Power is received by four substations from the Adirondack Electric Power Corporation at 60,000 volts. Each substation contains two synchronous converters of 300-kw. capacity, each with reserve space for an additional unit.

The rolling stock equipment includes 19 four-motor multiple unit cars, which are operated either singly or in trains as the traffic requires.

It is interesting to note that with the third-rail construction used this line has never been seriously handicapped by snow. Interruptions to the service from all causes have been practically negligible and the traffic of the system has shown a steady growth.

West Jersey & Seashore R. R.—One of the earlier railroads to take advantage of electrification as a means of increasing facilities for handling passenger traffic was the West Jersey & Sea Shore Division of the Pennsylvania System, extending from Camden to Atlantic City, a distance of 65 miles, and a branch from Newfield to Millville, a distance of 10 miles. The contract for the entire equipment of this railroad, including installation and the equipment, was placed in service in a little over five months, which is a remarkable record considering the fact that included in this work were the erection of a power station, eight substations and the electrical equipment of over 150 miles of single track, the building of 71 miles of high-tension transmission in duplicate and the equipment of 68 multiple unit cars. The line from Camden to Atlantic City is double-tracked throughout and at points there are three tracks. With the exception of a short stretch of track near Camden, the entire road is equipped with an overrunning third rail operating at 600 volts and taking power from the synchronous converter substations. Multiple unit equipment is operated in trains of from 3 to 10 cars without trailers. The express service between terminals operates on a headway of 15 minutes in each direction at speeds up to 60 miles per hour. Frequent local service is also provided for Camden suburbs and on the branch line to Millville.

Electricity is generated in a steam turbine station at Westville, generating 6,600 volts, 3-phase, which is stepped down and delivered from the synchronous converters at 650 volts to the third rail.

The power station equipment consists of three 2,000-kw. Curtis turbo-generators with the necessary auxiliary units. Each of the substations is equipped with two 750-kw. synchronous converters with space for an additional unit.

The present rolling stock equipment consists of 109 motor cars, some of which are constructed from combination baggage and smoking cars, and others for mail cars. Each is equipped with two 200-h.p. motors and Type "M" automatic control. The standard passenger cars have a weight of about 45 tons and a seating capacity of 58 persons.

The operation of this electrified steam road has been most satisfactory in every way. The number of delays charageable to electrical equipment has been less than 6 per cent of the total number of train minutes' detention, and the increase in traffic gained by the use of multiple unit cars instead of steam trains has enabled the railroad to make a remarkable increase in the number of passengers carried, on account of the local service furnished to the smaller towns and the high-speed express service between terminals.

Great Northern Ry.—Cascade Tunnel Electrification.—One of the most unique electrifications in the country and the only road to use 3-phase equipment is the Cascade Tunnel on the Great Northern Ry. near the summit of the Cascade Mountains, in the State of Washington. This tunnel is 14,000 ft. (2.65 miles) in length and has a uniform grade of 1.7 per cent. In the yards at each end of the tunnel are grades of 2.2 per cent, on which all trains must be started.

Under steam operation this tunnel had become the limiting feature of the road. Heavy freight trains, requiring from two to four of the heaviest locomotives, could not operate trains faster than from 7 to 8 miles per hour. In the tunnel operation was still more difficult. The smoke and steam coated the rails with damp, greasy soot causing the wheels to slip and the smoke and gases made operation positively dangerous to train crews.

The electrification involved about 4 miles of route with 6 miles of single track, including sidings. Power is generated in a 5,000-kw. hydro-electric plant at Leavenworth, transmitting 3-phase, 25-cycle current at 33,000 volts a distance of about 30 miles. The contact system consists of double trolley construction carrying 3-phase, 6,600 volts A. C., using the rail and ground return for the third conductor. These overhead wires are spaced about 8 ft. apart in the tunnel and 5 ft. apart in the yards. Ordinary pole trolleys are used for collecting the current.

There are four electric locomotives weighing 115 tons each, all of which is on the driving axles. Three-phase induction motors are connected by twin gears to each axle and the trucks are adequately equalized to take care of twisting strains. These motors are of the 3-phase induction type wound for a primary voltage of 500, the rotors being equipped with wound secondaries brought out through collector rings. There are 13 steps in the resistance used in connection with the rotor, allowing for ample speed control. The average freight train hauled weighs approximately 2,000 tons, including both steam and electric locomotives. On down grades the induction motors automatically return power to the system when the train exceeds the normal speed of about 15.5 miles per hour.

The Great Northern has the distinction of being the first railroad electrification in this country to use regenerative braking, this feature having been in very successful operation for more than six years. The Norfolk & Western Ry. has recently begun operation, using the same principle, and the Chicago, Milwaukee & St. Paul Ry. has adopted direct current regeneration.

This installation was made in July, 1909, and since that time all traffic through the tunnel has been handled by the electric locomotives, with the exception of delays due to avalanches and snow slides, some of which have interrupted traffic for several days at a time.

On March 1, 1910, an avalanche came down the mountain through the yards near the tunnel carrying all the coaches of two trains with two steam and three electric locomotives down into the bottom of the canyon, from 200 to 400 ft. away.

The electric locomotives were untouched for about three weeks during the task of clearing the line. They were then taken to the railway company's shops and put in operating condition. It is worthy of note that the average cost of repairs, including labor and materials on the three electric locomotives, was $962 each, while the expense of similar repairs on the two steam engines was $1,284 each.

St. Clair Tunnel Electrification.—The Grand Trunk Ry. in May, 1908, replaced four steam locomotives of 100 tons with six 66-ton electric units, which, as a rule, are used in sets of two. During the period that these electric units have been in service no failure has yet occurred in the main motors, and they have been available for service throughout 90 per cent of the time. The average annual cost for the maintenance of the four steam locomotives was $21,173, while that for the six electrical locomotives has been $11,131. The average cost per car handled through the tunnel, a distance of approximately five miles, by steam locomotives was 26.6 ct., as against 17.2 ct., by electrical locomotive, although the capacity of cars handled today is much greater than the capacity of those of 1907 and 1908. The cost of fuel for the steam locomotives was $42,000 per year, whereas the average cost of fuel consumed for generating energy for the electric locomotives is $17,000 per year. This difference in cost is partly due to the fact that slack coal is now used, whereas hard coal was used for the steam locomotives. Power is supplied from one plant containing two 1,500-h.p. turbo-generator sets, and stokers of boilers are so controlled that their operation is practically controlled

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automatically from the operation of locomotives on the main line.

Detroit River Tunnel Electrification.—One of the most successful electrifications of a trunk line steam railroad is the section of the New York Central system now operating under the Detroit River. The 2-track tunnel connecting the lines of the Michigan Central R. R. terminating at Windsor, Ontario, and those in the United States, terminating at Detroit, was completed in 1910, and since that time all trains have been hauled by electric locomotives through the tunnel instead of being ferried across the river. Under the old method it required about 30 minutes to make the crossing and the facilities were very limited. With the tunnel, however, trains pass through in less than six minutes, and the capacity of the tracks is limited only by the length of train which can be handled. The general scheme of electrification includes the purchase of 3-phase, 60-cycle energy at 4,400 volts from the Detroit Edison Co. and transformation in the company's substation to 650 volts direct current. At this voltage current is fed to the locomotives through an underrunning protected third rail reaching all of the electrified tracks.

The substation is located near the Detroit end of the tunnel and contains two 1,000-kw. synchronous motor generator sets with auxiliary equipment for excitation and for controlling a 312-cell storage battery (capacity 630 amperes, for 8 hours, and momentary discharges up to 11,000 amperes). The control equipment is so arranged as to reduce the peak loads and thus obtain a practically constant load at unity power factor.

The original equipment consisted of six electric locomotives designed for hauling both freight and passenger cars through the tunnel and also for switching service in the yards. Each is equipped with four railway motors and weighs 200,000 lb., all of which is on driving axles. The service consists of hauling an 1,800-ton trailing train from one yard to the other, negotiating a 2 per cent grade when two locomotives are operated multiple unit. The second order of locomotives placed in service in 1914 consisted of four similar units, each weighing 240,000 lb. The total electrified trackage now in operation is approximately 24 miles, including yards on both sides of the river and the two-track tunnel.

Norfolk & Western Ry.—The electrification of 30 miles of this road was the solution of the problem to double the capacity of a hilly section with a tunnel. The limit in capacity by the use of the heaviest steam power had been reached, and continual delays were being met with through the severe starting difficulties on grades. The latter condition arose partially through necessary stops for coal or water. Twelve electric locomotives have displaced 33 Mallet locomotives, and have increased the average speed up the ruling 2.4 per cent grade from 6 to 14 miles per hour. The principle of braking by regenerating power has proved a complete success on this railway. The fact that the speed on down grades is constant and inflexible prevents the possibility of surges in the train which would result in broken drawbars. The main electrical feature in this electrification was the application of the polyphase induction type of motor to locomotive axles and the use of a converter on each locomotive so as to permit operation by single phase alternating current, and thus permit of the advantages of a single trolley wire. Trains are operated with one locomotive hauling and a pusher on the heavier grades. The method of starting is for engineer on the head locomotive to release brakes and let the slack run back. As soon as the engineer on the pusher feels the resulting blow, he applies power and holds the train till the front man gets under way. This method is due to the two men not being able to signal due to curves and train length and works out very satisfactorily.

Suburban Lines of the Southern Pacific Co.—Oakland, Alameda & Berkeley Divisions.—The suburban lines of the Southern Pacific Railroad Co., in the immediate vicinity of San Francisco, were changed over from steam to electric operation in 1911. The electrified district includes what is known as the Oakland, Alameda & Berkeley Divisions, which carry the heavy suburban traffic from the ferries to the residential districts.

Power is generated for this system in an oil burning steam station located at Fruitvale, the generating units consisting of two 5,500-kw. turbo-generator sets delivering 3-phase, 25-cycles. Power is transmitted at 13,200 volts to two outlying substations, the third being located in the power house. Each of the substations is equipped with two unit synchronous converter sets operating two in series for 1,200 volts. Each of these sets is of 1,500-kw. capacity, there being in all 10 double units in the three substations.

The rolling stock equipment consists of 81 all-steel multiple unit cars, each equipped with four 145-h.p. 600/1,200-volt motors. Trains of from 2 to 12 cars, made up of motor cars and trailers, are operated, depending upon the demands of the traffic.

The contact system on the Southern Pacific lines is of a flexible type built for the use of pantograph trolleys.

Pennsylvania R. R.—In addition to the direct third rail electrification of its New York entrance, this railway has recently electrified suburban lines operating out of the Philadelphia Broad Street Station. This station when completed, in 1881, contained 8 tracks and handled 160 trains each day, with 18 trains in the rush hour. In 1910 tracks had been increased to 16 and trains to 574, with 53 in the rush hour. Electrification has given relief by reducing the train movements, averaging from 4 to 15 down to 2. This was achieved by the use of 93 motor cars. Up to the present, trains of these cars are only running on one division, but this will shortly be increased. It is found, due to the higher rate of acceleration possible, that these trains can be more quickly dispatched, this permitting reducing running time considerably. Each car has two 225-h.p. motors and an 8-car train is found to draw 6,800 h.p. when accelerating. The fluctuations in power demand for present service varies from 27,000 h.p. to zero, averaging 8,000 h.p. per hour during the rush period. The power demand in this service is, therefore, not only considerable, but very fluctuating. Power service is purchased from the Philadelphia Electric Co.

Butte, Anaconda & Pacific R. R.—The Butte, Anaconda & Pacific Ry., which began electrical operation in 1913, is in many ways one of the most remarkable examples of electric train haulage in this country. While previous examples of steam road electrification have been equipped for various reasons, either tunnel and terminal operation or for high-speed suburban service, this road was electrified purely for reasons of economy. The results of this changeover have amply justified the initial cost of the electrification, a comparison of operating results during the first six months of electrification showing a saving of an amount equal to 20 per cent of the initial cost, not allowing any salvage for steam engines released.

The electrified tracks of this company consist of 30 miles of route between the mines at Butte and the smelters at Anaconda and about 114 miles on a single-track basis. Power is purchased from the Montana Power Co.'s extensive system at 2,300 volts, 60 cycles, and is transformed by motor generator sets to 2,400 volts direct current for use on the trolley. There are two substations, one located at Butte and the other at Anaconda, both of these being installed in the existing transformer stations of the power company. The initial rolling stock included 15 freight and two passenger locomotives, and eight additional locomotives have since been purchased to take care of the heavy increase in traffic.

The freight traffic consists largely of transfer of copper ore, and at present amounts to more than 6,000,000 tons per year. This material is handled in steel ore cars, having a capacity of about 50 tons each. The weight of train hauled over the main line, including a 3 per cent grade, frequently reaches 5,000 tons trailing.

Eight passenger trains per day are operated between Butte and Anaconda, each consisting of from three to five passenger and baggage cars.

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The overhead construction on this system is made especially flexible by the use of loop hangers which allow the contact wire to rise without lifting the weight of the messenger. There also may be other novel features in the switching yards and at street railway crossings.

The eminently successful operation of this initial 2,400-volt railway was largely influential in the decision of the Chicago, Milwaukee & St. Paul Ry. to electrify its mountain divisions at 3,000 volts direct current.

Chicago, Milwaukee & St. Paul Ry. Transcontinental Electrification.—The Chicago, Milwaukee & St. Paul electrification differs from all previous projects of this kind in that the transcontinental lines involved embrace four complete engine divisions as operated by steam locomotives. None of the existing electrifications on trunk line railways, either in this country or in Europe, have included more than one engine division. For this reason there has been no opportunity for interchange of spare locomotives and no possibility of materially reducing the number of spare steam locomotives required for the operation of the system.

The Missoula and Rocky Mountain Divisions of the Chicago, Milwaukee & St. Paul Ry. include 440 miles of route, embracing approximately 650 miles of single track lying between Harlowton, Montana, on the east, and Avery, Idaho, on the west. This road is one of the main transcontinental highways of the country and the divisions being electrified contain the most serious grades encountered on the Chicago, Milwaukee & St. Paul Ry. between Chicago and the coast. Under steam operation these four divisions required 103 steam locomotives of the heaviest types, and even with this number of engines the schedule was maintained with difficulty. In the winter when temperatures range as low as 40 to 50° below zero, it is extremely difficult to keep steam locomotives in operation. It is no uncommon occurrence to find several locomotives stalled during cold weather, with fires drawn and water removed from the boiler, owing to the freezing of some of the piping which is exposed to the weather. Furthermore, it has been found that after hauling a train over a 112-mile division for about three days in succession it is necessary to put the locomotive into the shops for a day's overhauling.

The electrical equipment for this electrification includes 42 main line passenger and freight locomotives and two switchers, and experience with electrical locomotives on the first two divisions seems to indicate that these locomotives will be amply sufficient to take care of the present traffic and normal increase within the next few years. In addition, it is probable that trains will be operated much more nearly on schedule time and with less damage to equipment owing to accidents. In the operation of the first division it has been found that one electric is capable of easily replacing three steam engines, and possibly four, when other divisions are put in operation. The reasons for the much greater capacity of the electric locomotives per unit are: first, ability to operate a large per cent of the 24 hours with minor inspections; and, second, ability to haul equivalent trains at approximately double the speed of the steam locomotives. Many other advantages may be mentioned which tend to increase the capability of the electric locomotive as compared with the steam. Not the least of these is the regenerative braking feature which relieves the brakes of a large portion of the wear and heating due to holding heavy trains on severe grades.

The 440 miles of route involved in this electrification will be fed from 14 substations located at points averaging 33 miles apart, each station receiving power from the Montana Power Co.'s system at 100,000 volts and transforming to 2,300 volts for synchronous motor generator sets. These sets are of the three-unit type, consisting of a synchronous motor and two 1,500-volt direct current generators connected permanently in series to deliver 3,000 volts to the trolley. Each station contains either two or three of these sets, there being a total of 32 sets in the 14 substations. Two small generators, one on each end of the set, furnish exciting current for the main fields of the generators and for the revolving field of the motor. The substation equipment is so arranged that in case the regenerated power sent back by the locomotives exceeds that being used nearby, the motor generator sets will operate inverted and thus return excess energy to the transmission system and thence to other substations requiring power. Measuring instruments are arranged to credit the amount of this returned energy to the railway company. Each of the substations is in charge of three operators working on 8-hour shifts, and these men are at all times under the direction of the train and power dispatcher, who gives instructions for the operation of the station. Two model bungalows have been built by the railway company at each station for housing the operators.

As above mentioned, electric power is received at 100,000 volts, 60 cycles, from the transmission network of the Montana Power Co., operating numerous hydro-electric plants in various parts of the state. The largest of these stations are located at Great Falls and at Thompson's Falls. In order to insure power supply at all times there are several feeding-in points, and the railway company maintains a separate 100,000-volt transmission line the entire length of the electrification.

One of the most completely equipped hydro-electric plants on this system is the Volta plant, in the Great Falls of the Missouri River. This station at present contains four 10,000-kw. vertical generators and two additional units are being installed. The available head at this point in the Missouri River is 155 ft., and the supply of water at all times is ample.

The main line locomotives, a number of which are now in service, have a total weight of 282 tons with 224 tons on the driving axles. The cab consists of two similar sections extending practically the full length of the locomotive. The freight and passenger locomotives are similar in all respects, except that passenger locomotives are provided with a gear ratio permitting the operation of 800-ton trailing trains at approximately 60 miles per hour, and are furthermore equipped with oil-fired steam boilers for heating the trailing cars. Each locomotive carries eight 430-h.p. motors, each geared to a driving axle with twin gears. These motors are designed to operate at 1,500 volts per commutator, two motors being permanently connected in series across the 3,000-volt circuit. The tractive effort available for starting trains is approximately 135,000 lb. at 30 per cent co-efficient of adhesion, and the continuous tractive effort of the freight locomotives is 71,000 lb. In addition to the eight driving axles, each half of the locomotive carries a two-axle guiding truck which supports approximately 30 tons weight. The motors are ventilated by a forced draft from a blower, which is driven from the control motor generator set located in the cab of the locomotive.

The control equipment is the well-known type arranged for multiple unit operation. This allows two locomotives to be operated from a single controller. The main control switches are located in steel compartments inside of the cab, convenient for inspection and repairs. Current for operating contractors, lights and other auxiliary apparatus is taken from a 3,000/125-volt motor generator set, one of which is located in each half of the locomotive. Compressed air for the air brakes, whistles, pantograph trolleys and other auxiliaries is supplied by a 3,000-volt, two-stage air compressor having a piston displacement of 150 cu. ft. of free air per minute against a pressure of 135 lb. Current is collected from two pantographs, one located at each end of the locomotive.

One of the most distinctive features of this electrification is the regenerative braking on the locomotives, which permits the return of energy to the system on descending grades instead of checking the speed of the train by means of the air brakes. The amount of braking is directly under the control of the engineer, and the air brakes are relieved of practically all service except when bringing the train to a final stop. It should be understood that when braking a train by the regenerative method, there is no overheating as is the case

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with air brakes, and consequently there is a material reduction in the wear on brake shoes, tires and rails. In addition to this the air brakes will always be in good condition when required for emergency service and delays due to excessive wear will be greatly reduced. In actual practice it has been found that a large portion of the power regenerated by trains on descending grades is used up by other trains taking power on the level or ascending grades. In some cases when there is no train available for absorbing the excess energy the power is taken up by one or more substations and returned to the transmission system connecting the several substations.

The overhead construction consists of two 4/0 trolley wires flexibly suspended from a steel catenary supported on wooden poles. Bracket construction is used wherever the track alignment will permit and cross span on the sharper curves and in the switching yards. The two wires are suspended side by side from the same catenary by independent loop hangers alternately connected to each trolley wire. This type of construction permits the collection of very heavy currents by reason of the twin contact on the pantograph with the two trolley wires, and also insures sparkless collection under the extremes of either heavy current at low speed or more moderate current at high speeds. A 500,000 c.m. feeder parallels the track for about 80 per cent of the 440 miles, being used on all grades up to and including 1 per cent. On heavier grades a 1,000,000 c.m. feeder is used. A 4/0 negative feeder or ground wire is carried on top of the poles.

During the early part of December, 1915, an interesting comparative exhibition was staged by the Chicago, Milwaukee & St. Paul Ry. for the purpose of showing prominent officials the comparative capabilities of steam and electric locomotives. The observation party was stationed at Janney Substation, on the western slope of the Rocky Mountains and about midway on the 1.66 per cent ascending grade. The first train sent up the hill was hauled by one of the 282-ton electric locomotives, assisted by a similar unit acting as a pusher. The train consisted of 48 cars weighing approximately 3,000 tons trailing and negotiated the grade very easily at about 16 miles per hour. Following this was a second train hauled by two Mikado type steam locomotives and one Mallet steam pusher. The steam train consisted of 37 cars weighing about 2,200 tons and difficulty was encountered in making the grade at a speed of from 9 to 10 miles per hour. Upon completion of the test, President Earling indicated his entire approval of the electrical equipment and gave instructions for putting it into regular service immediately.

Time Required for Transit Through Panama Canal.—The following tabulation from the Panama Canal Record shows the time required by the 158 transits through the canal in October. It will be noted that 89 of the ships, or more than half, were in the canal between 9 and 12 hours. The percentage requiring over 12 hours was 30.7, and the proportion passing through in less than 9 hours was 15 per cent. Detailed classification follows:

Time	Atlantic to Pacific	Pacific to Atlantic	Total	Per cent
Under 7 hours	..	..	..	....
7 to 8 hours	3	3	6	3.7
8 to 9 hours	9	9	18	11.3
9 to 10 hours	9	9	18	11.3
10 to 11 hours	13	9	22	13.9
11 to 12 hours	21	25	46	29.1
12 to 13 hours	8	13	21	13.2
13 to 14 hours	7	8	15	9.5
14 to 15 hours	1	4	5	3.6
15 to 16 hours	..	1	1	.7
Over 16 hours	3	3	6	3.7
Total	74	84	158	100.0

The aggregate time of all the vessels was 76 days, 19 hours, 33 minutes, giving an average time for all the vessels of 11 hours and 40 minutes. The minimum time was 7 hours, 17 minutes. The maximum time was 1 day, 8 hours, 10 minutes.

METHOD AND COST OF STRIPPING IN THE ANTHRACITE COAL REGION OF PENNSYLVANIA.*

The equipment required for a one-shovel operation is about as follows:

1 70-ton shovel.	1 steam drill.
3 18-ton locomotives.	1 water tank.
20 5-yd. dump cars.	1 boiler.
1 star drill.	1 blacksmith shop.

Necessary rails, sills, pipe lines, tools, etc.

The total capital outlay for such an outfit is approximately $30,000.

The average force required to operate a one-shovel stripping consists of about 35 men, roughly as follows:

1 foreman.	4 jackmen.	2 drillers, 8 helpers.
1 shovel engineer.	3 locomotive engineers.	1 boiler fireman.
1 craneman.	1 dump boss.	1 blacksmith & helper.
1 fireman.	6 dumpmen.	2 coal diggers.
1 watchman.	1 track boss.	1 driver.
2 laborers.	2 trackmen.	1 switchboy.

The wages paid these men amount to $2,100 per month. The shovel engineer is paid $140 a month, the craneman $95; locomotive engineers $0.25 per hour. These rates are all subject, however, to the recent increases granted the mine workers, ranging from 7 to 15 per cent.

When a stripping is decided on and its limits staked out by the engineers, an inspection of the ground determines the method of opening it. Usually the cuts at the higher elevations are made first. After that the problem is almost entirely a transportation one. Steady operation of the shovel or shovels is the object to be secured.

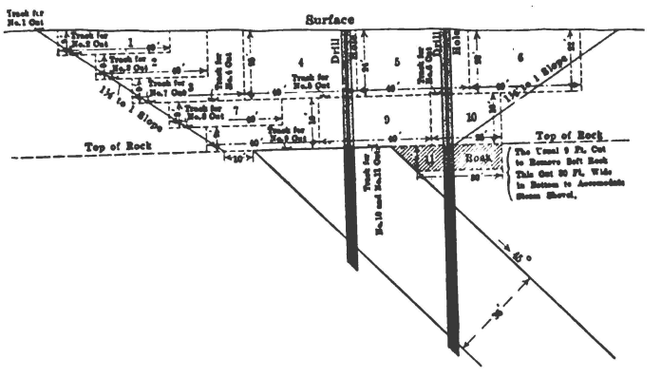


Fig. 1—Method of Opening a Stripping.

Everything must contribute to this end—tracks and rolling stock must be in good condition, turnouts must be maintained, and the grades must be as easy as the nature of the ground will permit. If in rock, drilling and blasting must be kept well in advance.

The method of opening a stripping with either a Bucyrus 70-ton shovel or a Marion 60-ton shovel, which are the two types most widely used in anthracite stripping work, is as follows (Fig. 1): For the first cut the track is laid on the surface along one limit of the stripping, usually the bottom rock side, and the shovel cuts down grade alongside the track until a depth of 9 ft. is reached, this being the maximum cut that the shovel can take and load overhead. When the first cut is completed for the length of the stripping, the track is laid in this cut and the shovel again cuts down grade until a depth of 9 ft. below the first cut is reached. The shovel then continues cutting toward the other limit, the additional depth being determined by the depth of surface over the vein up to 30 ft., which is considered the proper maximum height for a clay cut. In working by the above method, it is necessary to leave a bench at least 13 ft. in width for the laying of the track. Local conditions, as a rule, render it impossible to maintain any such plan for the entire life of a stripping.

The first cut as described above is always the first made in a stripping except in the case of what is known as a side-hill stripping. Here the track is laid on the surface and the shovel started at an elevation that will give the required cut at the vertical limit.

Rock cuts are usually made from 22 to 25 ft. in height,

*From a paper by J. B. Warriner, Lansford, Pa., Chief Engineer of the Lehigh Coal & Navigation Co., prepared for presentation at the February meeting of the American Institute of Mining Engineers and printed in the January Bulletin of the Institute.

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