



Partly Finished Fill at Micajah Gap; Deepwater Railway.

meant to build this practically straight line of 10 miles, with heavy rock cuttings, fine tunnels and a 2,100-ft. bridge, can best be appreciated from an examination of the sections of the profile shown. Set well up on the hillside, and crossing the flow of the streams into the East river at right angles there is a constant succession of steep rise and fall of the surface of the ground. And it is here that the most spectacular piece of work on the line is to be found.

Coming down the East river, the first location followed the bank of the stream below milepost 335, as shown by the light line, and on the same side but well above the Norfolk & Western. The excessive curvature, the difficulty of construction and the expense involved in doing the work so as not to interfere with the traffic of the other road, led to a radical revision of the location. As first laid out the road would have followed the East river to its mouth and then swung across the New river at an elevation of about 45 ft. on a bridge carrying a 6-deg. curve after which it would have followed up the right bank. Induced by these considerations of location and difficulty of constructing close to the line of another road in rock work that was apt to slide, together with the excessive amount of curvature and the natural objections to crossing a broad river on a sharp curve, the engineers took the bold step of leaving the East river at milepost 335, and running almost on a tangent to the bluff on the up-stream side of the two rivers, and then by holding diagonally across the New river, strike the face of the bluff on the bend beyond by means of a 2,100-ft. bridge at an elevation of 115 ft. above low water and on a tangent for the whole distance. Certainly this is one of the boldest grapplings of a difficult problem that is recorded, and required courage not only to propose but to finance. But in its completed form it will stand as a piece of engineering work justifiable and pre-eminently fine.

The next 40 miles follows the course of the New river, whose fall is approximately that of the limiting grade or .2 per cent. This grade is compensated on curves so that frequently the actual rise is not more than 5 ft. to the mile. In this 60 miles the maximum curvature is 6 deg. except for three short curves of 8 deg. each. There is a gradual rise until at Whitethorne, 295 miles from Norfolk, the road leaves the New river and commences the serious business of crossing the Alleghanies.

In this run from milepost 330 to 290 the proper route was along the river, but for the passage of the mountains the policy of extensive surveys of alternate lines was resumed and a large number of alternatives were run and located, as shown by the fine lines on the engraving, and these were studied in all of their features with the result that the line being built was selected. This gives a practically straight run from the foot of the mountain to the summit up Lick Creek hollow, a distance of about 10 miles, in which the rise is 265 ft. with a maximum compensated grade of .6 per cent.

Throughout this division up the New river and to the crest of the Alleghanies the cutting is all in rock. The material is a hard sandstone, sometimes alternating with a limestone, for it is along New river that the limestones are first encountered. It is hard and offers a heavy resistance to the drills and stands well, but is apt to be seamy and contain pockets and fissures of clay that may come down with almost no warning. It is the material found directly east of the fault in the Pocahontas coal measures, and extends from that point to the Alleghanies which form a dividing line between the sand and limestones, the former being to the west and the latter to the east. This passage of the Alleghanies with a line built within the limits of the grade and curvature that has been imposed was one of the most serious tasks imposed, and required the expenditure of much time and labor in which a number of alternative lines were located as indicated on the map.

Passing Summit at an elevation of 1,963 ft. the road drops down to Fagg on a 1.50 per cent. grade, which is the equivalent to the .6 per cent. ascending grade for empty car traffic. These grades, of course, involve the use of pushers, and they will be used on every train each way between the foot of the grade at Whitethorne, on the western slope, and Fagg, on the east, the extra engine remaining with the train on the down grade in order to work on the return. The distance thus worked will be about 17 miles.

Beyond Fagg the line strikes the North Fork of the Roanoke river, which it follows on to the Staunton river at milepost 240, when it again leaves the waterway to strike across the Blueridge mountains. It is in this section just beyond Roanoke that the road runs definitely into a limestone country. It would have been possible to have passed this barrier by following Staunton river just as the Chesapeake & Ohio effects the passage by way of the gap of the James river, and a complete survey and location was made over this route, but the stream is so crooked and the distance so much greater that it was abandoned for the sake of the line to the north, which crosses on an adverse eastbound grade of .2 per cent. at an elevation of 942 ft. This is not only high as compared with sea level datum but is well above the river, being 150 ft. above the river where it strikes it at milepost 240. This naturally requires heavy cutting, the heaviest being at Moneta station, where there is the 260,000 cu. yd. cut, elsewhere alluded to.

Along this section the excavations and fills are very heavy, but they are generally in the red clay that is the covering mate-

125-ft. Fill at Micajah Gap; Deepwater Railway.

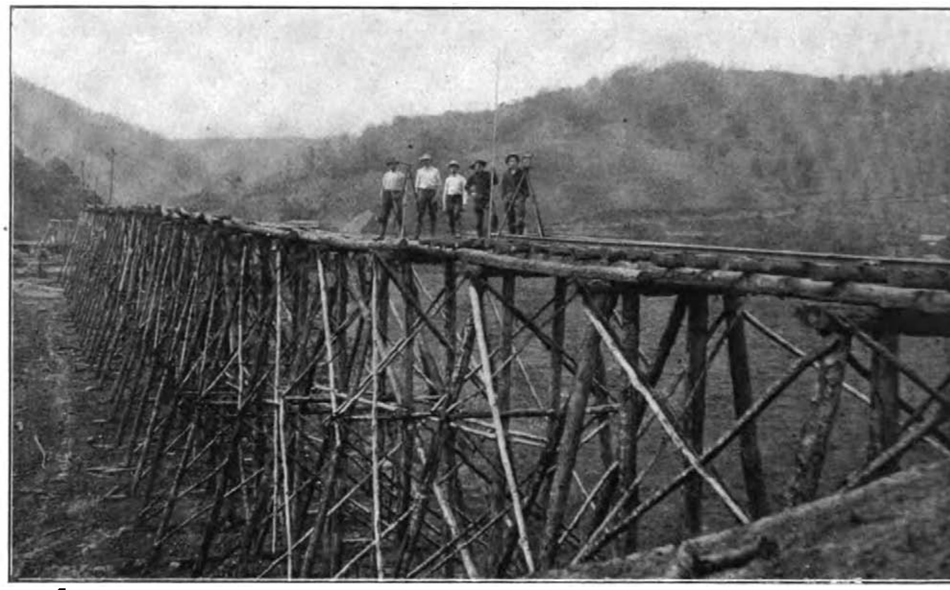
rial for this section of the state and is, therefore, steam shovel work. The work can be carried on very expeditiously, the banks stand well, except for the washing down of the surface that occurs in heavy rains. Beneath the clay is the strata of granite that underlies the whole at varying depths, with 40 ft. as an average. Then, as the work goes on to the east, this clay is mingled with pieces of soft, almost disintegrated granite, which finally develops into a distinct rock in the neighborhood of Brookneal. Thence on to Jarrett, 80 miles from Norfolk, work becomes more difficult and, for the last 60 miles beyond Victoria, along what is known as the Nottaway Ridge, there is a light earth covering of about 15 ft. above the rock, which is hard granite, so that, in the deep cuts the work is severe. It is along this section, also, that great pains were taken in the location, and four general lines were run before a decision as to the final location was made. With this condition of the country in view, it will readily be seen that the climb to the summit of the ridge at Meherrin and the subsequent drop to the Staunton river were strenuous work.

Along this portion of the line we again come upon a section of country where alternate lines were possible and a wide reach of territory, approximately 20 miles across, was thoroughly covered by the surveys and carefully mapped. Then came the comparatively level country rolling down into the plain to the east of Norfolk and the Dismal Swamp. This level country across which it would be easy to run an ordinary line offered a good many difficulties to the location of this .2 per cent. compensated eastbound grade. Again it is desired to impress upon the reader that this means a change of elevation of never more than 10 ft. to the mile and frequently not more than 5 ft. And when this is to be done across a country at right angles to the general trend of the streams it involves long cuts and fills, not necessarily deep, but from their very length involving the removal of a large mass of material.

After leaving Brookneal the disintegrated granite mixed with the clay develops into regular ledges, and this in turn is followed by the very hard granite outcropping that runs north to Petersburg and Richmond, and from which the quarries at those places obtain their material.

All through the region alternative lines were run, sometimes covering a territory 40 miles across. For example, from milepost 135 to milepost 65 an alternative line was surveyed along the Nottaway river, which was abandoned in favor of one adopted. In the approach to Norfolk the line is run north and clear of the Dismal Swamp, so that easy connection can be made into Portsmouth and Norfolk. The latter city is avoided by a wide detour through the lowlands finally reaching the coal wharves at Sewall's Point, the terminal of the line. At this eastern end there is nothing but sand as far west as Suffolk, beyond which the country is rolling and the construction comparatively easy.

From what has been said it will be realized that the amount of excavation required along this line has been very great. Take the work in the mountains between Mullens and Micajah's Gap; there is one fill 125 ft. high that contains about 140,000 cu. yds. of material, most of which is rock from adjacent tunnels. After leaving Clark's Gap the country is easier and yet even through here the excavation amounted to from 60,000 to 70,000 cu. yds. to the mile. The profiles that are shown give a clear idea of some of the exceptionally heavy character of the work between Princeton and the New river bridge. The approach cut to the Oney Gap tunnel, for example, involved an excavation in rock of 153,000 cu. yds. at the west end and 30,000 cu. yds. at the east; and, again, at the New river, there is a cut of 100,000 yds. in rock. These are but typical of the work along the whole distance. Further to the east, after leaving the mountains and crossing the Alleghanies, there are exceptionally heavy cuts and fills. One cut near Moneta required 260,000 yds. of earth and rock excavation in a distance of 4,000 ft., and in the six miles beyond the material to be moved runs from 50,000 to 100,000 cu. yds. to the mile. Again in following the Nottaway ridge to cut off the bend of the Staunton river the grading is about 100,000 cu. yds. to the mile, through clay and rock.

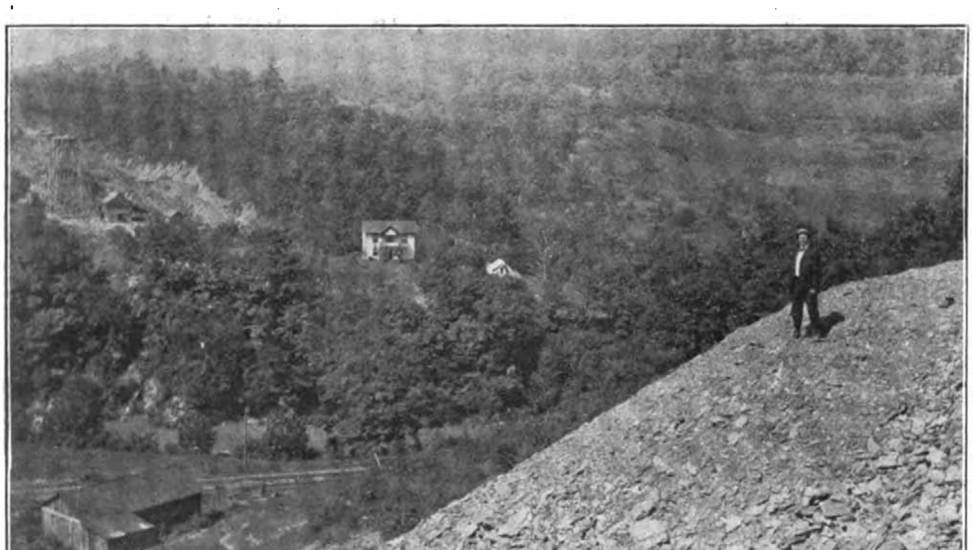


Preparing to Fill at Rock, W. Va.; Deepwater Railway.

To revert again to the general profile and the task involved in building this low grade line, attention is called to the map, upon which the two existing lines running from West Virginia coal fields to tidewater are shown.

In a way the Tidewater and Deepwater Railways will be in competition with the Chesapeake & Ohio and Norfolk & Western in that it runs from the Pocahontas coal fields to the sea. But, aside from this matter of general location, it does not touch the territory served by either of the other two except at a few isolated points, and will hardly compete in the sense of offering its facilities to any mine already reached by either of the other two. Its success, however, will depend upon the facilities which it can offer to proposed operations to market the output in competition with either or both of the other two lines.

The prospect of being able to place coal upon the market in the face of this competition can be gaged by a comparison of the profiles of the three roads.



Fill on East River, Deepwater Railway; N. & W. Tracks Below.

For this purpose we may start at the assembling point of the traffic of each. These may be taken as at Hinton for the Chesapeake & Ohio; at Bluefield for the Norfolk & Western, and Princeton for the Tidewater-Deepwater.

Taking the Tidewater-Deepwater, as shown in the upper of the three profiles, we have the assembling yard at Princeton from which there is a pusher grade to Oney Gap tunnel, about two miles; this is followed by an abrupt descent to the valley of the New river; with another adverse grade requiring a pusher at the crossing of the Alleghanies. This adverse grade is about nine miles long, though the pusher engines will run on to Fagg, eight miles beyond, to assist the westbound traffic. The same thing is done at Oney Gap, where there will be an overrun on the down grade of about 10 miles. Beyond this there is nothing to exceed .2 per cent. compensated grade against eastbound traffic. So that in a run of 350 miles double heading will be carried over only about 29 miles. Over the remainder of the line a single locomotive can haul the full rated tonnage of 80 loaded cars. In all the total rise of the Tidewater Railway between Princeton and Norfolk is 1,250 ft. on a run of 350 miles.

In the case of the Chesapeake & Ohio, with Thurmond as the assembling point, 418 miles from Newport News there is a continuous rise to the crest of the Alleghanies, a distance of 82 miles. Part of the distance is on comparatively easy grades, but most of the way would require pushers for handling the proposed train tonnage, and this service would have to be carried on to Clifton Forge, 304 miles from Newport News. From Clifton Forge to Richmond the line follows the old James river canal, and is a continuous down grade. Beyond Richmond there are two places of from five to eight miles in extent where pushers would be required if the proposed tonnage were to be moved. The total rise would be 1,347 ft. With Hinton as the point of assemblage the lift would be about 1,050 ft., and the distance 385 miles, with a pusher service approximating 90 miles. These figures may not correspond to the actual work done on the road, but they are approximately what would be required for a service similar to that proposed for the Tidewater-Deepwater.

On the Norfolk & Western, with the traffic originating at Bluefield, 364 miles from Norfolk, there is a total rise of about 2,894 ft., and a requirement for a pusher service of at least 130 miles if the same tonnage basis is to be preserved.

The following table gives a resumé of the data of these lines:

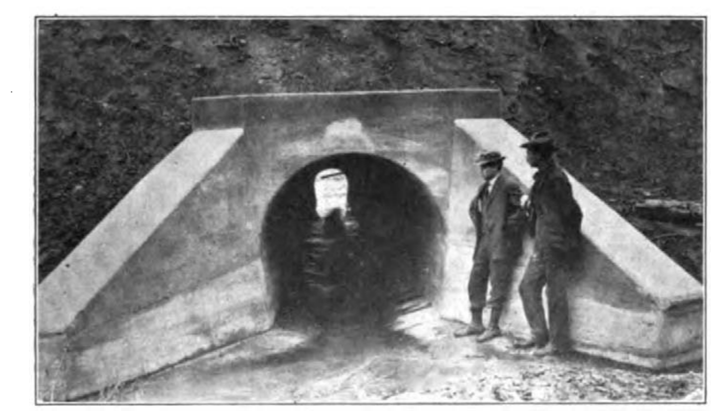
Line	From	To	Distance in miles.	Total rise in feet.
Tidewater-Deepwater...	Princeton	Norfolk......	350	1,250
Chesapeake & Ohio.....	Thurmond	Newport News	418	1,347
Chesapeake & Ohio.....	Hinton	Newport News	385	1,050
Norfolk & Western.....	Bluefield	Norfolk......	364	2,894

With these conditions in mind where distance, grades, curvature and total elevation are in favor of the new line, with the single exception of the total rise on the Chesapeake & Ohio, considering Hinton as the assembling point of originating traffic, it seems that that new line can reasonably expect to compete profitably with those now in existence. The officials who are directly responsible for the engineering features of the work are H. Fernstrom, Chief Engineer, and Raymond DuPuy, General Manager. W. N. Page is President of the Tidewater Railway and Dr. J. O. Green of the Deepwater. The other officials participating in the work and holding the same position in both corporations are: B. T. Elmore, Assistant Chief Engineer; L. R. Taylor and E. Gray, Jr., are the Principal Assistant Engineers; F. F. Harrington is Engineer of Bridges, and C. H. Stengel, Designing Engineer.

The Tidewater and the Deepwater Railways.

CULVERTS, TRACK AND TUNNELS.

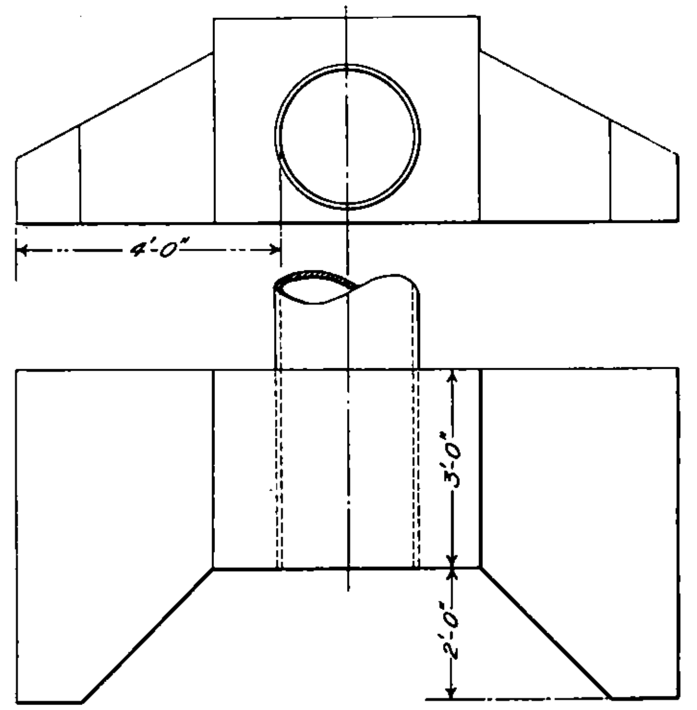
In the previous article on the Tidewater and Deepwater Railways, the general features of the line and the methods of conducting the surveys were discussed. From what has been said it will be seen that thoroughness is characteristic of the whole of the undertaking. It follows, then, that with such a preparation as that outlined, this thoroughness and carefulness should be carried into the execution of all of the work. Starting in the way it has, with no large towns except Roanoke to consider, and with the main fixed idea of obtaining low-cost hauling facilities for coal, it is natural that the adoption of standard forms of construction should have received early attention. As soon as any particular plan is determined on, a standard is developed that can be used the whole length of the line. These standards cover a wide range of items from stations to crossing signs, and from pipe culverts to viaducts, many of which will be illustrated in detail. In addition, standard methods of executing the work were prescribed.



Arch Culvert; Tidewater Railway.

The permanent way and that which pertains to it naturally received the first consideration, and so there have been developed an elaborate system of standards for culverts, viaducts and bridges. Starting with the smaller types of culverts that can be formed of cast pipe, a complete table of the lengths of the various sizes of pipes that would be required for different heights of fill was drawn up.

In laying pipe culverts it was specified that the grade should not be less than 1 in 100, and that the pipe should be cambered under the center of the fill so as to allow for settlement; the amount of this camber to be dependent upon the depth of the fill over the pipe and the character of the foundation. In no case, however, was the camber made so great that the central portion of the pipe was higher than the inlet. In other words, the camber must be less than 1 in 100. Ordinarily the pipe was laid in 12-ft. lengths, but where it was necessary half-lengths were used. The ends of all pipes of 18 in. or more in diameter were protected by rip rap laid by hand and to the approximate dimensions shown in the engraving. Further than this, the joints were made thoroughly watertight by the use of 1:2 Portland cement, mortar and oakum. These pipes were also carefully coated with asphaltum before being laid, and



Concrete Heading for Pipe Culvert.

were well tamped in place, excavations being made to receive the hell projections.

Length of Pipe in Feet for Various Heights of Fill and Sizes of Pipe.

Height of bank.	Diameter of pipe in inches 10	12	14	16	18	20	24	30	36	42	48
3 ft.	24	24	24	24	24	24	24	..	..	..	..
4 "	30	30	30	30	24	24	24	24	24	..	..
5 "	30	30	30	30	30	30	30	24	24	24	24
6 "	36	36	36	36	30	30	30	30	30	24	24
7 "	36	36	36	36	36	36	36	30	30	30	30
8 "	42	42	42	42	36	36	36	36	36	30	30
9 "	42	42	42	42	42	42	42	36	36	36	36
10 "	48	48	48	48	42	42	42	42	42	36	36
12 "	54	54	54	54	48	48	48	48	48	42	42
14 "	60	60	60	60	54	54	54	54	54	48	48
16 "	66	66	66	66	60	60	60	60	60	54	54
18 "	72	72	72	72	66	66	66	66	66	60	60
20 "	78	78	78	78	72	72	72	72	72	66	66
22 "	84	84	84	84	78	78	78	78	78	72	72
24 "	90	90	90	90	84	84	84	84	84	78	78
26 "	96	96	96	96	90	90	90	90	90	84	84
28 "	102	102	102	102	96	96	96	96	96	90	90
30 "	108	108	108	108	102	102	102	102	102	96	96

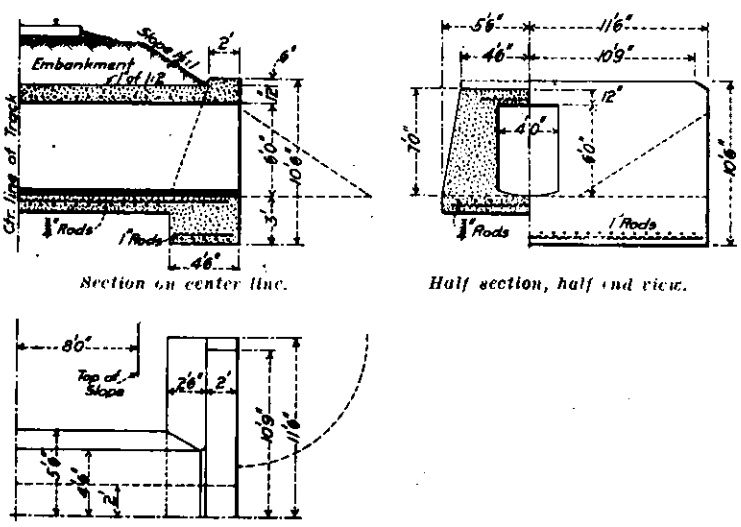
Where the drainage area was too great for the flow of water to be cared for by 36-in. pipes, box or arch, culverts were used and these were also standardized. These standards ranged from 2 ft. by 2 ft. to 4 ft. by 6 ft. for the box type, after which comes the arch construction in sizes running from 4 ft. by 6 ft. to 15 ft. by 15 ft.; the intermediates being 6 ft. by 6 ft., 8 ft. by 8 ft., and 10 ft. by 10 ft.

These box culverts are all of concrete and are of the general design shown in the illustration of the 4 ft. by 6 ft. box culvert. In this the dimensions shown for the foundations are the minimum allowed, and they are carried deeper where the nature of the soil requires. The reinforcing consists of 1 in. rods laid in both directions, as shown, near the base of the foundation. The cover and sides are made of 1:3:6 concrete with a somewhat poorer invert, which is of 1:4:7½ with a coating of 1:2 cement mortar 1 in. thick. The top and sides of the barrel of the culvert are waterproofed with a coating of straight run coal tar pitch ⅛ in. thick. All exposed edges of the concrete are rounded to a radius of 1 in. to prevent chipping, and the tops of the parapet walls are sloped inward. It may be added that, in the reinforcing of these culverts, the contractors were allowed to use old rails instead of the rods if they so desired.

The arch culverts were developed with the same completeness of detail. They conform, in a general way, to the scheme followed in the design of the box culvert, in that the reinforcement of the foundation is formed by rods at right angles and extending the whole length near the bottom. In the 12 ft. by 12 ft. culvert, illustrated, the arch is reinforced with a galvanized wire mesh, made of No. 8 wire laid in a 1-in. by 2-in. mesh. The arch is formed of 1:2:4 concrete on a foundation of 1:3:6, and this latter mixture is also used for the invert, which is made thin and not carried down to the bottom of the foundation. Where the bearing soil is poor, piles are driven to carry the load. As in the case of the box culverts, the top of the arch construction is coated with a layer of straight-run coal tar pitch ⅛ in. thick for reinforcing at the bottom of the foundation, 1-in. bars are shown, but the contractor was at liberty to substitute old rails if he preferred.

For open drains one general plan was followed, that of laying up side walls of 1:3:6 concrete upon suitable foundations, using piles where necessary and carrying the track upon two stringers, each made of three I beams, bolted in nests, and placed directly beneath the rails, as shown in the illustration. These carry the ties to which the rails are spiked. This is a somewhat more expensive construction than that used on many older roads where old rails are substituted for the I beams, but in this new road old rails are not available.

In deciding upon the type and size of culverts to be used at any



Section on center line. *Half section, half end view.*

Half plan.

Standard 4 ft. x 6 ft. Box Culvert.

particular place, the engineers were guided by a very carefully compiled table drawn up in accordance with the flow produced by a maximum rainfall over the drainage area involved. This is based not only upon the area drained but also the character of the country. The line from Norfolk to Princeton is, therefore, divided into sections, to each of which a coefficient is assigned. Of course, as in all cases, these are not hard and fast conditions from which there can be no variation, for the judgment of the engineer must be exercised in the selection of the coefficient to be used in the determination of the size of the opening. For large openings greater than that of 10 ft. by 10 ft. culvert, the decision as to what it should be was made by the chief engineer. Then, too, there might readily be a variation from the coefficient laid down for any particular section, because of local information regarding the flow of streams and their high-water marks.

Bearing in mind the character of the country through which the road passes, as set forth in the previous article, it will be seen that the coefficient by which the final area of the opening is determined increases as we move west from Norfolk. In other words, as the country becomes rougher, and the flow of water more rapid, the area of opening to care for a given watershed increases twofold. The table, as it stands, is therefore adapted to water openings in the comparatively level country immediately west of Norfolk, but is insufficient for the rougher country. Hence the coefficients used, with variations subject to the judgment of the engineer, are as follows:

Section.	Coefficient.
Norfolk to Jarratt	1.00
Jarratt to Meherrin	1.50
Meherrin to Brookneal	1.75
Staunton River, Goose Creek, Roanoke and New River sections, with a few exceptions where a higher coefficient may be used	2.00

The method of using the table and coefficient is this:

For any given drainage area, select the opening given in the table as a base and multiply it by the proper coefficient using the product as the area of the opening actually to be used. For example:

Norfolk to Jarratt, area drained, 20 acres—3.1 sq. ft. x 1 coef. = 3.1 sq. ft. opening = 24-in. pipe.

Jarratt to Meherrin, area drained, 20 acres—3.1 sq. ft. x 1.5 coef. = 4.7 sq. ft. opening = 30-in. pipe.

Meherrin to Brookneal, area drained, 20 acres—3.1 sq. ft. x 1.75 coef. = 5.4 sq. ft. opening = 2 ft. x 3 ft. culvert.

Staunton River, etc., area drained, 20 acres—3.1 sq. ft. x 2.00 coef. = 6.2 sq. ft. opening = 36-in. pipe.

Sizes of Culverts and Pipes for Various Drainage Areas.

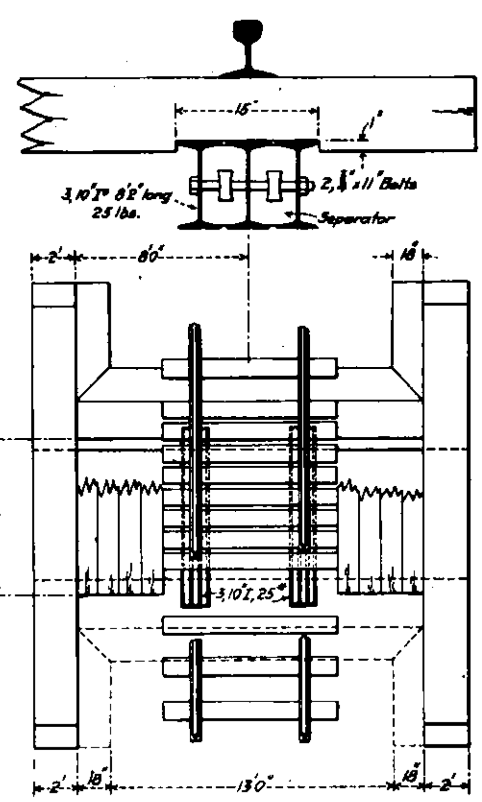
Area drained.	Area opening required— In sq. ft.	Size clvrt or pipe.	Area drained.	Area opening required— In sq. ft.	Size clvrt or pipe.
1 acre.	0.4	....	126 acres.	9.6	....
1.3 acres.	0.5	10-in. pipe.	140 "	10.2	....
2 "	0.7	....	152 "	10.9	3x4 or 4x3 ft. cul.
2.7 "	0.8	12-in. pipe.	160 "	11.1	....
3 "	0.9	....	180 "	12.0	....
4 "	1.1	....	198 "	12.6	....
6 "	1,4	16-in. pipe.	200 "	12.7	....
8 "	1.7	....	240 "	14.3	4x4-ft. culvert.
8.4 "	1.8	18-in. pipe.	280 "	15.5	....
10 "	2.0	....	320 "	16.6	....
11.2 "	2.2	20-in. pipe.	360 "	17.8	4x5-ft. culvert.
12 "	2.3	....	400 "	19.0	....
14 "	2.6	....	500 "	22.0	4x6-ft. culvert.
16 "	2.8	....	600 "	24.2	....
20 "	3.1	24-in. pipe.	1 sq. mi.	25.0	....
25 "	3.5	2x2-ft. arch clvrt	1.4 sq. mis.	30.4	6x6-ft. culvert.
30 "	4.0	....	1.5 "	32.5	....
35 "	4.4	....	2 "	39.0	....
40 "	4.8	....	2.5 "	44.0	....
42 "	4.9	30-in. pipe.	2.7 "	46.0	8x8-ft. culvert.
45 "	5.2	....	3 "	49.0	....
50 "	5.5	2x3 or 3x2 ft. cul.	3.5 "	54.0	....
60 "	6.0	....	4 "	60.0	10x8-ft. culvert.
70 "	6.6	....	4.5 "	65.0	....
78 "	7.1	36-in. pipe.	5 "	70.0	....
80 "	7.2	....	5.2 "	72.3	10x10-ft. culvert.
90 "	7.8	....	6 "	75.0	....
100 "	8.3	3x3-ft. culvert.	7 "	85.0	....
120 "	9.3	....			

The above table is based on coefficient — 1.

The importance of this standardization of culvert construction can hardly be exaggerated for, by this careful study of the character of the country, it made it possible for the division engineer in the field to decide as to the size and character of all minor openings as they were reached without the necessity of referring them to headquarters, and yet with the assurance that the practice both as to size of opening and character of the construction should be uniform throughout the whole extent of the line. When it is remembered that the road is carried across innumerable small streams, as it cuts across the natural flow, the value of such uniformity is very great.

THE TRACK.

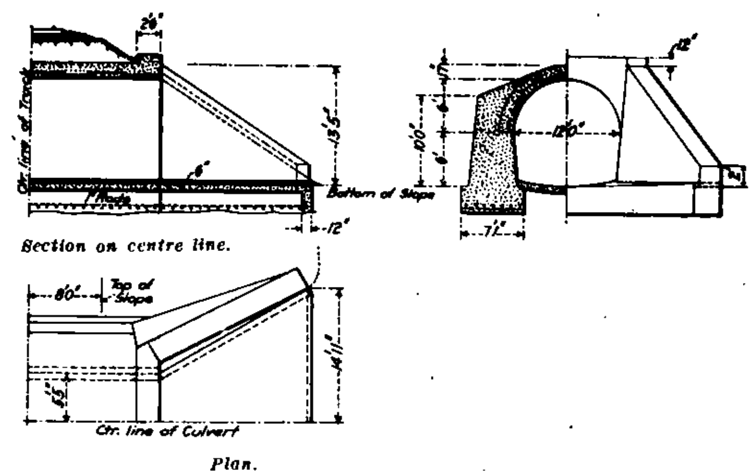
It is seldom, even on old and well established lines, that the degree of excellence in track construction is required that there is in the case of the Tidewater-Deepwater, and it is almost never



Standard Open Drain.

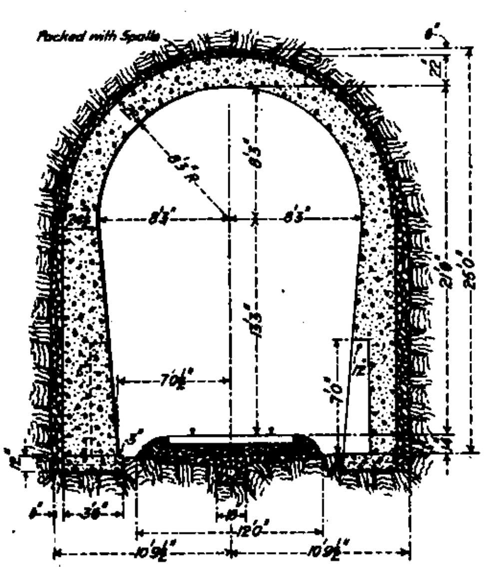
required for a new road through a sparsely settled country where there are no large centers of trade.

To start with, the width of the grade in cuts is 20 ft., and in fills, 16 ft. On fills the slopes come down at the rate of 1 in 1½. In cuts there is a 12-in. ditch beyond the grade slope, from which the bank rises at the rate of 1 in 1. This is common construction, but it is not common for a road to be ballasted with broken stone from end to end even through districts where no stone is to be found. This is being done in this instance. After the track has been laid on the subgrade it is raised about 3 in. and blocked with flat spalls until the ballast can be spread and tamped beneath the ties. When

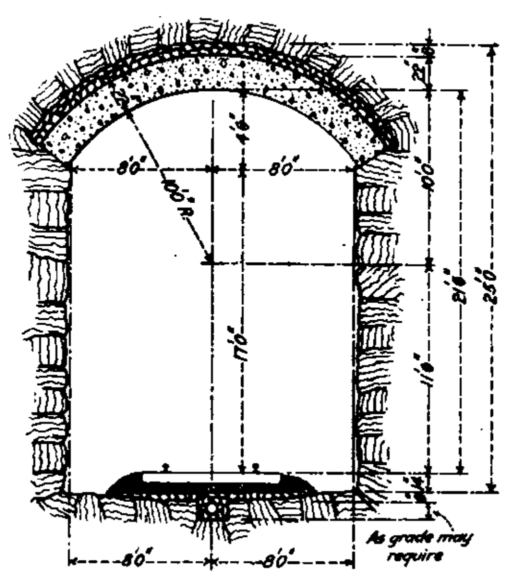


Standard 12 ft. x 12 ft. Arch Culvert.

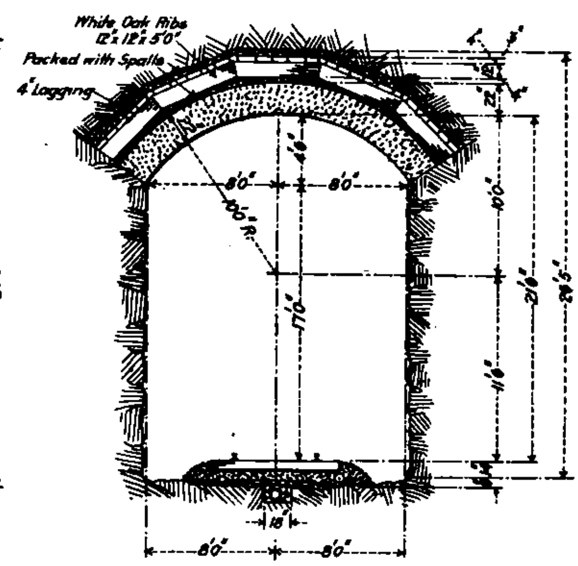
this has been done, the track will be allowed to stand and settle under the traffic of the construction trains until everything has come to a bearing. It will then be jacked up and the ballast tamped beneath the ties until the top surfaces of the latter are 15 in. above the subgrade. The ballast will consist of crushed rock that will pass



Standard Single Track Tunnel.
Firm, but not self-sustaining material.



Standard Single Track Tunnel.
Solid rock, firm sides and roof. Danger of future falls.

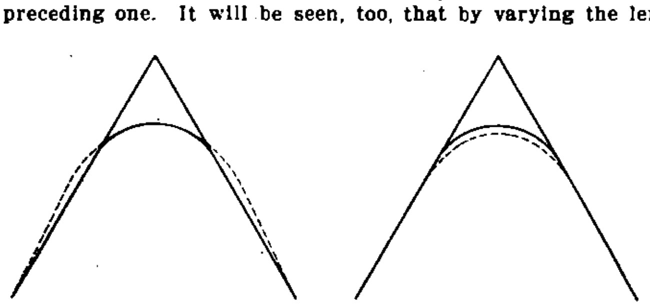


Standard Single Track Tunnel.
Solid rock, yielding roof, firm sides.

through a 2½-in. ring, with all screenings and particles less than ¾ in. in diameter removed.

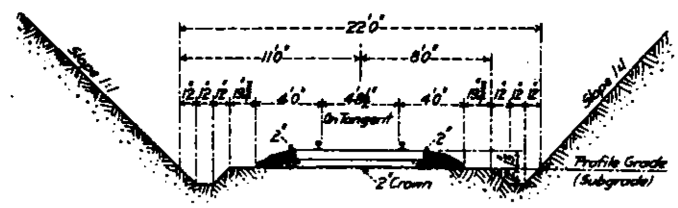
The track will be laid with 85-lb. rail of the A. S. C. E. section on ties of 9-in. face. The latter will be piled in accordance with the standards adopted as shown in the illustrations. The open method will be used for ties to be used by contractors, with the alternate layers removed to facilitate inspection or where the ties are to remain in the pile for more than three months. After the ties have been accepted and distributed they will be piled in crib work, provided they are not to remain in the pile for three months.

The alinement of the track, of course, follows the grade, and this has been laid out with an easement approach at both ends of every curve. These easements form a spiral curve that approaches that of a parabolic arc though the method of laying it out is much simpler. This easement curve has twice the length of the circular arc which it replaces, though the angle subtended remains the same. In laying it out, the spiral curve is divided into as many stations as there are degrees in the curve for which it forms the approach, and each of these stations increases one degree in curvature above the preceding one. It will be seen, too, that by varying the length of the stations the spiral may be made as sharp or as easy as the tangent conditions will allow. For example, if the stations are made 50 ft. long the approach will have but half the angular sharpness that it would have were the stations to be given a length of 25 ft.



Method of Laying Out Curves; Tidewater and Deepwater Railways.

The principal advantage of this method of easement approach lies in the fact that it leaves the tangent in its original position instead of shifting out to meet the spiral when the latter is substituted for the circular arc connecting the two tangents. At the same time the center of the curve is drawn into the angle, as shown by the sketches. In one the easement throws the tangents out but



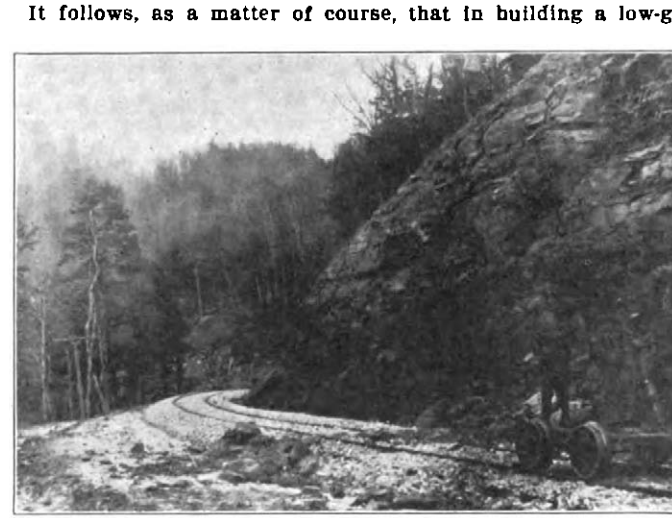
Standard Single Track Roadbed.
Earth excavation.

leaves the center of the original curve unchanged in its position. In the other the tangent remains fixed and the connecting curve is drawn in.

There is a slight difference in the character of the easements on the Deepwater and Tidewater sections of the line, on account of the difference in the character of the country through which they run. On the Deepwater, spiral approaches are used for all curves of 5 deg. or more, while on the Tidewater this rule holds for all curves of 2 deg. or more. Further spirals are used to connect any two adjacent sections of a compound curve where the difference between them is 2 deg. or more, as in the case of a 4-deg. and 6-deg. curve. Finally, wherever there is a break in the grade of more than $^2/_{10}$ per cent. a vertical curve is used to connect the two sections, but where the break is $^2/_{10}$ per cent. or less no vertical curve is used.

TUNNELS.

It follows, as a matter of course, that in building a low-grade



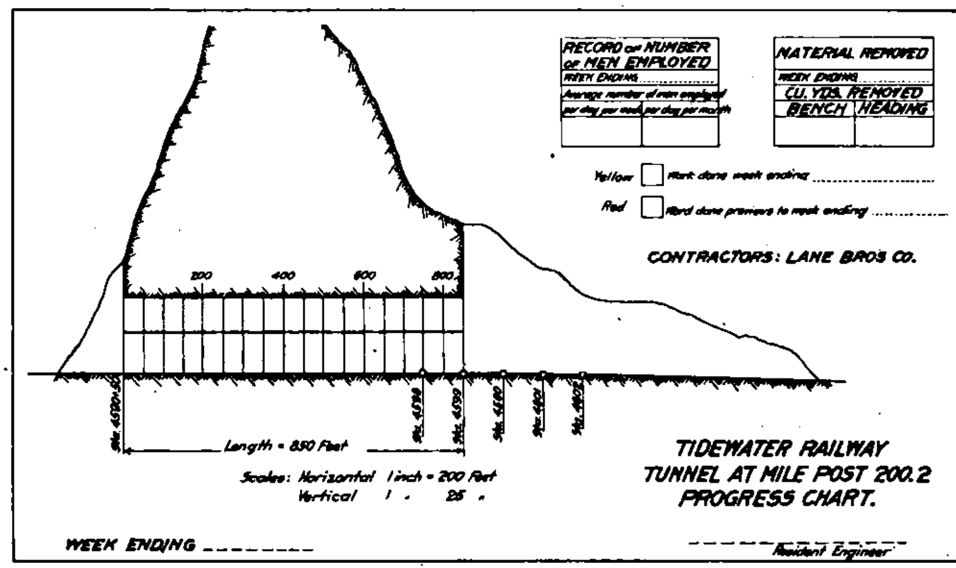
Track and Cut near Elmore, W. Va.; Deepwater Railway.

line through such a country as southern and western Virginia and West Virginia, tunnel work must be frequent. It has been remarked that a low grade air line can be built through any country if you will only stay under ground enough of the time. So while tunnel work has not been courted in the work, it has not been avoided at the expense of grade or alinement. As in the case of other details of the road, the tunnels have been standardized to as great an extent as the nature of the work would allow.

In much of the work west of the Alleghanies the treacherous nature of the rock is such that a facade is required for the entrances and one has been designed and is used wherever it is directed by the chief engineer. It is of concrete and for a single track; slightly oval in section with a diameter of 16 ft. 6 in. at the spring of the arch and 14 ft. 1 in. wide at the subgrade. The top of the parapet is 13 ft. 8 in wide and is backed by a paved ditch that empties into a circular catch basis from which a pipe whose size depends upon the area to be drained leads down to the ditch at the bottom of the tunnel. The catch basis has a depth of 2 ft. and a diameter of 18 in., and is fitted with a perforated cast-iron cover to keep out the coarse material. The ditch itself is paved with cobbles. Finally waterproofing is applied to the crown of the arch as indicated, the concrete used being the standard class B or 1:3:6 mixture, while a 1:2:4 mixture is used for the cap of the parapet.

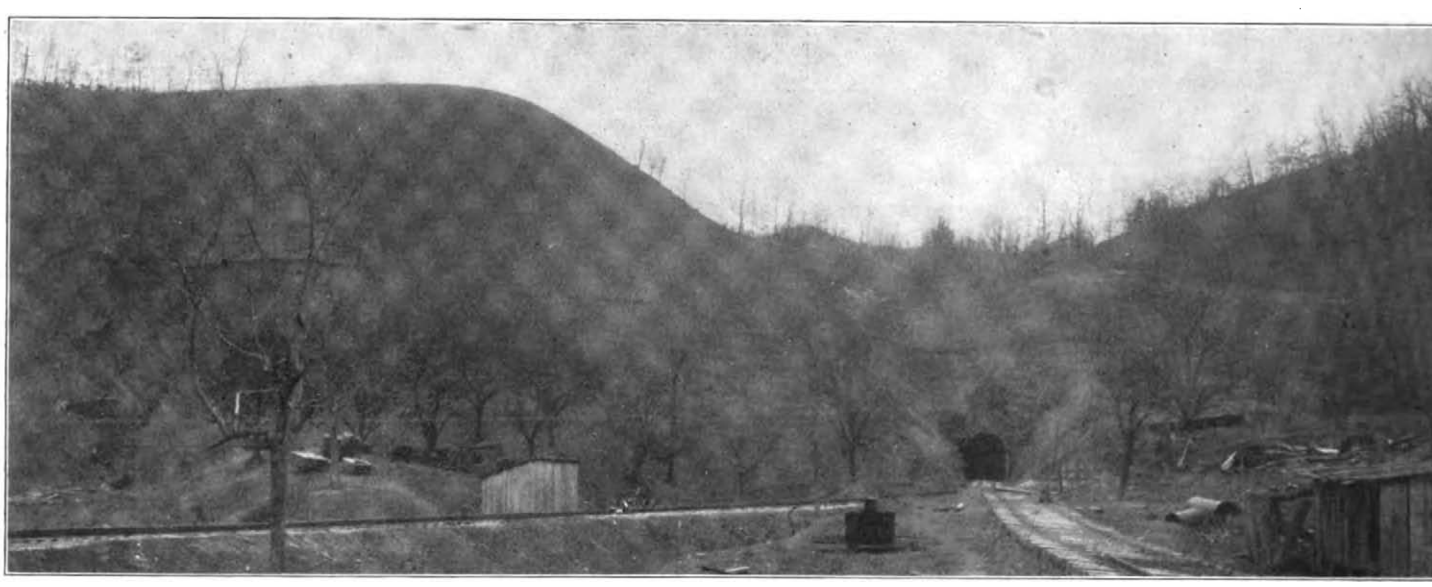
For the tunnel sections themselves, five standards have been adopted, to be used according to the nature of the material through which the excavation is made. These sections are known as types A, B, C, D and E. In all of these the clear height of the crown of the arch above the base of the rail is 21 ft. 6 in. Of these types, A is the simplest. It is applied in rock where there is no danger of cave-ins. It has a semi-circular roof with a radius of 8 ft. with vertical sides 16 ft. apart and is not lined. The bottom beneath the ballast is paved with coarse stones, and there is a pump and drain pipe as with type B. Type A requires about 12.63 cu. yds. of excavation per lineal foot. Type B is also used in rock where the sides are firm, but where there is danger of the roof coming down. In this the sides are vertical, as in class A, up to a height of 17 ft. above the base of the rail, at which point a concrete arch of 4 ft. 6 in. rise and 10 ft. radius is sprung. This arch is of 1:2:4 concrete, of a thickness varying with the character of the cover to be held, but which is made 22 in. as a minimum. The space above the arch and beneath the rock is packed with spalls as a protection against sudden falls upon the concrete itself. On curves the section is widened according to the degree of curvature of the track. The drainage at the bottom is of the same character as that of type A, vitrified pipe with open joints being laid beneath the ballast, as shown in the section. The quantities required for this section are 14.809 cu. yds. of excavation and 1.435 cu. yds. of concrete masonry per lineal foot.

Type C is the section that has been adopted where the sides of the tunnel are firm and the roof yielding. In this the roof is timbered for support and before the concrete arch is laid. The main support is in the 12-in. by 12-in. timbers that are cut to 5 ft. lengths and formed into an arch over which a 4-in. lagging is placed. The space above the timbering, as well as that between it and the concrete, is packed with spalls. In other respects this section corresponds to the type B both in the quality of the concrete and the general dimensions used. Owing to the space occupied by the timbering the amount of excavation is greater than in type B, it being 16,233 cu. yds. per lineal foot. The concrete remains the same at 1.435 cu. yds. and to this must be added 171 ft. of timber, board measure, based on a rib spacing of 5 ft. centers, a spacing that is varied with the nature of the cover.

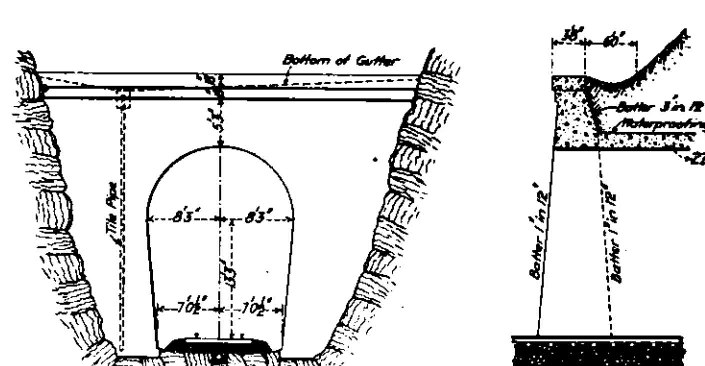


Progress Chart; Tidewater Railway.

The D section is one lined with concrete and is used in materials that are firm but not self-sustaining. The cross section of the opening is identical with that of the concrete portal, and the method of draining is the same as that of the other tunnel sections. The concrete used is poorer in cement than that used for the arches



Jenney's Gap Tunnel; Deepwater Railway.



Facade. Standard Single Track Tunnel.

of types B and C, it being a 1:3:6 mixture. The thicknesses of the lining, as given in the engraving, are the minimum dimensions that are allowable, and these are increased as occasion may demand. In this section refuge niches 3 ft. wide with circular tops are provided every 200 ft. on each side and staggered so as to provide a refuge at half that interval throughout the whole length of the tunnel. Weep holes are also provided, leading from the sides to cross drains, as local conditions may require. The space between the concrete and the material on all sides is packed with a layer of 6 in. of spalls. In this section the excavation exceeds that of any

Ingleside Tunnel; Tidewater Railway.

of the others, it being 18.537 yds. per lineal foot, with 1.955 cu. yds. of concrete masonry in the arch and 3.085 cu. yds. in the side walls.

The E section is used in yielding material, and is a timbered tunnel lined with concrete; the dimensions of the latter corresponding with those of the D section, though a richer or 1:2:4 mixture is used. The timbering is of the same character as that used in the C section, except that it is carried down the sides instead of being confined to the roof. This section requires 21.82 cu. yds of excavation and 489 ft. board measure of timbering per lineal foot. The masonry for the same distance consists of 1.955 cu. yds. in the arch and 4.323 cu. yds. in the side walls.

In driving these tunnels various methods have been employed in the detail of the work. Sometimes it has been from shafts

Portal of Tunnel at Mile Post 58; Deepwater Railway.

sunk from above with a heading driven in each direction, though usually the work has been by approach from the two ends. In a number of cases elaborate preparations had to be made in the way of building roads, sometimes laying rails on them for the transportation of material and supplies, and in many instances this also involved the erection of expensive compressor plants to supply air to the drills.

A very complete system of progress charts was also provided by which the condition of the work could be exactly determined at any time. This was quite essential to a proper supervision from headquarters since, in the distance between mileposts 103 and 362, there are twenty tunnels with a total length of 18,786.3 ft., the longest being the one at the summit crossing the Alleghany mountains, with a length of 5,139 ft., and the shortest at milepost 291, which is but 450 ft. long. The system by which the reports of progress were kept consisted of a blueprint upon which there was a longitudinal section of the tunnel divided vertically by lines 50 ft. apart on the scale and by a horizontal line to separate the bench from the heading. Two sets of these prints were provided, one for the week ending and one for the month. These were colored red and yellow, as directed, and sent to the office of the chief engineer at the end of each week and month by the resident engineer, with the other data called for. In this way a complete record was obtained of the number of men employed and the material removed as called for on the blank. The two blanks are identical in every particular, except that one is for the month and the other for the week.

It is this portion of the work that will probably fix the time for the opening of the road, and the tunnel that will be the last to be completed will undoubtedly be that at the summit of the Alleghanies, and this is now being pushed as rapidly as possible.

The prosecution of this work may be taken as a sample of that done elsewhere, though it is on a larger scale than is ordinarily required. The contractors have installed a very complete power plant near the opening of the shaft that is about midway between the two portals, besides having built a standard gage railroad from a connection with a local mining road up to the power-house. In this way a direct connection is made with the Norfolk & Western and all supplies are brought in over the line, which is about 2½ miles long. Four headings are being driven, and the advance is at the rate of about 380 ft. per month, through rock.

Norfolk & Western Improvement Work.

BY GEORGE L. FOWLER,
Associate Editor of the *Railroad Gazette*.

GENERAL FEATURES AND IMPROVEMENTS.

In the issues of the *Railroad Gazette* for July 3, July 24, September 25, and October 2, 1903, there was published a series of articles relating to the physical and operating conditions of the Norfolk & Western Railway as they existed at that time. The coal traffic from the Pocahontas and Thacker districts was increasing rapidly and the company found that unless the facilities for handling this traffic were at once increased there would be a congestion which it would be impossible to relieve. Already conditions of this sort had been encountered on the westbound work, which had been relieved by building the Big Sandy line from Naugatuck to Kenova, by which a low-grade track for westbound traffic had been obtained and the distance shortened by about 24 miles. This had not, however, afforded any relief at division points where the yards were too small for the demands made upon them, to say nothing of the requirements of the future. Accordingly, at the time of the publication of the articles referred to the company had planned an elaborate range of improvements in the form of yards at Roanoke, Va.; Bluefield and Williamson, W. Va., and Portsmouth, Ohio, in addition to a straightening of the exceedingly crooked portion of the line lying in the midst of the West Virginia mountains between Vivian and Naugatuck. A considerable proportion of this work has now been completed. But, while none of the yards is entirely finished, the work has been executed to such an extent in all of them that they are in operation, and a great deal of the double-tracking on the mountain portions of the line has been finished or is under contract. Not only has this been done, but much additional work made necessary by increase in traffic has been planned and partially contracted for in double-tracking the main line on improved alinement and grades. The principal part of these additions are to be found in the reconstruction and double tracking of the line on the Norfolk division between Montvale and Forest, a distance of 27 miles, and the construction of a low-grade line on high ground around the city of Lynchburg from Forest to Concord, a distance of about 21 miles, while the distance between these points by the present line is about 23½ miles.

In order to appreciate the true significance of these improvements and why these new alinements were not used in the first place, a few words regarding the general topography of the country