THE DEVELOPMENT AND OPERATION
OF
A STRIP COAL MINE
USING
MODERN METHODS

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By
HENRY C. WIDMER.
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PREFACE

Coal mining has been carried on in Cherokee and Crawford Counties, Kansas for nearly seventy years. The coal mined in this area up until twenty years ago had been carried on by deep shaft mining. Since the year 1910, strip mining has largely supplanted the deep shaft method of mining coal, principally because the coal can be mined cheaper and because all of the coal can be recovered, while approximately only sixty percent of the coal mined in a deep shaft mine is recovered. Strip mining consists of moving the earth or overburden from the coal by means of a large shovel and then recovering the coal by other mining methods. Various methods and types of equipment have been used in strip mining during the last two decades. Equipment and methods of the old strip mines are rapidly being supplanted by newer, more modern equipment and more up to date methods. Strip mining has become an extremely scientific business, each problem entering into the development, operation and sales department of the coal mine now being handled by scientific business methods. The strip mine industry also has its engineering problems, every modern strip coal mine now being developed and operated using the most modern of engineering methods. The purpose of this paper is to show the development and operation of a coal mine using modern stripping methods.
The Pittsburg & Midway Coal Mining Company of Pittsburg, Kansas, one of the oldest coal mining companies in this mining district and one of the coal companies that operate their mines by using every modern and scientific method known, acquired during the last few years, approximately twenty-seven hundred acres of coal land near the town of Mineral, Kansas. This land was purchased from the Missouri-Kansas-Texas Railroad Company, who had previously been mining the coal by deep shaft methods.

This land lies east, northeast and south of the town of Mineral and is very good farm land. The land has been farmed every year, wheat being raised chiefly, although some corn has been grown and there is also some good pasture land in the area. The area consists of gentle rolling land draining into Cherry Creek on the east and southeast. (See Map No. E-2-12). The area owned by The Pittsburg & Midway Coal Mining Company embraces all of the area of land within the heavy boundary lines on the map, this area embracing all of Section 4 and 8, all of Section 5, except the SW\(\frac{1}{4}\) of the SW\(\frac{1}{4}\), the NE\(\frac{1}{4}\) of Section 7, all of Section 9, except the NE\(\frac{1}{4}\) of the SW\(\frac{1}{4}\) and the S\(\frac{1}{2}\) of the SW\(\frac{1}{4}\) and the W\(\frac{1}{2}\) of the SW\(\frac{1}{4}\) of the SE\(\frac{1}{4}\), the NE\(\frac{1}{4}\) of the NE\(\frac{1}{4}\) of Section 16, the NW\(\frac{1}{4}\) of Section 17 and the S\(\frac{1}{2}\) of the NE\(\frac{1}{4}\) of Section 18, Township 32, Range 23, Cherokee County, Kansas. The area is dotted with houses of the farmers who rent and farm the lands. The land is very rich and has grown very good crops, which is very evident when one sees the crops raised on the lands along Cherry Creek, the land near the Creek having unusually rich soil. The only means of rail transportation
to and from the area is by means of the Missouri-Kansas-Texas Railroad and the Joplin & Pittsburg Interurban Railway. The Joplin & Pittsburg Interurban Railway is at present not operating, but will probably sell their interests to an Oklahoma Company who will operate freight service at least. The Joplin & Pittsburg Railway connects with Scammon, Cherokee, Pittsburg, Columbus, Kansas and Joplin, Missouri in the near vicinity, extending easterly from the town of Mineral. The Missouri-Kansas-Texas Railroad through Mineral is what is known as the Joplin Division and runs from Parsons, Kansas through Mineral, to Joplin, Missouri. Map No. E-2-12 shows the location of the railroad with respect to the different sections in the area. There are no state highways within several miles of the area, but there is a very good shale road extending east and west through Mineral, toward Pittsburg and Parsons, Kansas.

The town of Mineral, Kansas is situated on the west edge of the property and has a population now of about six hundred people. These people are largely engaged in farming and a few in working in the coal mines near town. The houses in the town are nearly all in need of painting, many of them need repairing and the town, as a whole, looks shabby. There is very little business carried on in the town, most of the business coming from the farmers of the community. Seeing the Mineral, Kansas of twenty years ago causes one to wonder if it is the same place. Twenty years ago, when the Missouri-Kansas-Texas Railroad was operating it's deep mines and several other
deep coal mines were working near Mineral, the town of Mineral had a population of nearly ten thousand people. These people, for the most part, were making their living in the coal mines or by means of the coal mines, although farming was also carried on extensively. The Mineral of today, consists of only West Mineral, East Mineral that occupied the south area of Section 5 having now been torn down or moved away. The Mineral of twenty years ago was a wide awake community with plenty of money and was widely known as a coal center. It resembled any coal mining town, the average home being neat but not elaborate. The railroad shipped out approximately seventy cars of coal every day, this being considered a very good output for the mines as they were all deep mines and the production not as large as the strip mines of today. The town, during the time of its greater prosperity, was known as a prosperous coal mining center but has, during the last twenty years declined until it is the Mineral of today with little to look forward to, in the way of progressive civic advancement.

Coal mining carried on near Mineral during the time of its greatest prosperity, consisted of the mining of the deep shaft mines on the Missouri-Kansas-Texas holdings and in several mines near Mineral. The Missouri-Kansas-Texas Railroad worked out by deep shaft methods, mines Nos. 1, 2, 3, 4, 5, 6 and 7, while the Mayer Coal Company's Mine No. 11, located in Section 33, Township 31, Range 23 was worked as well as the N. Smith mine in Section 7, Township 32, Range 23. These mines had a very large output per day and employed a great number of men at each mine.
The coal mining now being carried on near Mineral consists of a strip pit owned by a man named Brenner, his pit being located in Section 19, Township 32, Range 23, two miles south of Mineral, by the strip mine of the Pittsburg & Midway Coal Mining Company, only recently installed and by the deep mine, Mayer No. 11, just north of the Pittsburg & Midway Coal Mining Company's holdings. There are strip mines and deep mines four miles east near the town of Scammon, and of course numerous mines northeast and south of Scammon. Several small deep mines and strip pits are found west of Mineral. The strip and deep coal mines found near Mineral and in other parts of Cherokee and Crawford Counties, comprise one of the largest coal districts found in the State of Kansas. Other coal areas in Kansas are the Osage City Coal Field, south of Topeka, the Ft. Scott and Pleasanton areas, the coal area near Leavenworth and small coal areas near Chanute and Lawrence, Kansas.

Coal mining is carried on in Kansas by deep shaft mining and by strip mining methods. The trade territory of Kansas coal is the State of Kansas itself, south for a distance of approximately one hundred and forty miles, or as far as Oklahoma coal, oil and gas prices justify shipping, north into Nebraska and east and west as far as coal prices will justify shipping against the competition of Colorado and Missouri coal.
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Gasoline locomotive with tripload of coal.
Shooting coal with "squib".

View of 50B-Boyn Machine and 50 B-2 CY Loader.
Loading coal cars with "Skip"
THE DEVELOPMENT AND OPERATION OF A STRIP COAL MINE USING
MODERN METHODS

I. Geology of the coal deposits near Mineral, Kansas.

There are three principal geologic horizons in which coal is found near Mineral. These different seams of coal are all found in the Cherokee shale, the Cherokee shale being the basal member of the Pennsylvania formation, the Pennsylvania foundation resting unconformably upon the Mississippi limestone. The normal dip of these formations is about twenty feet per mile, away from the Ozark uplift to the southeast of the area. The lower seam of coal about three feet in thickness, is the most important economically, but is found too deep at Mineral to work by stripping. This coal seam is what is known as the Weir-Pittsburg coal seam. Separated from this coal seam by shales and limestones, and approximately 35 feet higher in the geological cross-section, is found a coal seam about 14 inches thick that is called the "Prairie" seam, and 15 feet above the "Prairie" seam of coal is found a 22 inch seam of coal that is commonly called the "Mineral" seam. This seam of coal is the coal that is to be worked at Pittsburg & Midway Coal Mine No. 15. Approximately 15 feet above this 22 inch seam lies a 15 inch seam of coal, what we call the "Pioneer" seam. This coal seam is not found in all the sections of land of Mine No. 15, it being found chiefly where the overburden is too deep for any of the coal in any seam to be worked, however, this 15 inch seam is found spotted throughout the area. No attempt will be made to mine this 15 inch seam as it is not found throughout all the area and because it is very difficult to sell coal from this seam.
The following is a typical analysis of nut coal mined from the lower or Weir-Pittsburg coal seam.

<table>
<thead>
<tr>
<th></th>
<th>As Received</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>3.24%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Ash</td>
<td>5.98</td>
<td>6.18</td>
</tr>
<tr>
<td>Sulphur</td>
<td>2.74</td>
<td>2.83</td>
</tr>
<tr>
<td>V.C.M.</td>
<td>31.93</td>
<td>33.00</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>58.85</td>
<td>60.82</td>
</tr>
<tr>
<td>B.T.U.</td>
<td>13,507</td>
<td>13,939</td>
</tr>
</tbody>
</table>

There are quite a number of "horsebacks" or barren clay streaks in this 36 inch coal seam, making their removal imperative before loading the coal.

The following is a typical analysis of coal mined from the 22 inch or Mineral seam of coal.

<table>
<thead>
<tr>
<th></th>
<th>As Received</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>2.54%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Ash</td>
<td>7.94</td>
<td>8.15</td>
</tr>
<tr>
<td>Sulphur</td>
<td>2.74</td>
<td>2.81</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>35.20</td>
<td>35.12</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>54.32</td>
<td>55.73</td>
</tr>
<tr>
<td>B.T.U.</td>
<td>13,565</td>
<td>13,918</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>1.38</td>
<td></td>
</tr>
</tbody>
</table>

There are not many "horsebacks" in the Mineral coal seam, although a few very narrow seams a few inches wide, were found zigzagging in every direction in the coal in the first pit mined.

II. Drilling on Land Area.

The area of land embracing the proposed mine No. 15 had been rather extensively drilled by the Missouri-Kansas-Texas Railroad Company during the period of time they owned and operated their deep coal mines. The drill holes that they had put down were all in the vicinity of the workings of the old deep mines,
these drill holes being chiefly in the west half of Section 4, some in section 5, a few holes in the northwest quarter of section 9, and section 8 was rather extensively drilled except in the south half of the south half of the section, this area being close to the crop line. The holes drilled by the Missouri-Kansas and Texas Railroad were all some distance from the crop line of the upper or "Mineral" seam of coal, as they were not contemplating working this 22 inch seam of coal approximately 90 feet lower. Nearly all the holes drilled by the Missouri-Kansas-Texas Railroad were drilled to this lower seam, although a few drill holes to the 22 inch seam only were placed by them in the southeast quarter of the southwest quarter of section 4.

In operating a strip coal mine it is necessary to determine at what point the operator is to start his shovel operation. The coal seam to be mined at Mine No. 15 outcrops on a line near the center of the east half of section 4, and runs southwest through the northwest part of section 9, down through the south half of the southeast quarter of section 8 and then turns south through the center of section 17 (See Map No. E-2-12). This crop line was located by placing drill holes every two or three hundred feet apart, these drill holes remaining on the edge of the coal. These holes were put down by drillers using a hand auger, the depth of the holes being always under twenty feet and in some cases only fifteen feet, numerous holes being put down at a small expense. When the drillers found no coal, they would place the next drill hole slightly to the northwest until they got back on the crop line. The crop line
was thoroughly prospected and stakes with the drill hole numbers on them were placed at each respective drill hole by the drillers, in order that they could be easily found when the land was surveyed, and the position of the drill holes properly located.

III. Preliminary Surveys.

In order to compute the exact acreage of coal that could be mined profitably now, figuring that fifteen cubic yards of overburden could be moved for one ton of coal at the present prices, it was necessary to make a topographical map of the section of the area, making this map on a contour interval of five feet. Then, after having located the drill holes in the different sections and using the logs of these drill holes, contours on the top of the coal were drawn. Using the depth of overburden to thickness of coal of each drill hole, the maximum digging line (Ratio 15 to 1) that it would be profitable to dig to now, was drawn. The topographical survey was made using a plane table with a Gurley alidade. Two rodmen, using stadia rods were used, but no note keeper, the man using the alidade, taking his own notes. The survey was started in Section 4 and proceeded southwest and west, until all of Section 4 and nearly all of Section 5, except the extreme southwest part of the section, all of Section 9 north of Cherry Creek and the southeast quarter of Section 8 was contoured. The survey consisted of setting the plane-table up on a high advantageous point, orienting it with respect to its proper
position in the section and then taking observations or (shots) on the stadia rods at such intervals as to properly contour the land on a 5 foot interval. An elevation was assumed to begin the survey and carried throughout the survey and will be carried until the mine is worked out. "Shots" were taken on the top of drill holes that were now drilled away from the crop line at portions of the sections that were not drilled thoroughly enough to know exactly how the coal laid. These drill holes were put down by a competent driller, who has done drilling in this coal district for many years. He used a percussion drill mounted on wheels. The holes he drilled averaged about thirty feet in depth. Enough "shots" were taken on the land to delineate the slope and gradient of the land, the contours of the map showing this. Contours were drawn on the map in the field, so that the map was finished when the survey was completed, excepting the work of tracing the map in ink. The culture of the land, such as fences, railroads, roads and buildings were also located on the map. The survey was made, using two rodmen and the instrument man, but fairly good time was made on the survey, practically two hundred acres of land being contoured each day. The total acreage of land contoured at this time was sixteen hundred and forty acres. The northeast quarter and the west half of section, as well as the acreage in Section 17 was not contoured at this time, as it will be years before it will be needed and because of the limited amount of time that we had for preliminary investigation.
IV. Analysis of drillings and surveys to determine whether or not mine could be profitably worked.

The area of land, having been topographically surveyed and the respective drill holes located, the contours were drawn on the maps and the latest drill holes placed on the map at their respective points. The drill holes drilled by the Missouri-Kansas-Texas Railroad were already on the map. Using the ratio of 15 to 1, the maximum digging line was drawn on the map, as previously said, this being as far west and north as strip mining will be carried at the current price of coal. This maximum digging line is shown on the map by a series of broken lines, consisting of one long line and then three shorter lines, this combination of lines being repeated. The crop line, or the line from which stripping would begin, was plotted on the map and designated by a long line and then a shorter line, this being repeated throughout the crop line length.

The area of land between the crop line and the maximum digging line is the area of coal land that can now be profitably worked. The area of coal that can be worked profitably now is as follows:

Section 4, Township 32, Range 23 = = 197.5 A.
Section 9, Township 32, Range 23 = = 123.0 A.
Section 8, Township 32, Range 23 = = 290.1 A.
NW 1/4 Section 17, Township 32, Range 23 = = 60.0 A.

Total acreage of coal land ratio (15 to 1) 670.6 A.

The average thickness of the coal in this area was found to be 22 inches, while the average overburden was found to be 26 feet.
Observation of Map No. E-2-12 will show the roads between Sections 4 and 9, Sections 4 and 5 and Sections 8 and 9. Attempts were made to have these roads abandoned so that stripping could be carried along continuously through these sections, but the County Board of Commissioners of Cherokee County would not abandon the roads. The road running east-west between Sections 4 and 9, is a shale road connecting Mineral with Scammon and points east. The north-south road between Sections 8 and 9 is a township road, but fairly well traveled and the Township Board would not listen to its being abandoned. Because of the fact that these roads could not be abandoned, so that continuous pits could be dug, it was deemed advisable to plan a haulage system using the track on the natural surface or high-wall, and carry the tracks over these roads when the shovel dug up to them. Two methods of track system are used in strip mines, one carrying the track on the coal seam itself and the other consisting of laying the track on the "high-wall". The method of carrying track on the high-wall was deemed the best plan because of the fact (1) that the roads could not be abandoned, (2) it reduces the angle of swing of the stripping shovel and (3) because of the elimination of the extra cost of tearing up the track after each pit by sections. The location of the tipple site, or the place where the coal would be hauled and prepared for shipping was an important problem. The tipple was located in the east half of the southeast quarter of Section 5 as shown on the map, because of the proximity to good shipping facilities with the
least amount of track to be built, because of an old railroad grade coming off Mine No. 11 spur to the southeast through Section 4, south into Section 9 and because of the fact that it was west, or back of the maximum digging line. The tipple located at this point would be centrally located to the coal in Sections 4, 8 and 9 and a minimum of track would be necessary for future development. Another reason for its selection was the fact that it is located on an old railroad grade, this eliminating an extra amount of earth fill and because of the fact that the contour of the land northeast of the proposed tipple site made construction of the "tail" or empty storage tracks a comparative easy matter, owing to the rise of the ground to the northeast, this reducing the amount of earth fill at the site of the proposed "tail" tracks.

V. Marketing prospective coal to be obtained from mine.

Marketing the coal obtained from a coal mine is a very important factor to be considered in its development. Before work was started on this mine, the trade territory of the mine was analized to ascertain whether or not it was possible to sell the additional tonnage of coal from this mine. Arrangements were made with the Missouri-Kansas-Texas Railroad to take most of this tonnage, the rest of the tonnage to be sold either to retailers, other railroads or steam plants. The general sales office of the Pittsburg & Midway Coal Mining Company is located at Kansas City, Missouri and it has branch offices at Omaha, Nebraska, Wichita, Kansas, Henryetta, Oklahoma
and Joplin, Missouri. The main offices of the Company are at
Pittsburg, Kansas and, of course, sales are handled from this
office also. The Company has a very efficient sales organization
and it will be this organization’s business to sell the additional
 tonnage from this mine.

VI. Selection of tipple site.

A topographical survey of the land having been made
and enough drillings having been drilled to clearly delineate
the coal body, the proper selection of the tipple location had
to be made. A tipple is a building erected, containing all the
necessary machinery to thoroughly prepare and size the coal and
load it into coal cars, after the coal is hauled and carried up
into the tipple. The factors governing the selection of the
tipple were (1) the contour of the land where it was proposed
to erect the tipple, (2) proximity to good shipping facilities,
(3) the amount of grading or earth that had to be moved to bring
the grade of the tracks up to the proper elevation, (4) additional
tracks that had to be constructed, (5) cultural features, (6) avail-
ability of good roads and (7) the esthetic value of the proposed
site.

The yard tracks were to be built on a grade, this grade
increasing from six tenths of one percent on the storage track
side of the tipple, to one and one-half percent on the opposite
side of the tipple, or the storage tracks for the empty coal
cars, these tracks being called the "tail" tracks. Because of
the high percent of grade of "tail" tracks, it was necessary to
locate a tipple site where the land raised in elevation at the
position of the proposed empty storage tracks. The natural
profile of the land where the tail tracks are now located is on a general rise to the northeast, this rise not being very noticeable, but enough to appreciably decrease the amount of earthwork that had to be moved to place in the railroad grade. At the location of the tipple site, as laid out, the tracks west of the tipple follow the grade of an old track that previously had been constructed, there being a little cut in the proposed track subgrade at this point, in order to decrease the fill that had to be made east of the tipple under the "tail" tracks. The availability of good shipping facilities such as the tipple has, as chosen, was a very concrete reason for its selection, as all yard tracks from the tipple connect with the Missouri-Kansas-Texas Railroad spur No. 17 to Mine No. 11 and to the town of Mineral. North of this track, west of the yard tracks, a fill had already been made for an additional storage track, under the storage track as shown now built, on Map No. E-2-12.

Placing the tipple at this location decreased the amount of tracks that had to be built to make the proper connections, there were no houses, barns or obstructions to be cleared away from the site, except a few trees. There were good shale roads to the proposed tipple within a quarter of a mile, the tipple site was only a mile from the town of Mineral and it was believed that from an esthetic viewpoint, the site could not be improved, as the tipple would be very easily seen from all directions and, when built with the other buildings that were to be built near it, it would be a very impressive sight from the viewpoint of a coal miner at least. The proposed location of the tipple is in the southeast quarter of the southeast
quarter of Section 5, Township 32, Range 23, approximately seven hundred and eight feet north and two hundred and thirty feet west of the southeast corner of the Section.

VII. Tipple Foundations.

The tipple, as constructed was laid out at an angle of approximately forty degrees east of north, the tipple tracks extending northeast and southwest away from the tipple. The tipple foundations consist of concrete piers set at right angles with each other at the proper spacings for the different bents of the tipple. Map No. E-7-18 shows the plan of the tipple foundations. The main tower of the tipple, where the heaviest machinery is set, is set at 16'0" centers. This main bent which houses the shakers and where the dray conveyor is located is spaced at 16'0" centers the entire distance from the coal hopper to the north side of the tipple. There are three other bents west of the main conveyor or shaker bent. These bents are spaced at 13'0" centers along the tracks and 16'0" centers at right angles to the tracks. These 13'0" center bents are over the lump, nut and one of the slack tracks. Map No. E-7-18 shows the exact spacing and arrangement of piers for the tipple foundations.

The tipple piers were designed to carry the dead load of the tipple, machinery and coal running through the tipple.

The dead load necessitated making the bases of the main coal conveyor bent with a four foot bottom width, while the bases of the piers of the 13'0" bents west of the main conveyor bent were all made with a base width of three foot six inches each way, except the extreme southwest pier that was made four
feet square. All piers were made with a top width of 24 inches parallel to the tracks and 20 inches at right angles to the tracks. The tipple piers were built of plain concrete, the top of the tipple piers being placed approximately two and one-half feet above the natural ground line at the tipple site, the piers being placed that high to lessen the depth of excavation at the proposed coal hopper south of the tipple. The concrete piers were designed to be placed approximately three feet below the natural ground line, well into good substantial soil, of a soil value of two tons per square foot, the batter of these piers to be three and one-half inches per foot on each side of the piers, down to the natural ground line.

It was proposed to survey the tipple placing its center line (the center line of the coal drag conveyor) at station 24 + 55 and this was done, the center line of the nut track being the center line of the straight track of the Missouri-Kansas-Texas Railroad line, west of the tipple extended eastward. All the yard tracks were laid out and slope stakes set when it was discovered that the proposed tipple, as staked out, was located over a worked out area of coal of the top 22'' seam of coal. The 22'' seam of coal at this point is found at a depth of approximately thirty feet with no good cap of shale or rock covering it. This compelled this tipple site to be abandoned, because the coal seam having been mined from underneath the proposed tipple site, no substantial footings would have been obtained by leaving the tipple at that location, it being feared that the ground might subside.
Drill holes were put down east and south of the proposed tipple and hopper locations to determine where the coal had not been removed. The coal had been mined by a small deep shaft or "dinkey" mine by the long wall method of mining, which consists of starting at a central point and gradually working away from this point in a circle. It can be seen that once the drill hit the coal, it could be figured that none of the coal beyond that point had been mined. Enough drill holes were put down to delineate the coal body and the tipple was resurveyed, placing its center line at Station 25 + 94, or one and thirty-nine feet northeast of the former location, the extreme southwest pier of the west 13 foot bent being the only pier over the open space, this being taken care of by making the base of that footing four feet square instead of three feet six inches square, in order to distribute the load on that column over a larger area.

The tipple foundations were surveyed, using a party consisting of two rodmen and an instrument man. The tangent track of the Missouri-Kansas-Texas Railroad Spur No. 17 to Mine No. 11, west of the proposed tipple site was extended northeastward, by bisecting the track rails at two places, setting up over the east point, backsighting on the west center point a thousand feet farther west, plunging the telescope of the transit and carrying the channelling that was begun at the east end of the railroad trestle or Station 0 + 00, northeast to Station 25 + 94 or the center line of the conveyor bent of the proposed tipple. This line was continued northeastward on a straight line to Station 38 + 00, or the end of the empty car storage tracks. This line was taken as the center
The total number of piers footings to be dug for the tipple were thirty-two, all these footings being dug thirty inches into solid ground, the bases of the main conveyor bent of the tipple being made 4'0" square while all the other piers, except the extreme southwest pier of the west 13 foot bent, were made 3'6" square, this pier base having been made 4'0" square. The base of the batter piers for the batter posts to the main tower bent were made three feet wide by nine feet long. Eight men were used in digging these holes, one man working at one hole until completed and then beginning with another hole. The holes were all dug in one day. The cost of excavating the earth for the pier foundations was $0.20 per cubic yard, there being sixteen hundred cubic yards of earth excavation moved by eight men at $4.00 per day.

The holes for the piers having been excavated, runways consisting of 3 x 12 inch timbers were laid to each hole in successive order and the holes filled up to the natural ground line with plain concrete, using a 1:3:5 mix, which consists of one part of cement to three parts of fine aggregate, which was Arkansas River sand, to five parts of coarse aggregate, which was in this case, Joplin screened chats. This concrete was not run very wet and was spaded sufficiently. "Rubble" stone, or
large limestone rocks, were thrown in the bottom of each hole to fill the space and to decrease the amount of concrete needed. The footing was in compression and no tension, so the footing was not weakened to any extent.

Forms for each pier were now built, the top section of each form being identical, the batters differing slightly because of the varying ground levels. The top of the piers were all to be at the same level, being one and one-half feet above the track elevation at the center line of the drag conveyor and at the track elevation of the hopper. The piers were built of 1 x 8 inch ship-lap material, reinforced with 2 x 4s at the corners and built to the proper height, width and batters. The pier forms were set to the proper position relative to shape of building and height of top of form, leveled and staked down thoroughly so they could not be moved out of that position. Forms to hold the one and one-half inch bolts were tacked across the top of the pier forms. These bolts were to fasten the bases of the tipple columns and consist of 1½ inch by 15 inch bolts, with a 6 inch bend on the end to be in the concrete for additional bond. The pier forms were now filled with concrete, using a 1:3:5 mix and running the concrete a little wet, the time each batch of concrete remaining in the concrete mixer being one minute. Runways were built to each row of piers to the proper elevation so that a wheel barrow could be dumped into the top of the forms. The concrete was well tamped. The total volume of concrete in all the pier footings was 99.8 cubic yards, the price per each cubic yard of concrete being $2.50, the total cost of concreting the tipple piers was $249.50, this being
rather high for the piers, as they were easier to pour than the walls of the hopper, a contract price for all concrete to be poured on the job having been let to a concrete contractor for $2.50 per cubic yard, it can be seen the plain concrete for the tipple footings was much easier to pour than the reinforced walls of the hopper that was to be built later.

VIII. Yard Tracks.

During the time the tipple foundations were being surveyed and constructed, work was also carried on building the yard tracks, needed for the proper operation of the mine.

As has been said before, the topographical outlook of the ground at the proposed track location of the yard tracks was a fairly uniform upgrade to the northeast. The Missouri-Kansas-Texas Railroad Spur No. 17 runs from near the town of Mineral, slightly northeast, to a point practically seven hundred and fifty feet southwest of the tipple location and then curves to the right or to the east and continues into Section 4, Township 32, Range 23. The grade of this track from the trestle or at Station 0 + 00 southwest of the tipple to Station 18 + 00 is a gradual rise of practically 0.6 of one percent. The center line of the nut track of the yard track layout is the center line of the Missouri-Kansas-Texas Railroad Spur No. 17 extended in a straight line from Station 0 + 00 at the railroad trestle, northeast over the gradually rising ground to Station 38 + 00 of the proposed yard track layout. The tracks previously built by the Missouri-Kansas-Texas Railroad and which were in use at the time of the construction of the mine, were
Spur No. 17, which runs through section 5, east to the half mile line of section 4 and then turns north and continues north to the north line of section 4, then deflects to the northeast and continues into section 33, Township 31, Range 23, running by the Meyer Mine No. 11. An old railroad grade extended from the point that the straight line of our nut track left the railroad curve on Spur No. 17, and continued northeast to Station 28 + 00 and then deflected north, running parallel with the north-south road between sections 4 and 5.

Because of the fact that the ground gradually raised in elevation to the northeast and because the grade of this old track grade could be used for a few hundred feet, the proposed track layout was ideal.

The yard track layout as planned and built, provided for six tracks at the tipple. (See Map No. E-2-33) These are the runaround, lump, two nut and two slack tracks. As can be seen by consulting the map of the yard layout, the yard tracks were built on somewhat of a ladder track, the point of switch of the first track that breaks away from the nut track southwest of the tipple, being eight hundred feet southwest of the center line of the tipple. At this point the different tracks, as shown, break off from the main track or nut track on No. 7 frogs and at the tipple are all at sixteen feet centers, except the runaround and lump tracks, these tracks being at twenty-one feet centers to allow enough space for the railroad locomotives to clear the tipple while taking the empty cars up the grade to the "tail" tracks. The outside slack track near the hopper, has straight tangent for fifty feet both ways from the center line
of the tipple and then swings back to connect with the ladder tracks. All tracks from the tipple converge into the main or nut track at Station 30 + 54. The point of switch of the first "tail" or empty track was placed three feet northeast of the point of switch of the last track from the tipple to intercept the nut track. Three tracks were used for the empty storage tracks, the nut track extending northeast to Station 38 + 00 and two other tracks paralleling this nut track and being at fourteen feet centers, one on each side of the middle or nut track. The track south of the center track has its point of switch (P.S.) at Station 30 + 57 while the north "tail" track has its point of switch at Station 31 + 32, this track being on the north side of the center track. Preliminary surveys were made to determine whether to continue the tracks on a straight line northeast on this center line of railroad Spur No. 17, or to put in a curve and continue on the old railroad grade to the north. It was decided not to follow this old grade because the ground fell in elevation and because of the objection to a curve being in the empty storage track.

The proposed plan of the yard tracks was laid out to a scale in the office and the approximate number of ties, rails and equipment necessary for the construction of the tracks were computed, an additional storage track being proposed, paralleling Spur No. 17 track from Station 18 + 00 to Station 0 + 10, the track centers of these two tracks being placed at fourteen feet. The track grades as planned and constructed (See Map No. E-2-53), beginning at Station 10 + 00 and continuing northeast to the east end of the empty storage tracks
were a 0.5 percent grade from Station 10 + 00 to Station 18 + 00, a 0.82 percent grade from Station 18 + 00 to Station 22 + 00, 0.72 percent grade from Station 22 + 00 to Station 25 + 34, 2.5 percent grade from Station 25 + 34 to Station 26 + 24, 1.5 percent grade from Station 26 + 24 to Station 28 + 50 and a 1 percent grade from Station 28 + 50 to Station 38 + 00 or the east end of the empty tracks. The proposed storage capacity for the empty coal cars was forty cars, while storage room for the filled coal cars was provided for ninety cars. The total length of tracks built in the yard layout was eight thousand seven hundred and seventy-seven feet. This does not take into consideration the sulphur track, track to dinkey shed or tracks over the hopper that were to be built later.

The proposed yard track layout was surveyed and staked out, the maximum earth fill being eleven feet at Station 38 - 00. Slope stakes using a shoulder width of six feet was used in staking out the fill for the proposed embankment for the empty tracks and where the fill exceeded four feet. The ladder track of the yard layout was surveyed, No. 7 frogs being used. After the center line of the tracks had been laid out, slope stakes were set, using a track center to center of sixteen feet at the tipple itself, and fourteen feet centers for the storage track center to center. Grade stakes with the cut or fill marked on them, were set at fifty foot intervals, the length of the ladder track, and at one hundred foot intervals, the length of the storage tracks, a slope of $1\frac{1}{4}$ horizontally to 1 vertically was used for the repose of the earth, it being figured that this earth would stand and not cave off at this slope.
The grade and slope stakes having been set, work was commenced on the proposed embankment. A three cylinder oil burning Diesel motored drag line, made by the Bucyrus-Erie Company, was used to build this grade. This drag line has a bucket capacity of one cubic yard and a boom length of fifty feet and was operated by one man who had an assistant to alternate with him. The grade as built, was placed about eight inches higher than the correct grade, it being figured the earth would settle that distance at least. The total yardage of earth moved in the construction of this railroad grade was twenty-three thousand two hundred cubic yards of earth. This grade was built in forty-five days at a cost of $0.05 per cubic yard, allowing for the depreciation of the machine.

The tracks were again surveyed on the newly built grade and center line stakes set for the track crew to use in building the tracks. A track crew, consisting of ten men and a foreman, were used in building the tracks. The tracks were constructed with a standard gauged width of 4 feet 8 1/2 inches, the steel used, being 60 pound steel to the running yard. Good, standard six inches by eight inches by eight feet long, pine railroad ties, purchased from a point in Arkansas were used, spaced at two feet centers. The total length of tracks constructed in the ladder track of the tipple layout and in the storage tracks was eight thousand seven hundred and seventy-seven feet. Work on these tracks being carried along at the same time the tipple and hopper were being constructed. The cost of the construction of this track work was $2.50 per lineal foot.
The ballast for all tracks built at the mine was obtained from a shale pile approximately a quarter of a mile west of the tipple location at the old Katy Mine No. 6 site. This shale is a red shale, being very resistive and with good wearing qualities and is adherent. There was approximately ten thousand cubic yards of shale in the pile before hauling was begun from the pile. A railroad spur was run into the side of the dump and the drag line was placed on the dump by gradually eating away a place for it to work on. It then proceeded to fill two dump cars that the Missouri-Kansas-Texas Railroad Company loaned the Company, and these were used in hauling the shale or ballast. The coal cars proposed to be used by the mining company had not arrived at this time, so the railroad kindly loaned the company the two bottom dump cars. One of the two Vulcan gasoline locomotives that was to be used in hauling the coal after the mine was opened, had been shipped by the Vulcan Locomotive Company and it was used to haul the cars of ballast. Final grade sets were set for the top of the rails at the respective stations, and the tracks brought to the proper elevation by dumping the ballast on the tracks and then placing a tie in front of the car and pushing it against the shale as it fell in the middle of the tracks. This leveled the shale down to the elevation of the top of the tracks, and it was then worked underneath the ties. When the tracks were brought to the proper elevation, center lines were then rerun on these tracks and the tracks realigned.
IX. Car Retarders.

Car retarders were constructed east of the tipple, approximately thirty-two feet east of the east end of the tipple. Four retarders were constructed, these being erected eight feet south of the center line of the lump, nut and two slack tracks, these car retarders being in a straight line north and south and thirty-two feet east of the tipple. Map D-527 shows the design of the car retarders. Twelve inch H-beams were used for the vertical columns, which gave an ample safety factor.

The grade underneath the tipple is 2.5 percent, to allow the cars to roll away from the tipple easier. Drawing D-527 shows the mechanism of the car retarder. The purpose of the car retarders is to allow the coal cars to be lowered gently down the 2.5 percent grade under the tipple, thus insuring uniform and better loading of the coal into the cars. The operation of lowering the cars by the car retarders, is handled by the tipple man, who pulls a cable connected to the car and car retarder, that allows the car to be lowered down the track.

The 12 inch H-beams of the car retarders were set in concrete, the concrete base being four feet by four feet and extending down into good solid ground eighteen inches, making the vertical height of the retarders base, three feet-six inches, approximately. The concrete mix used in the car retarder bases was 1:3:5, some "rubble" stone also being used in the bases underneath the vertical H-beams, this concrete having been poured fairly dry. The 12 inch H-beams used to take the lateral pull of the coal cars being loaded give a
safety factor of probably 12, while the dead load of the concrete base resists the pull of the coal car which, when loaded, will weigh one and thirty-five thousands pounds, approximately. Because of the size of the H-beams and the concrete bases and the depth that they were excavated into solid earth, no difficulty will be experienced from any force placed on them in loading the coal.

X. Haulage Tracks to Proposed Hopper.

It was proposed to begin mining coal along the crop line in the east half of Section 4, so tracks had to be constructed from the proposed strip pit high wall, or edge west to and over the coal hopper that was to be built. This work was made a great deal easier because of the fact that the Missouri-Kansas-Texas Railroad Spur to Mayer Mine No. 11 extends east from near the town of Mineral, past the hopper site east, until it reaches the quarter mile line in the southwest quarter of Section 4, approximately eight hundred feet north of the south line of the section, where it curves to the north and intersects the half mile line of the section east and west at a point approximately sixteen hundred and forty feet north of the south line of the section. From this point, the spur track continues north along the half mile line to a point approximately five hundred and fifty feet south of the north line of the section, where it curves to the east and leaves Section 4 at a point three hundred and ten feet east of the half mile line on the north line of the section. The track then runs east, paralleling the section line and at a
distance of ninety feet north of it for a distance of approximately six hundred feet, where it curves sharply to the north and runs by the tipple of the deep shaft mine, Mayer No. 11. The total length of Missouri-Kansas-Texas Railroad Spur No. 17 track in Sections 4 and 5, west to the point of switch of the track over the proposed hopper, is eight thousand six hundred and sixty feet of track. This represents the trackage previously constructed by the railroad. It was necessary that our tracks to the strip pit, a quarter of a mile east of the half mile line of the section, take off from this track. The railroad had had a track serving their old deep shaft Mine No. 7, the tipple of which had been located several hundred feet southeast of the northwest corner of the northeast quarter of Section 9. The subgrade of this track was still more or less delineated, this grade leaving Spur track No. 17 at a point near the quarter line of the southwest quarter of Section 4, at the point of curve of the track to the north. Additional trackage constructed by the mining company consisted of building a spur track off from Spur No. 17, placing the point of frog of a No. 7 frog at the point of curve of the curve to the north and then running a track southeast along the center line of the old railroad dump, to a point two hundred feet west of the half mile line, this track then curving to the east and leaving the old grade at a point one hundred feet west of the half mile line. It was necessary to place a twenty-four inch tile, twenty feet long, under the small fill coming off the old railroad dump, to take care of
the drainage area north of this track. The track intersects
the half mile line approximately two hundred and ninety feet
north of the south line of the section, runs east two hundred
feet and curves sharply to the north and runs slightly north-
east paralleling the strip pit for a distance of approximately
five thousand feet, where it curves again sharply, to the left
or northwest, runs over a trestle constructed over a drainage
ditch and back onto Spur track No. 17, at a point about one
hundred feet northeast of the northwest corner of the north-
east quarter of Section 4. A No. 7 frog, with the proper lead
of 62.1 feet, was used at this switch. In order to facilitate
switching and to decrease the length of haul, a spur track was
constructed from Spur No. 17, this track leaving Spur No. 17
at a point one hundred feet north of the east-west half mile
line of the section, curves to the right or east and runs east,
paralleling and two hundred and fifty feet north of the half
mile line, until it reaches a point approximately one hundred
feet from the high-wall of each pit, where curves are constructed
to the north and to the south to connect with the track con-
structed along the strip pit high-wall. The total lineal feet
of track built from Spur No. 17 in Section 4, in nine thousand
feet, thirteen hundred feet of which were used in constructing
the cut-off track at the half mile line. The length of the
east-west tracks will decrease as each successive pit is dug
toward the west, the length of track needed along the pit re-
main ing practically the same.
XI. Tipple.

The tipple constructed at Pittsburg & Midway Coal Mining Company's Mine No. 15, is a steel structure, capable of handling two thousand tons of coal per day. A steel tipple was built instead of wood because of its rigidity, strength, longevity and because better workmanship could be obtained by building the tipple of steel instead of wood.

The contract for the tipple was let to the United Iron Works Company, one of whose plants is located at Pittsburg, Kansas. Their estimated cost of the tipple was approximately thirty thousand dollars, but the final estimate on the structure exceeded this figure by approximately eight thousand dollars.

The work of designing and detailing the different members of the tipple itself and the different machinery to be installed in it, was done by the United Iron Works' engineering force at Pittsburg, Kansas. The design of the work was carried on, either before work on the tipple was begun, or as it was being constructed.

The tipple, as completed, is the best tipple in Mine District No. 14, both as to design and workmanship. Drawing No. E-797 shows a portion of the main structural members composing the tipple, while Drawing No. E-7-18 shows a general plan of the structure.

Every steel member used in the construction of the tipple was designed to support any possible load on it, each steel member used, having a safety factor of five. The columns used in the tipple are 8 inch, 32.6 pound H-beams, while 10
inch 15.5 pound channels brace the tipple between the columns each way. The cross-braces used are 3 inch by 3 inch by \( \frac{1}{4} \) inch angle irons. Drawing No. E-797 shows a typical portion of the tipple and the steel members used in its construction, while Drawing No. E-858 shows a side elevation of the tipple. A general plan of the tipple itself is shown in Drawing No. 859. The general arrangement of the shaker screens, loading booms, crusher, eccentric and motors with the tracks underneath and with the coal hopper is shown in Drawings Nos. E-858 and E-859. The motors used in driving the different equipment are sufficiently powerful to drive them with the maximum load possible acting against them.

This tipple differs from other tipples in the mining district in that there are six tracks under the tipple, including the runaround track, that it is much larger than any other tipple, that it has a double deck shaker screen and that it is possible to load more different sizes of coal. The following are the sizes of coal that can be screened by this tipple.

<table>
<thead>
<tr>
<th>Number</th>
<th>Size</th>
<th>Name of Coal Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0&quot; x 3/16&quot;</td>
<td>Carbon</td>
</tr>
<tr>
<td>2.</td>
<td>3/16&quot; x ( \frac{3}{8} )&quot;</td>
<td>Pea Coal</td>
</tr>
<tr>
<td>3.</td>
<td>( \frac{3}{8} )&quot; x 1 1/4&quot;</td>
<td>Chestnut</td>
</tr>
<tr>
<td>4.</td>
<td>1 1/8&quot; x 3&quot;</td>
<td>Standard Nut</td>
</tr>
<tr>
<td>5.</td>
<td>1 1/8&quot; x 2&quot;</td>
<td>#2 Nut</td>
</tr>
<tr>
<td>6.</td>
<td>2&quot; x 3&quot;</td>
<td>Fancy Nut</td>
</tr>
<tr>
<td>7.</td>
<td>3&quot; x 7&quot;</td>
<td>Furnace</td>
</tr>
<tr>
<td>8.</td>
<td>7&quot; x up</td>
<td>Fancy Lump</td>
</tr>
<tr>
<td>9.</td>
<td>3&quot; x up</td>
<td>Ordinary Lump</td>
</tr>
<tr>
<td>10.</td>
<td>( \frac{3}{4} )&quot; x 7&quot;</td>
<td>Modified Lump</td>
</tr>
</tbody>
</table>

(All slack out)
Other features of the tipple, not found in the construction of other tipples in the district, are (1) building completely covers the drag conveyor and the coal hopper (2) a Bradford Breaker is installed to break up the sulphurs and chain conveyors to redeposit the coal from the sulphurs back on the drag conveyor, (3) a conveyor from the slack chute to deposit the fine material into car where it can be hauled away from the tipple, (4) a control platform from which every position of the tipple can be plainly seen, (5) a Reeves Transmission driving the drag conveyor, (6) a Tex Rope Drive on the eccentric and (7) sixteen foot clearance between center lines of adjacent tracks.

The operation of the tipple is taken up later in the summary of mine operation as one unit. The different drawings of the tipple shows clearly the tipple construction, the position of the motors and the general location of the tipple with respect to the tracks and to the coal hopper.

The mill work on the tipple was carried on in conjunction with the engineering department of the United Iron Works Company. As soon as the design of one portion of the tipple or machinery was completed, drawings were furnished the mill workers and the steel fabricated. The different steel members making up the tipple and machinery was hauled by trucks from Pittsburg to Mineral, a distance of twenty-two miles. No difficulty was experienced in transporting the fabricated material as the road from Pittsburg to Mineral is a hard surface road.
Work on the erection of the tipple was commenced in the second week of September 1929, under the supervision of H. A. Brown, erecter for the United Iron Works. A force of twelve men was used in the erection of the tipple, however, more men were used at various times when the occasion demanded, because it was necessary to erect the different units of the structure as soon as the fabricated members were hauled from the plant at Pittsburg.

The erection of the tipple itself was carried on in a workmanship manner, however, there was such a big delay in getting the different members designed and fabricated at the shop, that the tipple was not completed and ready for satisfactory operation until the second week of January 1930, or four and one-half months after the date of the contract. The tipple, as completed, however, represents the finest in tipple construction for the amount of money expended and is, without doubt, the most modern tipple in this mining vicinity.

XII. Reinforced Concrete Hopper.

The coal that is hauled from the strip pit or working face to the tipple, must be dumped into some space where it can be elevated by a drag conveyor to the tipple to be screened. The coal cars are designed with an automatic bottom dump, so that as they come to the edge of the hopper, an automatic trip opens the bottom doors of the car and the coal is dumped into the hole or hopper, onto the reciprocating feeder and then is carried on to the drag conveyor and up into the tipple.

A coal hopper in this mining district usually consists of a structure built of concrete with little or no steel re-
inforcement being used, this structure being of a size large enough to handle the amount of coal that the operator thinks he can mine and that his tipple is designed to prepare. The walls of the coal hoppers of this district are generally all made twelve inches wide at the top and approximately the same width at the bottom with no thought given to endeavor to really compute the widths of the walls to use at the different wall sections, or to compute what steel reinforcement should be used at different parts of the hopper walls and at different heights. There is, I believe only one other hopper in the vicinity, where attention was given to the engineering features, such as really designing the walls of the hopper. The coal hopper at Mine No. 15 was built from computations that endeavored to find good concrete reasons for building the hopper the way in which it was built. The sizes of the walls of the hopper and the amount and position of the steel reinforcement used, were fixed by computations used in designing the hopper. The hopper also differs from other hoppers in that columns and reinforced concrete beams are used to take the main load over the hopper and also in the fact that every effort was made to make the structure waterproof. In pouring the concrete for the floors of the hopper, waterproofing paste was used in the concrete, while the outside of the walls were also painted with an iron waterproofing compound to make it watertight. Two tracks over the hopper are an added feature also.

In designing the hopper, care was taken that the structure would be large enough to handle the coal tonnage that could be mined by the stripping units to be used, and that the tipple could handle satisfactorily. The hopper was designed to
hold approximately 160 tons of coal. The rail elevation of
the hopper was fixed by the distance that the grade at the
tipple was placed in reference to the natural ground profile.
It was thought best to keep the grade of the track elevation
at the tipple at a height so the track grade at the hopper was
approximately three feet above the natural ground line at the
hopper site. In order not to excavate any deeper in the ground
than necessary, the volume of the proposed hopper was computed
using a distance of eighteen feet below what was estimated the
steel I-beams would measure, namely twenty-four feet deep. This
distance from the bottom of the proposed steel I-beams to the
top of the reciprocating feeder governed the size of the hopper.
Four feet more of vertical height was necessary to the top of the
hopper floor, allowing three feet from the top of the recip-
rocating feeder to the bottom of the drag conveyor and one
additional foot for clearance underneath the conveyor. Figuring
the thickness of the floor would be at least twelve inches, this
placed the proposed structure 25'3" below the proposed grade
track elevation, or 22'6" below the natural ground line at the
hopper site. It was thought not advisable to go deeper, because
of the additional excavation. In order to get the volume of
hopper required, it was found necessary to make the structure a
distance of 37'6" inside length northeast by southwest, and
25'2" wide inside measurement, northwest by southeast, in the
main part of the hopper where the coal was to be dumped.

(SEE Diagram K-2-6) The inside width of the section of the
wall where the drag conveyor was to come out of the hopper to
the tipple was fixed by the amount of clearance that was desired on both sides of the drag conveyor for steps along side the drag conveyor on the incline. The width of the drag conveyor, center line of support to center line of support on each side was 5'3\(^\frac{1}{2}\)". Leaving a clearance of three feet on both sides of the drag conveyor made the inside measurement between the walls a distance of 11'4". The drag conveyor was to be built on an angle of thirty degrees with the horizontal. This inclination governed the point at which the conveyor incline hit the natural ground line, which was a distance of 46'7" from the proposed center line of the structure. Using the dimensions as given for the main part of the hopper and figuring that the coal would take a position on a slope of 1 to 1, from a point at the bottom of the proposed steel I-Beams, this slope from the bottom of the I-Beams determined the point where the coal would hit the hopper walls.

The coal as it leaves the car, is dumped on an incline of 42 degrees, while the other slopes of the hopper leave the reciprocating feeder at an angle of 45 degrees. The volume of the proposed hopper was computed, using one track over the hopper, but it was found that the desired volume could not be obtained unless two tracks were used, of standard gauge, at the center line of the inner rail of each track to be 9 inches away from the center line of the hopper, southwest by northeast. This spacing of the rails fixed the position of the steel I-Beams to carry the track and, assuming the I-Beams to be used would be 24 inches in depth and using the proposed slopes of the hopper
incline, the volume of the hopper was computed and fixed before any additional computations were undertaken.

The volume of the hopper having been ascertained, and the length of the hopper being known, steel I-Beams to span this length and strong enough to support the rails and superimposed load were designed. The factors that were taken into consideration in designing the steel I-Beams to be used across the hopper were (1) the weight of the locomotive to be used, (2) the wheel base of the locomotive, (3) the weight of the coal cars to be used, (4) the weight of the volume of coal to be carried in one coal car and (5) the wheel base of the coal cars.

The clear span of the hopper being 39 feet 6 inches, the steel I-Beams had to span this distance, plus a distance of at least eighteen inches for bearing on each end. The I-Beams, as figured, have a three foot bearing surface on each end. The size of I-Beams to be used, spanning the entire 39 feet 6 inches with no intermediate steel cross beam at half distance and carrying the load was computed. Following are the computations the computations figured on that basis:

DATA

Weight of each 35-Ton capacity coal car - - - 35,000#
Weight of coal in 35-Ton whopper car - - - - 70,000#
Dead load of coal car and coal - - - - - 105,000#
Dead load of locomotive - - - - - - - 50,000#

Load equally distributed at four points of trucks of coal car $ \frac{105,000}{4} = 26,250#$ - load on one rail at one truck
Load of locomotives figured equally, distributed on four wheels: \(\frac{50,000}{4} = 12,500\)\# at one wheel on one rail.

Distance from front truck of coal car to rear wheels of locomotive - 10' 6". Assuming I-beams of weight 90 pounds per lineal foot.

\[ M_{R_1} = 0 \]
\[-26,250 \times 19.75 - (90 \times 39.5) 19.75 - 12,500 \times 30.25 + 39.5R_2 = 0 \]
\[-513,400 - 70,200 - 378,100 + 39.5R_2 = 0 \]
\[ R_2 = 24,780\# \]

\[ M_{R_2} = 0 \]
\[ 39.5R_1 - 26,250 \times 19.75 - 12,500 \times 9.25 - (90 \times 39.5) 19.75 = 0 \]
\[ 39.5R_1 - 518,400 - 115,600 - 70,200 = 0 \]
\[ R_1 = 17,820\# \]
\[ 17,820 - 24,780 = 26,250 + 12,500 + 3560\# \]
\[ 42,500 = 42,310\# \]

Maximum Moment: \(a\) = \(17,820\# \times 19.75 - (19.75 \times 90) 9.88 = 334,380\#\text{Ft.} \]
\[ = 4,012,560\# \text{ In.} \]

\[ Z = \frac{4,012,560}{16,000} = 250.7 \]

Use: - 24" - 120\# I-Beams - 43'-6" long.
The weight and depth of the I-beams computed spanning the entire length of the whopper steel seemed excessive so the I-beams were recomputed, breaking the span at the half way point by an intermediate cross-beam. Following are computations on that assumption:

Assumed weight of each I-beam - 80# per foot.

Maximum moment was produced when one truck of coal car was located in middle of span.

Distance from truck center to truck center of coal cars = 9' 6".

Load acting on one rail on each side of truck 26,250#

\[ M_{R_1} = 0 \]
\[ -26,250 \times 9.9 - 26,250 \times 19.4 + 19.9 R_2 - (19.9 \times 80)(9.95) = 0 \]
\[ -259,900 - 509,250 + 19.9R_2 - 15,840 = 0 \]
\[ R_2 = \frac{384,590}{19.9} = 19,440# \]

\[ M_{R_2} = 0 \]
\[ 19.9R_1 - 26,250 \times 9.9 - 26,250 \times 0.4 - (9.9 \times 80)(5.0) = 0 \]
\[ 9.9R_1 - 259,900 - 10,500 - 15,840 = 0 \]
\[ 19.9R_1 = 286,240 \]
\[ R_1 = 14,380# \]
\[
14,380 + 39,440\# = 26,250 \Rightarrow 26,250 + 3960 = 53,820\# = 56,450
\]

\[
M_a = 14,380 \times 9.9 - (80 \times 9.9 \times 5.0) = 142,360 - 3960 = 138,400\# \text{ Ft.}
\]

\[
M_a = 39,440 \times 9.95 - 26,250 \times 9.5 - (80 \times 9.95)(5.0) = 392,430 - 249,370 - 3980 = 139,080\# \text{ Ft.} 
\]

Maximum Moment = 139,080\# \text{ Ft.} = 1,669,000\# \text{ In.}

\[
Z = \frac{1,669,000}{16,000} = 104.2
\]

Use: - 20" - 70\# I-Beams - 43'-6'' long.

Three - 20"-70\# I-beams were figured to be used to carry the tracks and the computations for the steel cross I-beam following was figured on that basis. Four 70\# I-beams were used as it made it much easier to come in and go off the hopper, and would have impelled a special arrangement of track frog to get on to the hopper. Using four I-beams across the hopper, increased the cost for the steel I-beams to be used, but was cheaper than the other method.

Computing the steel cross I-beam to be used to break the span of the long 43'-6'' - 70\# I-beams:

Weight of 20"-70\# I-beam per span of 19.9' = 1300#
\[
\frac{1}{3} \text{ of each span of I-beam on middle beam or all of one span = 1300#}
\]

Reaction at steel cross beam computing long 70\# I-beams was 39,440#.

The following figure shows position of loads over cross-beam, using only three I-beams across hopper.
\[
M_r_1 = 0 \\
-1300 \times 6.9 - 39,440 \times 11.58 - 39,440 \times 16.28 - (23.16 \times 80) \\
11.58 + 23.16R_2 = 0 \\
-8970 - 456,700 - 642,080 - 21,460 + 23.16R_2 = 0 \\
R_2 = 48,750\#
\]

\[
M_r_2 = 0 \\
23.16R_1 - 1300 \times 16.28 - 39,440 \times 11.58 - 39,440 \times 6.9 - (23.16 \times 80) \\
11.58 = 0 \\
23.16R_1 - 21,160 - 456,700 - 272,140 - 21,460 = 0 \\
R_1 = 33,310\#
\]

\[
33,310 + 48,750 = 1300 + 39,440 + 39,440 + 1850 = 82,060 = 82,030 \\
M_c = 48,750 \times 6.9 - (6.9 \times 80) 3.5 = 336,380 - 1930 = 334,450\# \text{ Ft.} \\
M_b = 48,750 \times 11.58 - 39,440 \times 4.7 - (11.58 \times 80) 5.74 = 564,500 \\
- 185,370 - 5320 = 373,810\# \text{ Ft.} \\
M_e = 33,310 \times 6.9 - (6.9 \times 80) 3.5 = 229,840 - 1930 = 227,910\# \text{ Ft.} \\
\text{Maximum Moment at (a) and (b)} \\
Mom. = 373,810\# \text{ Ft.} = 4,485,720\# \text{ Ins.} \\
Z = \frac{4,485,720}{16,000} = 280.3
\]

Use: - 24'' - 120# I-Beam - 25'-2'' long, weight 2770#.

The computations above show that 20'' - 70# steel I-beams 43'-6'' long, were to be used to carry the track and load
while one 24" - 120# I-beam, 25'-2" long was to be used as a cross beam to break the moment of the long span across the hopper. (See Diagram K-2-6 for position of I-beams used).

Four - 20" - 70# I-beams were used to carry the load instead of only three, as has been mentioned previously, as it simplified getting from the main track onto the hopper. The result of the computations show that using no intermediate cross-beam, the total weight of steel to be used would have been 20,900 pounds of steel, while using the intermediate cross-beam, with the lighter long I-beams, the total weight of steel to be used was 15,200 pounds, or a saving of 5,700 pounds of steel.

Reinforced concrete beams supported on reinforced columns and footings were computed to carry the load at each end of the hopper. Following are the computations of the reinforced concrete beams, the beams being figured assuming each support has the trucks of two cars over it, the support having to support one-half of two coal cars or all of one. A clearance of two and one-half feet from center line of each outer rail was allowed to each end of proposed concrete beam. (See sketch No.K-2-6) The rails were placed equally distant on each side of each proposed column, making the distance between the two columns to be used of 6' - 23/4".

DATA

LOADED TRACK

Using 35-ton whopper coal cars placed at maximum loading moment.
Weight of each 35-Ton capacity whopper car - 35,000#
Weight of coal in 35-Ton whopper car - 70,000#
Dead load of whopper car and coal on each rail - 105,000#

\[
\frac{105,000\#}{2} = 52,500\#
\]
Dead load of each I-beam and rail - 2,460#
Total dead load of each rail on each support on loaded track - 54,960#

Use: 24" = 105# I-Beam
Weight dead load I-Beam center line support to center line support = 105# x 39.41 = 4140#

\underline{UNLOADED TRACK}

Weight on each support = \( \frac{4140}{2} \) - 2,070#
Using 60# rail
Weight on each support for each rail - \( \frac{39.41 \times 60\#}{3 \times 2} \) - 390#
Total dead load of each I-Beam and rail on each support - 2,460#
Wheel base of coal car = 18'-6"
**LIVE LOAD**

Weight of each 35-Ton capacity car = 35,000#

Weight of coal in 35-Ton whopper car = 70,000#

Live load of whopper car and coal on each rail on loaded track = 105,000#

Using 25% Impact = 1.25

Total live load plus 25% impact on each rail = 65,700#

**LIVE LOAD MOMENTS**

\[ M_{R1} = 0 \]

\[ -65,700 \times 2.35 + 65,700 \times 2.35 - 6.2R_2 = 0 \]

\[ R_2 = \frac{-65,700 \times 2.35 + 65,700 \times 2.35}{6} \]

\[ R_2 = 0 \]

\[ M_{R2} = 0 \]

\[ -65,700 \times 8.55 + 6.2R_1 - 65,700 \times 3.85 = 0 \]

\[ R_1 = \frac{65,700 \times 8.55 + 65,700 \times 3.85}{6.2} \]

\[ R_1 = \frac{561,700 + 253,000}{6.2} \]

\[ R_1 = 131,400\# \]
CROSS-BEAM

Mom at \( R_1 = -65,700 \times 2.35 \times 12 = -1,882,700 \) # Ins.

Mom at inside track load = \(-65,700 \times 4.7 + 131,400 \times 2.35\)
\[= -308,790 + 308,790\]

Max. L. L. Mom. is at left of \( R_1 = 1,852,700 \) # Ins.

\[ M_{1l} = 0\]
\[-2460 \times 2.35 + 2460 \times 2.35 + 2460 \times 3.85 + 2460 \times 8.55\]

\[ R_2 = -2460 \times 2.35 + 2460 \times 2.35 + 2460 \times 3.85 \]
\[= \frac{R_2}{6.2}\]

\[ R_2 = \frac{-5780 + 5780 + 9070 + 21,000}{6.2} = 4920\] #

\[ R_1 = 4920\]

Estimated dead load of beam = \((2.5 \times 2.5)\) 150 = 940# per foot.

Mom at \( R_1 = -2460 \times 2.35 - (4.85 \times 940) \times 2.43\)
\[= -5830 - 11,100 = -16,930\#\text{ Ft.} = -203,160\# \text{ Ins.}\]

COMBINED MOMENTS

Max L. L. Mom = \(-1,852,700\) # Ins.

Max D. L. Mom = \(-203,160\) # Ins.

Combined Moment = \(-2,055,860\) # Ins.

Make width beam = 30"
\[ \begin{align*}
\frac{d}{2} &= \frac{2,055,860}{20} = 0.096 \sqrt{68,530} \\
\frac{d}{2} &= 0.096 \times 261.7 = 23.1" \\
A_s &= 0.0077 \times 30" \times 25.1" = 5,798 \text{ Ins.} \\
\text{Max Shear} &= 65,700# + 2460# + 11,100# \\
&= 79,260# \\
\text{Shear} \ v &= \frac{79,260}{30 \times 0.874 \times 25.1} = \frac{79,260}{588.4} = 134# \text{ per sq. in.} \text{ O.K. Web reinforcement is necessary - also use haunches on columns} \\
\text{Make width of beam} &= 24" \\
\frac{d}{2} &= \sqrt{\frac{2,055,860}{24}} = 0.096 \sqrt{85,660} \\
\frac{d}{2} &= 0.096 \times 292.6 \\
&= 23.1" \\
\frac{v}{2} &= \frac{79,260}{24 \times 38.1 \times 0.874} = \frac{79,260}{589.4} = 134# \text{ per sq. in.} \text{ Too high. Increase depth.} \\
A_s &= 0.0077 \times 24 \times 23.1" = 5,933 \text{ sq. ins.} \\
\text{Use: } 5 - 1" \text{ sq. bars.} \\
\text{Increase } (d) \text{ to 32.5} \\
\frac{v}{2} &= \frac{79,260}{24 \times 38.5 \times 0.874} = \frac{79,260}{807.6} = 98# \text{ per sq. in.} \text{ O.K. Web reinforcement is necessary - also use haunches on columns} \\
\text{Bond} \\
\frac{u}{2} &= \frac{79,260}{0.874 \times 38.5 \times 5.4} = \frac{79,260}{673.0} = 117# \text{ per sq. in.} \text{ O.K. Hook bars} \\
\text{Make total depth of beam} &= 40.0" \\
\end{align*} \\
A \text{ beam with a depth of forty inches, using 5 - 1" sq. steel bars in the top and bottom for compressive and tensile strength and these joined together at the critical points of shear by } \frac{3}{8}" \phi \text{ steel stirrups, satisfied every requirement for strength, shear and bond. The long 1"sq. (o) bars were hooked}
at the ends to provide more area of steel against concrete, thus providing more bond. At the places of maximum shear, near the edges of the columns, the columns were flared on both sides 18 inches, to better take the shear of the concentrated wheel loads of the cars. \( \frac{3}{4} \)" \( \phi \) \((x)\) and \((z)\) bars were used, as shown on the drawing, to brace the concrete beam with the column.

The reinforced concrete beam having been designed, suitable footing for its support had to be found. The total dead load that was to act on each column and footing was found to be 115,360 pounds, counting in the dead load of the concrete beam which amounted to 7,900 pounds. An 18 inch square column, supported on suitable footing, would have been ample for the load designing the concrete for 2000 pound strength, using a mix of 1:2:4, as it would support 125,000 pounds. A square 24 inch column was used to provide more room for the vertical steel to be placed inside the column and to give a larger safety factor. \( \frac{1}{2} \)" \( \phi \) \((n_1)\) \((n_2)\) and \((n_3)\) bars were used in the corners of the 24 inch square columns, the bars all being the same weight bars, but varying in length as to the place they were to be used. These bars were tied together above the footings by \( \frac{1}{4} \)" \( \phi \) \((o)\) bars, spaced at 18 inch centers. The length of the \((n)\) bars and the number of the \((o)\) bars to each column varied as the west columns were not taken to as low an elevation as the middle cross beams support columns or the east column, a shelf being left under the west incline of the hopper, as the space under the incline was not needed and ample support for braces could be derived by bracing up from this
shelve, thereby breaking the long span of the west incline from the top of the west end of the hopper, down to the reciprocating feeder opening. The footings for the columns were carried on the east, north and south sides of the hopper down well into the black slate, but the west footings not going so deep, didn’t get into the black slate but were in the blue shale. All of the footings were on good solid bearing. Following are computations for the design of the reinforced concrete footings:

**DESIGN COLUMN AND FOOTINGS**

- Wt. of 1 car on 1 column = 35,000#
- Wt. of 1 car loaded with coal = 70,000#
- Dead load I-beam and rail = 2,460#
- Total Dd. load acting on beam = 107,460#

Estimated dead load of beam on each column = 150(5.0x14.0x2.5) = 7,900#

Total Dd. load on each column = 115,360#

Column load = 115,360#

Make footings 6’0” square \[ \frac{115,360}{36} = 3,200/ \text{sq. ft.} \]

(Good safety factor on shale.)

Soil value figured at 3200# per sq. ft.

Net area = 36 - (2.0)^2 = 32 sq. ft.

\[ 8 \times 115,360 = 99,500 \text{#} - \text{Punching force.} \]

Perimeter of column = 24”x 4 = 96”

\[ \frac{99,500}{96 \times 120} = \frac{11,500}{11,500} = 8.6” \text{ (Minimum depth of footing)} \]
Make \( d = 22'' \)

**COMPUTING DIAGONAL TENSION**

Side of square = \( 24 + 2 \times 22 = 68'' = 5.66'' \)

\[
\frac{c}{a} = \frac{5.66}{6.0} = 0.94
\]

\[
c_{f1} = \frac{1}{4} (1 - (0.94)^2) = 0.03
\]

\[
v = \frac{0.03 \times 115,360}{68 \times 0.874 \times 22.0} = \frac{3460}{1500} = 3\# \text{ per Sq. In. O.K. (No shear reinforcement necessary)}
\]

**BENDING MOMENT**

\[
\frac{c}{a} = \frac{2}{6} = 0.333 \quad c_{f} = 0.043
\]

\[
M = 0.043 \times 115,360 \times 6 \times 12 = 357,100\# \text{ Ins.}
\]

**COLUMN FOOTINGS**

\[
As = \frac{357,100}{0.874 \times 16,000 \times 22.0} = \frac{357,100}{307,600} = 1.16 \text{ sq. ins.}
\]

Use: 10 - 3/8" bars both ways in footing @ 6\( \frac{3}{8}'' \) ctrs.

**Periphery** = \( 10 \times 1.178'' = 11.8'' \)

**BOND** Shear at one edge of column = \( \frac{99,500}{4} = 24,900\# \)

\[
u = \frac{24,900}{0.874 \times 22.0 \times 11.8} = 109\# \text{ per sq. in. Too high}
\]

Effective width = \( 24 + 2 \times 22 = 68'' = 5' - 8'' \) (No steel should be placed 4" from the sides)

Increase \( d \) to 24"

\[
As = \frac{357,100}{16,000 \times 0.874 \times 24.0} = \frac{357,100}{335,500} = 1.06 \text{ sq. ins.}
\]

Use 10 - 3/8" bars each way in footings.

**BOND** \( u = \frac{24,900}{0.874 \times 16,000 \times 11.8} = 100\# \text{ per sq. in. O.K. for deformed bars.} \)
The total depth of the footings were made 26 inches, the size of each footing being 6' X 6' X 2'-2". The steel to be used satisfied every requirement for area of steel, bond and shear.

The walls behind the west and east columns were computed, using the Theorem of Three Moments. All walls of the hopper were designed, figuring the wall as a vertical slab supported at the ends by the action of the adjoining two walls against it. In the case of the walls behind the two columns, the earth pressure and dead and live loads are resisted by the two columns as well as the two adjoining walls, giving four different reactions against the load to be taken care of and for this reason, the Theorem of Three Moments had to be used. Following are computations for the design of the walls behind the west and east columns and concrete cross beams:

Width at top of wall taken as 12 inches.

Maximum depth of earth fill, using no surcharge = 17.0'

Uniform distributed earth pressure at a depth of 17.0' = 500# per Ft.

Maximum Moment = Negative moment at R₂ and R₃

\[ M_1 = M_4 \]

\[ M \oplus R_2 = (1) M_1 L_1 + 2M_2 (L_1+L_2) + M_3 L_2 = \frac{-W_1 L_1^3}{4} - \frac{W_2 L_2^3}{4} \]
(2) \( M_2 \cdot L_2 + 2M_3 \cdot (L_2 + L_3) + M_4 \cdot L_3 = \frac{W_2 \cdot L_2}{4} \cdot 3 - \frac{W_3 \cdot L_3}{4} \cdot 3 \)

**SUBSTITUTING VALUES**

(1) \( 2M_2 \cdot (10.0 + 6.2) + 6.2 \cdot M_3 = -\frac{W_1 \cdot L_1}{4} \cdot 3 - \frac{W_2 \cdot L_2}{4} \cdot 3 \)

(2) \( 6.2 \cdot M_2 + 2M_3 \cdot (6.2 + 10.0) = -\frac{W_2 \cdot L_2}{4} \cdot 3 - \frac{W_3 \cdot L_3}{4} \cdot 3 \)

(1) \( 32.4 \cdot M_2 + 6.2 \cdot M_3 = - \frac{500 \cdot (10.0)^3}{4} - \frac{500 \cdot (6.2)^3}{4} \)

(2) \( 6.2 \cdot M_2 + 32.4 \cdot M_3 = - \frac{500 \cdot (6.2)^3}{4} - \frac{500 \cdot (10.0)^3}{4} \)

(1) \( 32.4 \cdot M_2 + 6.2 \cdot M_3 = -125,000 - 29,800 \)

(2) \( 6.2 \cdot M_2 + 32.4 \cdot M_3 = -29,800 - 125,000 \)

(2) \( M_3 = \frac{-154,800 - 6.2 \cdot M_2}{32.4} \)

Multiplying (1) by 5.22 and subtracting equation (2)

(1) \( 169.1 \cdot M_2 + 32.4 \cdot M_3 = -808,060 \)

\( 6.2 \cdot M_2 + 32.4 \cdot M_3 = -154,800 \)

\( 162.9 \cdot M_2 = -653,260 \)

\( M_2 = -4,010 \# \text{ Ft.} = -48,120 \# \text{ ins.} \)

\( M_2 = M_3 = -48,120 \# \text{ Ins.} \)

\( v_2 = \frac{M_3 - M_2 + W_2 \cdot L_2}{L_2} \cdot 2 = -\frac{4010 - (-4010)}{6.2} + \frac{6.2 \cdot 500}{2} \)

\( v_2 = 1550\# \)

\( v_1 = \frac{4010 - 0 - 500 \cdot 10}{10.0} \cdot 2 \)

\( v_1 = 401 + 2500 \)

\( v_1 = 2900\# \)

\( v_1 = v_1 - \frac{W_1 \cdot L_1}{2} = 2900\# - 500 \cdot 10 \)
\[ v_2^1 = -2100# \quad R_1 = v_1 = 2900# \]
\[ R_2 = v_2 - v_1^1 = 1500# - 2100# = 3600# \]
\[ R_3 = 3600# \]
\[ R_1 = 2900# \]
Distance from left support to point of zero shear
\[ X_1 = \frac{2900}{500} = 5.8' \]
\[ X_2 = \frac{1500}{500} = 3.1' \]
\[ X_3 = 5.8' \]
Maximum moment was found to be negative moment of \(-48,120#\) ins.
Solving for necessary depth of wall at bottom of wall
\[ d = 0.096 \quad \frac{48,120}{12} = 0.096 \quad 4010 = 0.096 \times 63.5 \]
\[ d = 6.1' \]
Top width of wall was made twelve inches, so the bottom width of wall was increased to twelve inches, making both walls behind the reinforced concrete beams and columns a thickness of one foot from top of wall to bottom of wall.

\[ As = \frac{48,120}{16,000 \times 0.874 \times 10.5} = 0.31 \text{ sq. ins.} \]
Use \(\frac{3}{4}\) sq. (h9) bars @ 12" ctrs. up the walls
\[ v = \frac{V}{b \cdot d} = \frac{2100 - \frac{1}{2} (10 \times 500)}{12 \times 10.5} = \frac{4600}{126} = 36# \text{ per sq. in. O.K.} \]
\[ u = \frac{V}{b_1 \cdot d} = \frac{4600#}{0.874 \times 10.5 \times 1 \times 2.0} = \frac{4600}{18.3} = 25# \text{ per sq. in. O.K.} \]
The bars were bent with a forty-five degree bend to reach the dirt face of the wall to take the negative moment behind the columns. \(\frac{3}{4}\) sq. \(v_1\) and \(v_2\) bars were used vertically in walls to provide temperature reinforcement. All of the reinforcement was
placed on the inside of the walls away from the earth face the main reinforcement running parallel with the top of the wall and the temperature steel running vertically. The steel ratio \( p \) used was 0.003.

The south wall of the hopper was made twelve inches wide at the top and by using the Theorem of Three Moments, the bottom width was ascertained, this width being found to be 18\( \frac{1}{2} \) inches. The long space of the wall was broken by a reinforced concrete column, 24 inches square, the top of the column being high enough to set the 24\( " \) - 120\# steel I-beam on to support the I-beams carrying the tracks. (See drawing No. K-2-6 for arrangement of steel I-beams). The requirements for bond, shear and area of steel was satisfactory the entire height of the wall, the heaviest steel being at the bottom of the wall and decreasing in weight as the top of the wall was approached. The same percent of temperature reinforcement was used in all the walls, \( \frac{1}{2} \)" sq. (\( v_4 \)) bars being used at 12 inch centers, the bottom fifteen inches being bent down so the floor would be fastened to the walls. This was done to the vertical steel on all walls. Following are the computations for the design of the south concrete wall:

**WORKING STRESSES**

\[
\begin{align*}
    f_s &= 16,000\# \text{ per sq. in.} \\
    f_c &= 650\# \text{ per sq. in.} \\
    p &= 0.007 \\
    C &= 0.096 \\
    d &= C \frac{M}{b}
\end{align*}
\]
Figuring horizontal pressure - no surcharge @ 24' from top of wall.

Unit pressure @ h = 22'-0" = 650#

R₁ = 3/8 w₁ = 0.375 × 650 × 19.5 = 4700#

Max. pos. mom. @ 3/8 l from lt and rt supports = 0.070 × 650 × (19.3)² × 12 = 203,400# ins.

Max. Negative moment = - 1/8 w₁² = - 0.125 × 650 × (19.5)² × 12 = - 363,200# ins.

**NO LIVE LOAD**

\[ d = 0.096 \times \sqrt{\frac{363,200}{12}} = 0.096 \times \sqrt{30,500} \]

\[ d = 0.96 \times 174.0 \]

\[ d = 16.7" \]

Maximum shear = 5/8 w₁ = 0.625 × 650 × 19.3

\[ (v₂) = 7840# \]

\[ v = \frac{7840}{0.874 \times 12 \times 16.7} = \frac{7840}{175.1} = 44# \text{ per Sq.In.} \]

Web reinforcement needed - place 12" haunches on column in center of slab.

As = 0.0077 × 12 × 16.7 = 1.543 Sq. ins. per ft.

Use 1" bars @ 6" ctrs.
\[
u = \frac{7840}{0.874 \times 16.7 \times 2 \times 3.142} = \frac{7840}{9.13} = 85\text{# per sq. in.}
\]

0.K. for deformed bars.

Make total depth of base wall = 18.5"

\[
\text{Distance from center support to point of zero shear} = x_2 = \frac{V_2}{650} = \frac{1330}{650} = 2.0
\]

@ 4' above base of stem. Thickness of stem @ 4' = 1.45'

\[
(d) = 1' - 4" = 16.0"
\]

Unit pressure of earth @ 17' = 500#

Max. Pos. moment = \(0.070 \times 500 \times (19.3)^2 \times 12 = + 156,500\text{# ins.}\)

Max. Neg. Moment = \(-0.125 \times 500 \times (19.3)^2 \times 12 = -279,400\text{ # ins.}\)

As = \[
\frac{279,400}{16,000 \times 0.874 \times 16.0} \times \frac{279,400}{223,700} = 1.248 \text{ sq. ins. per ft.}
\]

Use 7/8" bars @ 6" ctrs.

@ 8' above base of stem. Thickness of wall @ 8' = 1.365'

\[
(d) = 1.24' = 1' - 3" = 15"
\]

h = 13.0'

p = 380# per ft.

Max. Pos. Moment = \(0.070 \times 380 \times (19.3)^2 \times 12 = + 118,600\text{ # ins.}\)

Max. Neg. Moment = \(-0.125 \times 380 \times (19.3)^2 \times 12 = -211,800 \text{ # ins.}\)

As = \[
\frac{211,800}{16,000 \times 0.874 \times 15.0} \times \frac{211,800}{209,700} = 1.01 \text{ sq. ins. per ft.}
\]

Use 1" sq. bar @ 12" ctrs.

@ 12' above base of stem. Thickness of wall = 1.28'

\[
(d) = 1.15' = 1' - 2" = 14.0"
\]

h = 9'

p = 270# per ft.

Max. negative moment = \(-0.125 \times 270 \times (19.3)^2 \times 12 = -150,900\text{ # ins.}\)

As = \[
\frac{150,900}{16,000 \times 0.874 \times 14.0} \times \frac{150,900}{195,700} = 0.765 \text{ sq. ins. per ft.}
\]

Use 1" @ bar @ 12" ctrs.
@ 16' above base of stem

(d) = 15.0"

h = 5.0'  p = 150#

Max. negative moment = - 0.125 X 150# X (19.3)² X 12 = -83,800# ins.

As = \frac{83,800}{16,000 \times 0.874 \times 15.0} = \frac{83,800}{181,700} = 0.461 \text{ sq. ins. per ft.}

Use 3/4" ø bar per ft.

@ 18' above base of stem

(d) = 12.5"

h = 3.0'  p = 90#

Max. neg. moment = - 0.125 X 90# X (19.3)² X 12 = -50,290# ins.

As = \frac{50,290}{16,000 \times 0.874 \times 12.5} = \frac{50,290}{174,800} = 0.287 \text{ sq. ins. per ft.}

Use \frac{1}{2}" sq. bars @ 12" ctrs. from here up to top of wall.

@ 6' above base of stem

(d) = 15.5"

h = 15'  p = 440# per ft.

Max. Neg. Moment = - 0.125 X 440# X (19.3)² X 12 = -245,800# ins.

As = \frac{245,800}{16,000 \times 0.874 \times 15.5} = \frac{245,800}{216,700} = 1.154 \text{ sq. ins. per ft.}

Use 7/8" ø bars @ 6" ctrs.

@ 10' above base of stem

(d) = 14.5"

h = 11.0'  p = 320# per ft.

Max. negative moment = - 0.125 X 320 X (19.3)² X 12 = -178,800# ins.

As = \frac{178,800}{16,000 \times 0.874 \times 14.5} = \frac{178,800}{202,700} = 0.881 \text{ sq. ins. per ft.}

Use 1" ø bar @ 12" ctrs.
@ 14' above base of stem

\( d = 13.5'' \)

\( h = 7.0' \) \hspace{1cm} \( p = 200\# \text{ per ft.} \)

Max. negative moment: \( -0.125 \times 200 \times (19.3)^2 \times 12 = -111,800\# \text{ ins.} \)

\[
As = \frac{111,800}{16,000 \times 0.874 \times 13.5} = \frac{111,800}{188,700} = 0.592 \text{ sq. ins. per ft.}
\]

Use 7/8" \# bars @ 12" ctrs.

The design of the north wall of the reinforced concrete hopper was computed similar to the south wall except, because of the fact that the conveyor incline breaks the north wall at a distance of 7'-3" from the outside northeast corner of the hopper, the wall was designed, using the section of walls as a simple beam from the center of the middle column to the retaining wall and then from the center line of the column to the west end of the wall. The required steel was computed for the two different sections. The section of wall under the drag conveyor was reinforced with \( \frac{3}{8}'' \) sq. bars horizontally and \( \frac{1}{8}'' \) sq. bars @ 12" centers vertically, the section of the wall east of the conveyor incline was reinforced with \( \frac{1}{8}'' \) sq. bars at 12" centers horizontally and vertically because of the short span. Following are computations for the north wall:

Figuring horizontal pressure using no surcharge and figuring section of wall as a simple beam. From bottom of floor up to top of retaining wall at west end of hopper = 8'-3".

Span length center line of column to center line of retaining wall = 12'-3"
@ depth = 21' below grd. level @ top of floor  \( p = 620\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{620\# \times (12.67)^2 \times 12}{8} = +147,000\# \text{ ins.}
\]

\[
d = 0.096 \sqrt{\frac{147,000}{12}} = 0.096 \sqrt{12,250} = 0.096 \times 110.6 = 10.7''
\]

\( d = 10.7'' \)

Make thickness at base = 18.5'' (Same as south wall)

\[
As = \frac{147,000}{16,000 \times 0.874 \times 16.7} = 0.631 \text{ sq. ins. per ft.}
\]

\( \frac{7}{8}'' \phi @ 12'' \text{ ctrs.} \)

@ 3' above top of floor  \( h = 18.0' \)  \( p = 530\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{530\# \times (12.67)^2 \times 12}{8} = +120,950\# \text{ ins.}
\]

\[
As = \frac{120,950}{16,000 \times 0.874 \times 16.2} = 0.533 \text{ sq. ins. per ft.}
\]

\( \frac{5}{8}'' \phi @ 12'' \text{ ctrs.} \)

@ 6' above top of floor  \( h = 15.0' \)  \( p = 440\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{440 \times (12.67)^2 \times 12}{8} = +101,200\# \text{ ins.}
\]

\[
As = \frac{101,200}{16,000 \times 0.874 \times 15.5} \ast = 0.467 \text{ sq. ins. per ft.}
\]
COMPUTING STEEL ABOVE JOG CAUSED BY RETAINING WALL

@ 8' above base of stem  \( d = 15'' \)  \( h = 13' \)  \( p = 380\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{380\# \times (21.33)^2 \times 12}{8} = + 259,350\# \text{ ins.}
\]

\[
As = \frac{259,350}{16,000 \times 0.874 \times 15.0} = \frac{259,350}{209,700} = 1.23 \text{ sq. ins. per ft.}
\]

@ 12' above base of stem  \( d = 14.0'' \)  \( h = 9' \)  \( p = 260\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{260\# \times (21.33)^2 \times 12}{8} = + 177,450\# \text{ ins.}
\]

\[
As = \frac{177,450}{16,000 \times 0.874 \times 14.0} = \frac{177,450}{195,700} = 0.911 \text{ sq. ins. per ft.}
\]

@ 16' above base of stem  \( d = 13'' \)  \( h = 5.0' \)  \( p = 150\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{150\# \times (21.33)^2 \times 12}{8} = + 102,400\# \text{ ins.}
\]

\[
As = \frac{102,400}{16,000 \times 0.874 \times 13.0} = \frac{102,400}{181,200} = 0.52 \text{ sq. ins. per ft.}
\]

@ 18' above base of stem  \( d = 12.5'' \)  \( h = 3.0' \)  \( p = 90\# \) per ft.

\[
M = \frac{WL^2}{8} = \frac{90\# \times (21.33)^2 \times 12}{8} = + 61,400\# \text{ ins.}
\]

\[
As = \frac{61,400}{16,000 \times 0.874 \times 12.5} = \frac{61,400}{174,800} = 0.35 \text{ sq. ins. per ft.}
\]
The areas of steel for the different sections of wall having been computed, the required steel for the wall was listed on the drawing.

The walls of the conveyor incline were reinforced with \( \frac{3}{4} \)" sq. stock steel at 12" centers horizontally and vertically, the walls to be poured first. \( \frac{1}{2} \)" sq. steel bars bent up into the walls were to be left in the sides of the conveyor walls and extending across the conveyor for main tension steel for the conveyor floor, this steel being placed at 12" centers up the incline of the conveyor.

The vertical and horizontal steel used in the walls was tied together securely and held within one and one-half inches of the inside face of the walls. All of the steel was cleaned of all dirt and kept either perfectly horizontal or vertical.

The computations for the design of the reinforced concrete hopper were computed in the office and took some time to complete them. Reinforcement was also computed for the bottom of the main floor and for the shelves left in the hopper at the west end. Piers to catch the different slopes of the hopper were computed as well as piers upon which to set the machinery. A reinforced concrete beam was designed to span the drag conveyor incline and to hold the top of the north hopper incline. The proper position for all \( \frac{3}{16} \)" bolts to catch the top of the hopper inclines and to hold the machinery was also laid out on the drawing. Two different views of the hopper were made (Drawings Nos. k-2-6 and k-2-7) and, owing to the amount of data that had to be placed on one of them, the drawing is rather congested.
A steel bending diagram was also made (See Diagram No. K-2-8).

SURVEY OF HOPPER

The center line of the reinforced concrete hopper (center line of the tracks across hopper) was laid out at a distance of one hundred and seventy-six and seven-tenths feet (176.7') parallel to the center line of the nut track of the track layout at the tipple, the nut track being the third track from the outer track or runaround. This distance was fixed by the vertical height above the proposed rail elevation of the tracks at the center line of the tipple (center line of drag conveyor), the height of the point the coal conveyor hits the tipple itself and by the slope of the coal or drag conveyor.

The tipple foundations, having been laid out, the hopper was surveyed by setting the transit up at the intersection of the line of the drag conveyor and center line of the nut track, which was straight track, sighting at a stake in the center line of the nut track some distance away, turning a right angle off that point and then chaining one hundred seventy-six and seven tenths feet (176.7') slightly southeast along the line of the proposed conveyor and setting the transit up at this point, this point being the center line of the hopper northeast by southwest. Setting the transit up at this point and back sighting on the point in the center line of the nut track on the drag conveyor line, a right angle was turned off and points on the extreme west and east ends of the hopper were set as well as permanent points thirty feet away from the hopper, on both sides were set for permanent reference points. Permanent points were
also set on both sides of the proposed hopper along the line of the drag conveyor. These permanent stakes were well set and well preserved. Several stakes having been set on the outside edges of the proposed hopper, the hopper was then surveyed, placing stakes at the corners of the proposed hopper and at the point where the conveyor hit the natural ground line. These stakes were set to excavate the hole for the hopper.

**EXCAVATION FOR HOPPER**

The hole for the proposed hopper was excavated, using a Diesel motor drag line made by the Bucyrus-Erie Company. This drag line is a three cylinder oil burning machine, with a one cubic yard bucket.

The proposed hopper was to be 43'-6" long by 28'-0" wide with the coal conveyor incline being 13'-4" wide, the distance from the north edge of the hopper to the point where the conveyor intercepted the natural ground line being 33'-0". The total area the hopper occupies within it's outside boundaries, is 1600 square feet. The maximum depth below the natural ground line that had to be excavated was 22'-5"; this being from the east end of the hopper over to the dirt shelf that was to be left at the west end of the hopper a distance of 34'-9". The distance from the top of the shelf to the natural ground was 15'-0"; the width of the shelf being 9'-9". The depth of the ground to be excavated in digging the conveyor incline varied in depth from 18 feet to no excavation at the point of intersection with the ground line.

The walls of the hopper were to be formed on both
sides to eliminate the danger of the ground caving in. The ground that was excavated would stand at a slope of $1\frac{1}{4}$ to 1 it was estimated, and the hole dug with that in view. The drag line was placed north of the proposed hole and a hole was excavated large enough, that a slope of $1\frac{1}{4}$ to 1 could be carried down to a point of one foot outside the neat lines of the proposed structure. The drag line, with it's 50 foot boom, had to change it's position constantly, keeping back from the edge of the excavation a distance of five or six feet on solid ground, to eliminate any danger of the ground caving in and letting the drag line fall into the hole. The ear shelf at the west end was left by the drag line, the drag line then digging the main section of the hopper deeper. After this main section of the hole was excavated, stakes were given the drag line operator to excavate the conveyor incline, which was very easily done, although the excavation on the incline was carried a trifle low in places.

The volume of earth excavated in digging the hopper hole was eighteen hundred cubic yards, the total actual time taken to dig the hole was seven days, or an average of two hundred seventy cubic yards per day, which was very good, considering the time lost in the deeper excavation. The cost of excavation was $0.10 per cubic yard.

No great difficulties were experienced in digging the hopper holes, however, on the west and south sides of the excavation, several cave ins occurred that necessitated cleaning up with the corresponding amount of needless excavation.
PREPARATIONS FOR CONSTRUCTING HOPPER

The excavation for the hopper having been completed, a cement shed large enough to hold several thousand sacks of cement was constructed near the hopper site, and several cars of cement were ordered for it. The necessary lumber for the hopper consisting of ship-lath, 2 x 4s, 2 x 6s and 2 x 12s were ordered and hauled on the ground site. Eleven cars of chat were ordered as well as six cars of Arkansas River sand. All other necessary material, such as nails, reinforcement wire was bought. The men necessary to build the hopper were hired, these consisting of the company's foreman of carpenters, several assistant carpenters, six laborers besides the concreting crew. The actual pouring of the concrete was let by contract for $2.50 per cubic yard, this consisting of the concrete foreman furnishing the concrete mixer, wheelbarrows and the men necessary to haul the concrete, dump it into the forms and thoroughly spade it, working it around the reinforcing bars.

CONSTRUCTING HOPPER

The walls of the hopper were poured before the floors, for safety, to prevent any earth from caving in, although the earth had been excavated back to a point away from the walls so no difficulty was expected from this source. It was deemed easier and better alignment of the walls could be obtained by squaring up the sides of the hopper, getting the proper batter of the walls set and then carry the walls up to the top. Three carpenters were used in forming the walls, while the laborers helped them get the steel in the proper place, securely tied it
together and brought lumber to the carpenters. The walls were formed on both sides, 8" width ship-lath being used with 2 x 4s vertically placed. 2 x 6s were placed across the inside of the hopper for bracing at four foot spacing, every four feet, from the bottom of the walls to the top. After the first four feet of walls were poured, the men would work overtime and raise the deck up four feet, so the concreting crew could work the first thing the next day. The outside wall form was braced against the walls with 2 x 4s, nailed to the forms, and to stakes driven in the earth. 2" x 12" lumber was laid down on the 2 x 6s inside the hopper to allow the concreting crew to haul the concrete in the wheel barrows to the forms. A twelve inch reinforced concrete retaining wall was poured to support the shelf of earth left in the west end of the hopper and to keep out seepage of water from this earth. One-half inch square bars were used at 12 inch intervals, horizontally and vertically. Bolts were left in the top of the retaining wall to catch a 6" x 6" timber. The horizontal steel used in the walls was wired to the vertical temperature bars tightly, and the steel wired to the inside wall form at various intervals, in order to keep the reinforcement in close to the inside face of wall at a distance of one and one-half inches. The main tension reinforcement was horizontal, as has been said before. The concrete used in the walls was of a mix of 1:1\frac{2}{3}:3\frac{1}{3}, the coarse aggregate used, being Joplin washed chats, while the fine aggregate used was Arkansas River sand. The cement used was a good standard cement, the number of sacks used per cubic yard of material being seven. The concrete poured
into the walls was poured rather wet as it facilitated the
tamping of the concrete around the reinforcement. It was im-
possible to pour the concrete dry, because of the inability to
properly tamp it and because of the fact that "honeycomb" places
would have been left in the walls. The concrete was kept at a
rich mixture, just enough water being used to allow the men to
properly tamp the concrete around the steel. Each batch of
concrete was left in the concrete mixer a full minute, an inspector
checking the batcher and amount of material used per batch. The
concrete was very well tamped, three men having been used in this
operation. As the walls of the structure were built higher,
wire spaces were placed at regular intervals and twisted to hold
the forms at the correct distance apart. Bolts of \( \frac{3}{4} \) inch diameter
and imbedded eight inches in the walls were placed at the proper
places, enough of the bolts being left out to catch a 6" x 8"
timber. (See drawing No. K-2-6 for proper location of bolts).
These bolts were set at the proper elevations with a level, and
at the proper distances apart, holes being drilled in the wood
forms and a timber fastened over the bolts to keep all of them in
the walls at the same distance out of the concrete.

The walls of the conveyor were poured first, the walls
being taken down into solid ground and a small footing poured for
them to rest on. At the elevation of one and one-half inches
above the bottom of the floor of the conveyor, one-half inch
square steel bars, the length of the width of the conveyor, were
left in the walls at twelve inch intervals. These bars were bent
six inches on the ends to allow them to stick up in the walls of the
conveyor incline and provide more bond. At a distance of fifteen
feet and thirty-two feet six inches up the incline from the inside edge of the hopper, the landings for the drag conveyor were made and for that reason a footing was poured under each of these to support the conveyor, as too much earth had been taken from underneath the bottom of the proposed incline. This necessitated forming the concrete piers to support the floor of the conveyor. The floor of the conveyor was then built and longitudinal steel at twelve inch centers was tied to the bars across the width of the hopper. The conveyor incline was poured by spouting the concrete down the incline, a cover being built over the incline twelve inches above the bottom of the floor, as the pouring preceded to the top of the conveyor. Truscon waterproofing paste was used in the floor of the main hopper and in the incline floor, about one pint of waterproofing paste being used per batch of concrete. At the proper places, the small piers were built and bolts left in the tops of them to catch the conveyor landings. Bolts were also left on both sides of the middle of the conveyor to catch a runway to be built later. The hopper was kept dry by the use of a pump installed in the bottom of the hopper.

The floor of the shelf at the west end of the hopper was next poured, 1/2" square bars used each way in the bottom of the floor, the same mix being used and waterproofing paste also being used. The concrete was spouted down into the hole. The steel was allowed to extend into the vertical retaining walls left unpoured near the top, so this wall and the floor were tied together.
It was desired to obtain permanent drainage for
the hopper so that a pump would not have to be installed in
the hopper. The top seam of coal is found at a depth of thirty
feet at the hopper. The deeper and thicker seam of coal is
found ninety feet underneath this seam of coal. It was thought
this bottom seam of coal has been worked out by the workings
of the old Katy No. 6 mine and that if a drill hole was placed
down to these old workings, permanent drainage could be
obtained. Pouring of the main floor of the hopper was held
up for a few days and a drill rig lifted into the hole by the
aid of the drag line and two holes drilled to the bottom seam
of coal, but coal was encountered in both holes. The drill
rig was then lifted out of the hole, the result of the drilling
being that a pump had to be installed in the hopper to be used
in pumping what water could leak into the structure.

The main floor of the hopper was next poured, waterproofing paste being used, the concrete consisting of the same
mix, although poured a trifle dryer. One-half inch bars at
twelve inch centers both ways, were used in the bottom of the
floor. The concrete was spouted down the conveyor incline
and the steel was securely fastened together and held up above
the dirt by the use of bricks, which were taken out later.
The waterproofing paste in the concrete made it an oily mixture
that worked very nicely. The concrete was tamped wherever it
needed tamping. Pieces of \( \frac{1}{2} \)" square bars were left in the
concrete at the proper places, in order that the concrete
piers for the different machinery could be poured the next
day. The center line of the hopper and the center lines of
the different machinery to go into the hole had been laid off and lines drawn on the walls of the hopper previous to pouring the floor. Stretching a string on the center line of the hopper and another one on the center line of the machinery, located it's position on the floor of the hopper. Several bolts were left in the floor to catch a six inch I-beam that was to help support the lower end of the east hopper incline. A sump, into which any water that might leak into the hopper might drain, was dug on the south side of the main floor of the hopper near the concrete retaining wall. A pump installed on bolts left in the floor of the shelve would then pump the water out of the sump out of the hopper. Small trenches in the concrete floor were left draining toward the sump. The top of the sump was placed five inches below the top of the floor grade, and the bottom of the sump reached three feet below the bottom of the floor. The sump had been placed over one of the drill holes drilled to the lower seam of coal. The men had been told to plug the two holes up good, with sacks and mud, and had presumably done so. About twelve inches of concrete was poured into the hole and the barrel that was to be used as a form, placed inside it and concrete poured around it up to the desired level, which was five inches below the top of the floor grade. Later on it was observed, that the top of the barrel in the sump had risen to a height above the floor grade. All of the concrete was then taken out of the hole and it was found that the drill hole was leaking water and that this hydraulic pressure was causing the barrel to raise, even though it was tied down to the floor reinforcement.
The drill hole was now thoroughly plugged up, and the concrete for the sump repoured, no difficulty now being experienced from this cause.

The piers for the machinery in the hopper was next poured, the mix of this concrete being 1:3:5 and the mixture not very wet. No waterproofing paste was used in these piers. The forms for the piers had previously been built. The machinery in the bottom of the hopper consists of the reciprocating feeder and eccentric, the Reeves transmission and the motor to drive the reciprocating feeder. (The position of the different machinery relative to each other, is shown by Drawing No. K-3-11.) The top of the piers of the eccentric and reciprocating feeder were built on an incline so that the reciprocating feeder would shed the coal easier onto the drag conveyor. The Reeves transmission is a device used to give steady operation at any speed of the reciprocating feeder, the eccentric to give it the necessary back and forth jerky motion so that the coal that falls onto the reciprocating feeder will be discharged readily onto the conveyor. Bolts were left in the top of the piers to catch 10" x 10" timbers, to which the machinery were bolted. One-half inch steel bars had been left in the floor at the proper location of the small columns to catch the bottom ring set of the hopper. These reinforced concrete columns were now poured and bolts left in the top of them to catch 10" timbers for the bottom ring set. Small piers, to fasten the bottom of the drag conveyor to the hopper floor, were also poured and bolts left in them to catch the conveyor. The reciprocating feeder, eccentric, Reeves transmission and
motor were set and fastened by the bolts left in the concrete piers and projecting through the 10" timbers. The different machinery fit very well in respect to each other, when bolted to their respective timbers.

The concrete for the walls, floor and machinery, piers having been poured and the machinery fastened to their respective piers, the inside wooden inclines of the hopper were formed. These inclines are built to allow the coal discharged from the coal cars to fall on them and be carried to the mouth of the hopper or on to the reciprocating feeder. The slope of the incline on the west side of the hopper or the end of the hopper, where the coal is discharged from the coal car, is a more gentle slope than the other slopes. This slope is on a 42 degree incline from the horizontal, the slope beginning at the top of the hopper and going on a 42 degree incline to the reciprocating feeder, the other inclines from the other walls being on a 45 degree pitch, converge and meet the 42 degree slope on the outside edges of the west, north and south edges of the reciprocating feeder, while the slope from the east side, or side closer to the discharging end of the reciprocating feeder, is built 4'0" from the end of the 42 degree slope. The opening at the discharge end of the slopes was made 5'0" by 4'0", the 5'0" length paralleling the conveyor, this giving 20 square feet of opening. The inside of the hopper, or the inclines, was formed by fastening 6" x 8" timbers to the bolts left in the walls at the top of the proposed inclines, this comprising what is known as the top ring set. Timbers were then formed over the small reinforced columns, extending up from the concrete floor, this
comprising the lower ring set. Timbers used in the lower ring set were 8" x 10" timbers. An opening the width of the reciprocating feeder and 30 inches high was formed with 8" x 10" timbers, this comprising the area that the coal would be discharged off the reciprocating feeder and on to the drag conveyor. The lower and top ring sets having been formed, long 8" x 8" stringers spliced with bolts when necessary, to make the necessary length were bolted at one end to the top ring set and at the lower end to the lower ring set. These stringers were set at about 30 inch centers, the four stringers from the corners of the hopper being bolted down first, the other stringers were built to them. Bolts of 3/4" round diameter were used to bolt the stringers together. A brace of timbers was built up from the timber placed on bolts left in the concrete retaining wall on the shelf. This reduced the strain on the long 42 degree incline coming down from the west end of the hopper. Timber was then laid on these long stringers, running parallel with the top edges of the respective sides of the hopper. The timber used in this construction was of 3" x 12" dimension. These timbers were nailed securely to the large stringers. The inside of the hopper having now been formed, sheet steel of 3/16" thickness was nailed on the 3" x 12" timbers, so that the entire area of the hopper inclines was covered with the sheeting. All irregular surface of the sheeting was smoothed down so that the coal would be able to slide down the incline smoothly. Three carpenters and several laborers were used in forming the inside of the hopper. The inside forming of the hopper was completed in eight days working time.
The large steel I-beams to carry the tracks across the hopper were carried to their respective places by rolling them over the ground on rails. It had been planned to let the drag line lower the I-beams into their respective positions, but at the time work was begun on placing these beams, the drag line was digging a large ditch a mile away so it was thought best not to bring it back to lower the beams, but to move them with rails and men. The cross I-beam to set on the center columns and to support the four long 20" - 70# I-beams carrying the rails was lowered into place by laying one rail end on back pier and the other end laying up against the west edge of the hopper. The rails were then greased and the I-beams allowed to slide down these rails, held back by ropes securely fastened, until the beam set on the columns. It was then placed in it's proper position and the four other I-beams were rolled to their position by means of the rails and eight men. It took one day to get the steel beams in to their proper positions.

The track across the hopper was constructed next, this track having already been constructed up to a distance of eighty feet southwest of the west end of the hopper. This track is a spur built from the Missouri-Kansas-Texas Railroad Spur to Mine No. 17 (See Map No. E-2-12), and is a very sharp curve, the point of curve being the heel of the No. 7 frog used at the switch. The track deflects to the right on a 40 degree curve, the point of tangency of the curve being 72.1 feet west of the west edge of the hopper. This is single track up to the point of tangency of the curve. The point of
switch of the two tracks over the hopper was placed on the
point of tangency of the 40 degree curve, and the point of
frog placed forty-four feet east, or twenty-nine feet west
of the west edge of the hopper. The frog used here was a
No. 8, this small frog being used because of the double track
and because of the 6'-2" track centers over the hopper. The
reason for using the two tracks was, as has been said before,
to allow the coal to be discharged from two tracks instead of
one, so the volume of coal the hopper could hold would be
increased. The track consists of 60 pound steel, the rails
on the 24" I-beams over the hopper being fastened to the
previously drilled I-beams by clamps at twenty-four inch
centers, on both sides of the rails and held more securely by
the aid of lock washers. Automatic door opening devices were
placed on the outer side of each track on the west side of
the hopper. The coal cars have a steel rod sticking out from
the side of each car, and as the coal cars approaches the
hopper edge, this rod strikes the automatic door opening de-
vice that, in turn, springs the catch on the bottom doors of
the coal cars and causes them to open and to discharge the coal
into the hopper. The door opening device consists of a catch
and heavy weight, the catch being knocked off, the back balance
takes it down and springs the rod on the cars so the doors can
open. The automatic door opening device then springs back into
position, ready to open the next car. (See Map No. K-3-10 for
design of automatic door opening device). Automatic door
closing devices were set in the middle of each track at the
east end of the hopper at such an elevation and extending out
into the hopper such a distance, that the coal having been discharged from the car, the doors swinging open hit the edge of the door closing device and are gradually closed, the proper elevation of the top of the door closing device to the hinges of the car doors attending to this closing.

XIII, Drainage,

The drainage of the area of mine land is very well shown on Map No. E-2-12. Shovel operation was to begin in Section 4 and because of this, ditches and dams were constructed before or at the same time, the shovel having been erected, was digging north. For the width of the first three pits in the southeast quarter of section 4, or for a distance of about two hundred feet, the coal dips slightly to the southeast or toward Cherry Creek. A ditch was needed to carry away water falling in the strip pits in this particular section. This would eliminate the need of pumps at this particular time and place. The natural fall of the land in the east half of Section 4 is to the east, draining toward Cherry Creek. A ditch was needed paralleling the strip pit in the southwest quarter of the southeast quarter of section 4, that would take care of the water flowing off the watershed of the slough.

A large dam was needed to be constructed a few feet east of the north end of the ditch that was to have its beginning in the slough and to be dug south to dump the water into the ditch on the north side of the east-west road, where it would drain into Cherry Creek to the east. The dam to be constructed at
the north end of the ditch was to be constructed across the ravine and to be wide enough on top so that cars could be driven across it. Dams were needed at sixty-five intervals up each slough in the east half of the section so that the track could be laid across these sloughs as each successive pit was dug and the coal removed. A ditch was needed at the slough in the northeast quarter of Section 4, to carry away any water from the watershed of the slough, northeast around the north end of the strip pit and then east to Cherry Creek. Dams were also needed up the slough at sixty-five intervals, to lay track on, each pit to be sixty-five feet wide. Surface ditches were needed to drain the water from the high places to the ditches behind the dams and then around the pit to the creek. These ditches and dams were needed before mining was to be carried on to any extent. These ditches and dams were all surveyed and constructed, the ditches being made wide and deep enough at any place to take care of a drainage area using a coefficient of 1.0 percent. Slope stakes were set on dams and ditches using a 1\(\frac{1}{3}\) to 1 slope in each case, the dams being made wide enough to lay track over or to drive over. The flow line of the starting point of the north-south ditch paralleling the strip pit face in the southwest quarter of the southeast quarter and the flow line of the large drainage ditch, running slightly northeast from the north slough, were both raised several feet above the bottom of the flow line of the slough. This reduced the amount of earth excavation in each ditch, but allowed two feet of water to remain in the gulley but this was held by the dam, the maximum height the water could rise being
three feet below the top of each dam. The large ditch draining the pits southeast to Cherry Creek, was excavated with a \( \frac{1}{2} \) to 1 slope and four feet bottom width, the flow line of the ditch at the pit being at the elevation of the fireclay or bottom of the coal. A flood gate was built a few feet east of this point in the ditch to allow water to flow through, but not to back into the pit. All ditches and dams were excavated using the Eucyrus-Erie one cubic yard drag line, the bottom width of each ditch being four feet, the width of the drag line bucket, each ditch having side slopes of \( \frac{1}{2} \) to 1. The yardage of earth moved in the large ditch from the pits southeast to Cherry Creek, was approximately seventy-five hundred cubic yards, while ten thousand cubic yards of earth was moved in excavating the ditch draining from the north gulley, northeast to the north line of the section. Accurate cost data on this ditch was kept; the ditch being cross-sectioned accurately, the cross-sections planimetered and the total volume of earth excavated tabulated. The cost of excavating this ditch, allowing for depreciation of the drag line, was \$0.03\) per cubic yard. This being the most difficult ditch to dig, it can easily be assumed that the average price of moving this dirt was around \$0.025\) per cubic yard. As mining progresses westward into the southwest quarter of section 4, a ditch will be constructed, extending from the gulley at the north-south half mile line in the south half of the section, southwest paralleling Spur No. 17 to the gulley west in the southeast quarter of the southeast quarter of Section 5, the maximum cut of this ditch to be six feet. Mining carried into Section 8 will entail the digging of a drainage
ditch, large enough to take the drainage of Cherry Creek, this ditch to be dug west of the creek, paralleling the railroad on the east side down to the trestle over the creek. No attempt will be made to change the present creek location southwest of the trestle. There will be other small drainage ditches needed to take the surface waters and also some dams needed, but these will be of minor importance.

XIV. Electric Pumps.

The pumps used in the strip pit at Mine No. 15 are Ingersol-Rand pumps. These pumps have a four and one-half inch intake and a four inch discharge so it can readily be seen that each pump is capable of pumping a large quantity of water per hour.

There are four of these pumps being used at the mine at the present time, these pumps being stationed in the lowest points of each successive pits, so that water falling into the pit will drain toward each pump, which will pump the water out of the pit, over the high wall and into surface ditches which in turn, carries the water to one of the large drainage ditches and is then carried to Cherry Creek.

The pumps use the same voltage of electricity that the air compressor used, the voltage used being 440 volts.

XV. 385-B Electric Stripping Shovel.

The shovel used in stripping the overburden from the coal seam at this mine is a 385-B electric shovel, with a dipper of 12 cubic yards capacity. This shovel was made by the Bucyrus-Erie Company of South Milwaukee, Wisconsin. This model of
shovel was used because a shovel of this type is built for the digging that this shovel will have to do at Mineral. The maximum depth to be dug at Mineral will be thirty feet, although a rise in the price of coal would permit the mining company to dig a trifle deeper. The boom length, length of sticks and dipper capacity and other features were computed by the Bucyrus-Erie engineers to handle the amount of overburden that had to be moved at the mine. A Bucyrus-Erie shovel was used at this mine in preference to other types, because of the fact that the Pittsburg & Midway Coal Mining Company's operators and superintendents are more familiar with this type of shovel and have had very good success with them. Some of the features of the 385-B, 12 cubic yard stripping shovel are as follows:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of base</td>
<td>30 feet x 30 feet center to center of girder</td>
</tr>
<tr>
<td>Revolving frame</td>
<td>20'-1&quot; wide x 48'-8&quot; long</td>
</tr>
<tr>
<td>Weight</td>
<td>450 Tons (approximately)</td>
</tr>
<tr>
<td>Length of boom</td>
<td>78 feet</td>
</tr>
<tr>
<td>Length of sticks</td>
<td>52 feet</td>
</tr>
<tr>
<td>Size of dipper capacity</td>
<td>12 cubic yards</td>
</tr>
<tr>
<td>Area of caterpillar traction</td>
<td>309 square feet</td>
</tr>
<tr>
<td>Outside type of dipper handle</td>
<td>Dipper handle straddles boom, being clear of it, the sticks are not likely to become &quot;bowed&quot;. The wide spread dipper handle steadies the dipper as it passes through the bank.</td>
</tr>
</tbody>
</table>

House - corrugated steel supported by structural steel arches
Motor generator set:

Make: General Electric Company.

Arrangement: Five units direct connected and mounted laterally on the rear of the revolving frame so digging vibrations are normal to the bearings.

Equipment: The set is driven by a synchronous motor 435 KVA, 0.8 Power Factor, 1200 R.P.M., 4000 volts, 3 phase, 60 cycles, direct connected to and mounted on the same bedplate with hoist generator 275 KW, 600 volts, D.C.
differential compound wound, and exciter 20 KW, 125 volts, D.C. flat compound wound, mounted on a separate bedplate and driven through a flexible coupling are the 75 KW.
swing generator and the 50 KW. thrust generator, both 250 volts D.C. and differential compound wound.

Motors:

Make: General Electric Company.

Ratings: Hoist: Two 150 HP motors
Swing: one 100 HP motor
Thrust: one 100 HP motor

Base: Machine mounted on caterpillars crawlers.

Equalizing beam: Heavy structural beam extending full length of base and carrying at its center a bearing for supporting the base, producing a three point support arrangement, insuring even load distribution when moving up.
Jack screws: At ends of equalizer, over center of caterpillar units, and are set against the base to relieve the equalizer while the machine is working and transmit the load directly to the caterpillar units. These screws are released for moving up, allowing the caterpillar units to adjust themselves to an uneven ground surface.

Hoisting drum: 54" in diameter, grooved for the hoist cable consisting of a twin 2" in diameter hoist rope, the total length being 1400 feet long.

It was planned to use an electric shovel at Mine No. 15 because power could be taken off the Empire District Electric Company's high voltage line that extends from a power plant at Riverton, Kansas, to another power plant at Service, Kansas, about nine miles east of Parsons, Kansas, thus making it fairly easy for the electric company to put in a large transformer and any sub-lines needed. The power line runs southeast by northwest and extends northwestward a few miles east of Mineral. The electric company had to lay a line to the mine from their high power line and had to change the rating of current from 25 cycle to 60 cycle in all the nearby towns and farm houses, thus making it very costly to the Empire District Electric Company. Other reasons why it was planned to use an electric stripping shovel in preference to a steam shovel, is because of the low cost of the electric current which will average approximately $0.02 per kilowatt-hour used, because of the waste of time used in "coaling", or refueling a steam shovel, one hour to two hours a day being used in refueling a steam shovel. The stripping
shovel operated by electric current operates very smoothly, every motor being electrically driven and operated, making the operation of the machine very efficient. The electric shovel is much cleaner than the steam shovel, because there is no smoke like there is from the steam shovel. It has been proven that an electric shovel is much more efficient and more economical to use than a shovel operated by steam.

The large 385-B, 12 cubic yard electric shovel was shipped from the Bucyrus-Erie Company's plant at South Milwaukee, Wisconsin in twenty railroad cars, some flat cars being used while some of the parts were shipped in ordinary coal cars and box cars.

As previously stated, a spur track was built off Spur Track No. 17 in the southeast quarter of the southwest quarter of Section 4, which extended south and east to the crop line of the coal where it was proposed to erect the stripping shovel. The stripping shovel was erected at this point because it was on the coal crop line, a minimum of track would be built at this location and because as it was proposed to strip the coal along the coal outcrop in Section 4 first, it was the best location as the machine, being on the south edge of Section 4, could then work north along the crop line.

The site of erection of the stripping shovel was chosen and the guy ropes of the large terrick laid out so that guy ropes securely anchored the terrick from all sides at an interval of sixty degrees in a circle around the terrick. The terrick was set on good footings of large timbers, embedded in good soil. No trouble was experienced in raising the large
terrick that extended sixty-five feet above the ground level at the base of the terrick. The Bucyrus-Erie Company sent an erector from their plant to erect the shovel, the cost for this erector having been figured in their total cost on the machine. The shovel erector had full charge of erecting the shovel, although this erector was in charge, the work was given inspection by the mining company's engineers and officials as it progressed. The shovel erector hired the men used in the shovel erection, about twelve in number, and the labor expense, plus all other items of the cost of erection was charged to the mining company as shovel erection costs, not included in the first cost of the shovel.

After the terrick was raised and it's guy ropes securely fastened to large iron pegs driven in the ground to hold them, levels were given the erector by the engineer on a base of railroad ties, laid level so that the shovel could be erected on a level surface, thereby insuring better workmanship and parts fitting better. The different parts of the shovel were erected in the following order, (1) caterpillar, (2) lower frame, consisting of main girders and equalizing beam and main strength members, (3) upper deck or revolving frame, containing all the machinery needed to operate the machine, (4) the boom and (5) the dipper sticks with bucket attached.

The shovel erector used twelve men in erecting the shovel, and fairly good progress was made in the erection. Trouble was experienced in some of the parts not fitting as neatly as they should, this entailing reboring holes and much work in properly fitting these parts. Some trouble was ex-
perienced in getting the different sections of the cab fitted, the cab being built of steel. This cab consisted of flat steel sheets, the holes for which had not been properly drilled before being sent on the job. However, with a small amount of work and time, the shovel was erected, all parts fitting very nicely. The shovel was erected not without an accident however, one of the men employed falling down into the lower frame or girders, when the shovel was half erected and hitting his head on and I-beam. It was thought he would lose the vision of one of his eyes, but he has since recovered and can see very well.

The shovel was erected in six weeks, the time taken up in the erection being two weeks longer than it usually takes to erect a machine of this size. The cost of this shovel erection was approximately four thousand five hundred dollars.

XVI. Electric power.

The electricity used by the various units of the mine's operations is purchased from The Empire District Electric Company, the average price per kilowatt hour of electricity used varying with the quantity used; the average price per kilowatt hour being approximately two cents a kilowatt hour.

The Empire District Electric Company erected their large transformer station at the southeast corner of Section 5, Township 32, Range 23, one-quarter mile south of the tipple. This transformer station was built by the electric company's service men, a crew of six men being used in it's erection. A foundation of concrete of a 1:3:5 mix was used under the large transformers, the transformer also being surrounded by a wire fence to keep visitors away from the transformers. The trans-
former station was erected in seven days by the electric company.

The location of the power lines built by the electric company and the mining company was first laid out on a map of the mine, in order to better determine at just what points other transformers should be stationed and at what points steel lines should be built to carry the currents needed for proper operation. The currents to be carried by the power lines were 440 volts for the electric pumps and air compressor, while 4000 volts are needed for the large stripping shovel, 50-B bank machine and 50-B coal loader.

The power lines were surveyed and located as shown on Map E-2-12. The power line from the large transformer station at the southeast corner of Section 5, east to the cut down transformer near the half mile line of Section 4, carries 4000 volts. This cut down transformer consists of 3 - 2300 volt transformers Y connected. The power line north and south of this cut down transformer station carries both 4000 and 440 volts, this voltage being three phase, three wires were needed for each current, making six wires on each power line, three on the upper cross arm and three wires on the lower cross arm of the power pole. The north-south power line carries 4000 voltage and another transformer is used in the northeast quarter of Section 4, to reduce this voltage to 440 volts. Stub lines, carrying either 4000 or 440 volts, are laid off at the proper intervals on east-west lines, so the different shovel cables will just reach from one stub line to another stub line carrying the same voltage when using either the cable from the loader, bank machine or large stripping shovel.
The poles carrying the 4000 volt current are twenty-five feet long, while the poles carrying 440 voltage are twenty feet long. These poles were spaced at one hundred fifty feet centers, each pole being "deadheaded", or anchored to the ground by a guy wire, so as each end pole is taken up, the next pole will already be securely anchored. Each pole has six strain insulators on it, three on each side of each arm. The copper wire used to carry the 4000 volt main line is single conductor stranded, the 440 volt main line double conductor stranded, while the 4000 and 440 volt stub lines are single conductor stranded.

The mining company labor forces dug the holes for the poles on the stub lines, set the poles up, placed the cross braces on each pole and deadheaded the pole and also stretched the copper wires on the poles. The wires were stretched over the poles to the proper tension with the aid of a team of horses, that pulled the wires taunt and held them fast until they were securely fastened to the poles. The cost of the labor for a stub line nine hundred feet long, was four men working nine hours at fifty cents an hour, or eighteen dollars.

Most of the main power line, as surveyed and constructed, will not have to be moved until the mine is abandoned, as it was built back of the maximum digging line. The various stub lines carrying the 440 and 4000 volt currents will be taken up gradually as stripping operations continue to the west.

XVII. 50-B Electric Coal Loader.

The shovel used at Mine No. 15 to load the coal into the skip of the bank machine is a 50-B Bucyrus-Erie electric coal loader, with a bucket capacity of two cubic yards. This shovel
is mounted on caterpillars and is a revolving shovel. The bucket of the shovel is four and one-half feet wide and runs out on racking on steel members, the bucket being driven into the coal by the horizontal thrust of the machine. This coal loader is driven by electric power of 440 volts and can load the coal out of a pit seventy-five feet wide without moving on its caterpillars. The coal loader follows the large stripping shovel in the pit and loads the coal after it has been shot and broken up into the skip of the bank machine, where it is then hoisted out of the pit into the coal cars on the high wall. This machine was brought down to Mine No. 15 from the mining company's Mine No. 10, east of Pittsburg in Missouri, and originally cost fifty thousand dollars when new. It is estimated that the machine will handle sixteen hundred tons per day.

XVIII. 50-B Bank Machine.

The bank machine used at Mine No. 15 to load the coal cars is what is known as a 50-B machine made by the Bucyrus-Erie Company of South Milwaukee, Wisconsin. This machine is the same size as the 50-B coal loader used at this mine, but differs from it in that it has no thrust motion like the loader, but has hoist and swing motions. This machine has a boom sixty-five feet long and a bucket of six tons capacity. This bank machine is used to lift the coal from the pit and load it into the coal cars on the high wall, after the loader has filled the skip. The machine is mounted on caterpillars and is a revolving shovel, the operator's inclosed cab being on the top of the entire machine, high enough so he can see on the high wall.
to swing the bucket over the coal cars and discharge it's content into the cars. Seven skips of coal are needed to load each car, because each skip is not completely filled. The average tonnage loaded in the coal cars during the last few months was 36.7 tons. The machinery of the 50-B bank machine is similar to the machinery used in the 385-B electric shovel. It uses current of a 440 voltage, this current being carried to the machine through an insulated rubber hose from a tension line carrying 440 voltage. The cost of this bank machine was twenty-seven thousand seven hundred dollars.

XIX. Caterpillar Tractor.

The tractor used at Mine No. 15 is what is known as the "Caterpillar" Thirty Tractor, built by the Caterpillar Tractor Company, formerly the Holt and Best Tractor Companies. Following are specifications covering the "Caterpillar" Thirty Tractor:

- **Engine** - Bore 4 3/8"; stroke 6 1/2"; R.P.M. 850
- **Valves** - Exhaust, head diameter, 2-3/16"; stem diameter 3/4". Inlet, head diameter 2-3/16"; stem diameter 3/4".
- **Crank shaft** - Diameter 2.62"
- **Cam shaft** - Bearings, diameter 2-7/8"
- **Pistons** - Diameter 4 3/4". Length 6". Rings 1/4"
- **Piston pins** - Diameter 1 5/8"
- **Fan** - Blades 8. Fan diameter 22"
- **Brakes** - Drum diameter 13-3/8". Band width 2 1/2"
- **Fuel** - Gasoline. Fuel tank of 37 1/2 gallons capacity.
  Auxiliary tank 2.6 gallons capacity
Flywheel clutch - Drives upper transmission shaft through a leather link universal connection. Two friction surfaces. Clutch plates $13\frac{1}{2}''$ diameter. Friction surface area 119 square inches.

Transmission - Selective gear type, three speeds forward and one reverse. Single reduction in all forward gears.

Steering - Number of plates in each clutch - 16.
Number of springs - 8. Diameter moulded lining 12''. Area friction surface each plate - 44 square inch.

Final drive gears -Pitch 3.7'' - diameter assembling bolts 5/8''.

Sprocket - Number of teeth - 27, number of bolts - 9, width of face - 2\(\frac{1}{2}''\), number of bolts 19, diameter of bolts 5/8''.

Track - Width of track shoe 13''.

Grease pump - Capacity 25 lbs.


Speeds - First - 1.7 M.P.H., Second - 2.6 M.P.H., Third - 3.6 P.M.H. and Reverse - 2.0 P.M.H.

Dimensions - Overall length - 10'-9''. Overall width 4'-11''. Overall height, including canopy - 7'-7''. Height to top of radiator - 4'-11''. Treat - 43-3/4''.

Ground clearance under transmission - 11\(\frac{3}{8}''\).

Drawbar height above ground - 16\(\frac{3}{8}''\).
Weight - 10,000 lbs. (approximate)

While the plant was being constructed, the tractor was used in the construction of the tracks and in clearing out the small trees and hedge near the office. The Caterpillar Thirty Tractor is now being used at the mine to slide the built track along the high wall over to the next pit, thereby eliminating tearing this track up. The tractor is used in dragging material from one part of the mine to another, in grubbing hedge and in general, for all construction work where haulage is a problem.

The cost of the tractor delivered at the mine was eighteen hundred and seventy dollars.

XX. VULCAN GASOLINE LOCOMOTIVES

The locomotives used at the mine to haul the coal cars from the coal face to the coal hopper, are made by the Vulcan Iron Works of Wilkes Barre, Pennsylvania.

These locomotives are gasoline driven locomotives replacing the steam locomotives which is commonly found in the mines of this district. Gasoline locomotives have been used with great success by many industrial concerns throughout the world. The Pittsburg & Midway Coal Mining Company is the first company to begin the use of gasoline locomotives in this district.

Two of these locomotives will be used, each pulling a load of three Sanford-Day automatic bottom dump cars of 35-ton capacity each. Following are the standard specifications of these 25-ton, 4 speed gasoline locomotives:

Engine.

- Type: Four cycle, vertical
- Cylinders (number): Six (6)
- Size of cylinders: 6½" bore X 7" stroke
- Horsepower: 160 H.P. at 1000 R.P.M.
Transmission

Speeds - Four (4) forward, Four (4) reverse

Tractive power -

In low gear (3.3 m.p.h.) - 14,500 lbs.
In second gear (4.5 m.p.h.) - 10,500 lbs.
In third gear (8.3 m.p.h.) - 5,800 lbs.
In high gear (15 m.p.h.) - 3,200 lbs.

Driving wheels

Drivers (number) - Four (4); Diameter - 36".
Material (centers) - Cast Iron
Tires - Rolled Steel
Journals (Diameter) - 6-3/8", length 7"
Wheel base - 60"

Clearance Dimensions

Height to top of cab - 9'-1"
Height to top radiator cap - 6'-10"
Width over bumpers - 9'-0"
Length over bumpers - 16'-6"

Equipment and accessories

Cab - enclosed, locomotive type (material steel, entrance rear with curtain)

Fuel tank - Number (1) capacity - 24 gal.
Couplers - to fit Sanford-Day coal cars
Carburetor - Stromberg, Single type
Air cleaner - United
Magneto - American Bosch with distributor
Self Starter - 12 volt, Leece Neville
Lighting system - 12 volt, Leece Neville
Storage batters - Exide
Friction Clutch - Twin disc, dry plate
Radiator - Tubular type, protected
Sandboxes - Four (4) steel
Brake - operated by Hand wheel
Signal - Electric Klaxon Horn

Special features of the 25-ton gasoline locomotives.
Frames - Cast steel, locomotive bar type, located inside of drivers for standard gauge track used at mine.
Axles - Nickel-chrom, alloy steel, heat treated.
Bearings - Cast iron, bronze lined with removable cellars.
Springs - Semi-elliptic cross equalized.
Transmission - Four speed, constant mesh gear type. Forged nickel-chrom gears and shafts, heat treated, mounted on ball bearings, oil tight and dust proof case.
Side rods - Forged steel with solid ends, bronze bushed.

The above specifications cover the locomotives in every detail. These gasoline locomotives have been in use at this mine for some time and have given very good service, having plenty of power on any grade, are easily handled and are much easier to operate than a steam engine, although it has, of course, more wearing parts. Enough extra parts are kept on hand at the mine in anticipation of any sort of locomotive trouble that might arise. Each locomotive as used now, pulls three Sanford-Day automatic bottom dump coal cars of 35-ton capacity, the dead weight of each coal car being thirty-five thousand pounds, but as production increases, each locomotive will be required to pull more of a load. Each locomotive could haul seven coal cars of the above load very easily.
XXI. Dump cars to be used.

The coal cars used to haul the coal from the strip pit to the coal hopper have a capacity of thirty-five tons, although the average tonnage hauled since the mine began operating is thirty-seven tons. The cars used have an overall length of 37 feet, 5\(\frac{3}{8}\) inches and an overall width of 10 feet, \(\frac{1}{2}\) inch. The distance between the truck centers of the cars is 28 feet \(\frac{3}{8}\) inch, while the inside top measurements of the cars are 29 feet, 11-5/8 inches long by 9 feet, 4 inches wide. The dead weight of each car is thirty-five thousand pounds. The six coal haulage cars used at the mine are very sturdily built. The trucks of the cars were built by the Mt. Vernon Car Manufacturing Company of Mt. Vernon, Illinois, while the automatic bottom dump devices, used on the cars, were manufactured by the Sanford-Day Iron Works, Inc. of Knoxville, Tennessee. The size and shape of the body of the cars were fixed by Mr. K. A. Spencer, in charge of engineering for the Pittsburg & Midway Coal Mining Company, who specified the manner in which he wished the cars built. The cost of each coal car was Two Thousand One Hundred Fifty Dollars.

General features of the cars, other than their size, as specified above are that they are built for standard gauge track of four feet, eight and one-half inches and that the four bottom doors of the cars are automatically opened by a rod connected to the doors projecting from them, striking the automatic door opening device on the coal hopper, causing the doors of the car to open and to discharge it's contents into the coal hopper. The doors are closed as the car passes over the closing device that is high enough to force the doors closed.
The size and shape of the body of each coal car was fixed by Mr. K. A. Spencer also, who specified that each car should have the length and width as specified above and also specified the hopper shape of the cars and the size of the doors through which the coal is discharged.

XXII. Additional buildings and installations.

Locomotive shed and work shop.

The locomotives to be used at the mine are gasoline locomotives and it is very necessary that locomotives of all types be properly housed and a suitable place provided to work on them. The locomotive, or "dinkey" shed and work shop, was to be built as one unit, the locomotive portion of the building to house the two locomotives and a work pit to be provided under the track so the workmen would be able to get under the locomotives easier to work on them. The workshop built in conjunction with the "dinkey" shed was to house all the laths, drills and miscellaneous equipment necessary to equip a suitable machine shop.

All necessary plans for the construction of the building were drawn at the mining company's office in Pittsburg, and then were given to the contractors for their bids.

The combined locomotive shed and work shop was built two hundred and ten feet southwest of the west end of the concrete coal hopper; the building being so located that a railroad track could be built from the curved track over the hopper through the locomotive sections of the building. The point of frog, or the point of junction with the curved track, was one hundred and thirteen feet southwest of the west edge of the coal hopper.
A number 7 frog was used at this point, and the center line of this track extended to the southwest, passing through the center of the locomotive section of the building. This track intercepted the northeast side of the building or the side of the building nearest the coal hopper, at a distance of one hundred seventy feet southwest of the west end of the coal hopper. The track extends straight through the building and curves slightly more to the west at a point one hundred fifty feet west of the west end of the building to connect with the Spur track No. 17. (See map No. E-2-12).

The building was built sixty-seven feet wide at the northeast end of the building, the general plan of the building being as follows: Starting at the southeast corner of the building, or eight and one-half feet southeast of the center line of the track through the building, the northeast end of the building extends sixty-seven feet slightly northwest, at right angles, to the track already constructed through the proposed building to the northeast corner of the building, thence forty feet southwest at the northwest corner of the building, thence southeast fifty feet to a point eight and one-half feet northwest of the track center-line, thence ten feet to the southwest, thence seventeen feet to the southeast, thence fifty feet northeast to the southeast corner of the building or the point of beginning. The south portion of the building, consisting of the south seventeen feet of the building, eight and one-half feet on each side of the railroad track, is to be used to house the two locomotives, the building at this point being fifty feet long, there will be ample room for the two locomotives, the length of each locomotive being twenty-two feet,
this leaves a clear space of eight feet beyond the overall length of the two locomotives.

Under the railroad track and starting at a point five feet southwest from the northeast door or intersection of the track with the northeast edge of the building, a pit was dug the width of the gauge of the track, and seventeen feet long. This pit was made three and one-half feet deep and the walls and floor concreted, each track rail over the pit being fastened by rail clamps to a (4" X 9") channel embedded in the concrete. The purpose of this pit is to enable the workmen to get under and work on the locomotives easier. The gasoline locomotives have many wearing parts and because of the fact that they must be repaired rapidly when out of order. This repair pit simplifies this repair work to a marked degree.

This track through the building enables material to be brought from any place in the mine into the work shop to be repaired and also enables the coal cars to be hauled from the coal hopper, west through the dinkey shed to the main track west, and then back to the pit, this track being very useful in case the curved track to the hopper might be blocked.

Combining the dinkey shed and work shop into one building, reduced the amount of room space needed for this building, reduced the insurance rate and makes it much handier to do any repair work needed on the locomotives, as they are so close to the work shop that any part can be transported by the use of the mono rail to the various equipment in the workshop where the necessary work can be done on it.
The northwest portion of the building, consisting of a space fifty feet wide by forty feet long, parallel to the railroad track through the building, is the workshop for the mine, where all equipment is repaired. This workshop houses the laths, mono-rail, or horizontal hoist for transporting material from one end of the work shop to the other. All laths and machinery are bolted down to concrete bases poured in the ground to serve as footings. The equipment in this workshop is arranged so as to not interfere with each other’s operations, each piece of machinery having just enough space needed around it to allow the workmen to work in, but no space in this section of the building is wasted.

The construction of this building was let by contract to a contractor. The building, as constructed, consists of a concrete foundation, poured six inches into good soil, ten inches wide, extending up to a point a foot above the new ground elevation, a slight earth fill having been necessary at this point to bring the grade of the building up high enough to line in with the track grade coming off the curved track over the coal hopper. The height of the foundation was two and one-half feet, this concrete foundation being poured, using a 1:3:5 mixture. The concrete for the building foundations was poured fairly dry, the concrete being left in the concrete mixer for the customary period of one minute. The contractor’s bid for pouring the foundation for the building was $7.00 per cubic yard, exclusive of excavating the foundation below the natural ground and furnishing the form lumber. Water, also, was furnished him by the mining company. The contractor used a force of six men in pouring the
concrete foundation, a one-half bag rotating concrete mixer being used. The foundations were formed and poured in four days, some extra time being used in pouring the foundations, because of the small capacity of the concrete mixer. The total cost of the concrete foundations was $9.00 per cubic yard of concrete. All work on the concrete foundations, as well as any work on the building itself, was given suitable supervision by the mining company's engineer.

Red tile of a dimension of six inches by eight inches by one foot long, was used above the footings, up to the eaves of the building, red mortar being used in laying the tile. Steel truscon windows sashes were set in the walls on all sides of the building, and a large door built at each end of the track through the building, wide enough to permit the locomotives to enter and go out. Another large door was built in the north end of the workship, opening out on to a dock built on the north end of the building, so that material hauled on the sulphur track to the workship could be unloaded on the dock and taken into the workship. The roof of the building was constructed, using two by six inch rafters, inclined on a suitable pitch at two feet centers. Red asphalt shingles were used, allowing the shingles to lap over four and one-half inches to the weather.

The locomotive - work shop, as constructed, is a very nice looking, substantially built building. It is very warm in the building, not much heat being needed to keep the building warm, making it a very good storage place for the gasoline locomotives, as their radiators will not freeze and they are much easier to start in the mornings. From an esthetic view point, the building
is very pretty, the red mortar between the red tile, harmonizing with the color scheme of the red asphalt shingles on the roof of the building. This building, as constructed, fits every qualification for buildings of this sort, from a useful purpose as well as for its esthetic value.

The total cost of the building, including concrete footings, walls, roof and machinery bases was two thousand seven hundred dollars.

Sand-house.

The sandhouse was located and built about fifteen feet west of the curved track over the coal hopper with six feet clearance from the north rail of Spur Track No. 17. This building has a stove in it, which heats the sand from the sand storage bin, so that it can be used by the locomotives in overcoming track resistance.

The sandhouse was constructed of red tile of the same dimensions as used in the combination dinkey shed and work shop. The building was made twelve feet long by nine feet wide, the longer side paralleling Spur No. 17. A small concrete foundation was poured for the building to rest on and to allow the tile layers to get a uniform grade. A window was left in the south side next to the track and doors on the north and west sides were also built in the walls. The buildings is seven feet six inches to the eaves above the foundation level and has a conical roof shingled with red asphalt shingles like the shingles used on the locomotive shed. The same contractor built this building that constructed the dinkey shed, six men being used in pouring the foundation and two tile setters laying the tile with red mortar and placing the window
and doors, laying the roof, flooring and building the roof. A sand storage bin was also built joining on to the sandhouse, the width of the sandhouse and extending thirty feet to the west parallel to the track. Three rows of concrete block were laid parallel to the track on the outside edges of the building and in the middle, parallel to the track for foundation and three inch by twelve inch planks laid across these concrete blocks for the floors. Posts, six inches square, were then driven on the outside edges of these planks, down into solid ground, and two inch by twelve inch timbers were nailed for the outside walls of the sand storage bin were nailed on the inside of these brace posts. The walls were made six feet high, high enough to hold two cars of sand. Cross-braces, consisting of two inch by six inch timbers were nailed across the bin to these upright posts, these braces making the structure very firm. Sand is unloaded from the railroad cars into this storage bin and is taken into the sand house through the door built in the west side of the sand house to be heated in the stove.

The cost of this building and storage bin was approximately, three hundred dollars.

Oil House.

The oil house, or the building where all the oils used in the operation of the various equipment, used in the operation of the mine are stored, was located and built on the east side of the curved track over the coal hopper, approximately fifty feet slightly southeast of the southeast corner of the combination locomotive shed and work shop. The building, as built, is twenty feet long by fifteen feet wide, the longer side of the building
being parallel to the side of the office building or parallel to the north side road. This building is used to store all the barrels of oils and greases used by the stripping shovel, loading shovel, drag-line, tractor, bank-machine, locomotives and electric pumps. A dock, or unloading platform, was built on the west side of the building so that material can be unloaded off the curved track over the track onto the unloading dock. A door was built in the west side of this building so that the oil barrels and greases could be taken through from the unloading dock into the building. The building was built identical in construction as the sand house, doors being left in the north and west sides of the building and windows on the east and south sides. The building is seven feet six inches high from the top of foundation or approximately ground elevation to the eaves. This small building was built at a cost of approximately four hundred fifty dollars.

Gasoline pump.

The locomotives and tractor used at Mine No. 15 are gasoline burning machinery, using approximately sixty-five gallons of gasoline a day. In order to save money in the purchase of the gasoline, it was necessary that a storage tank be installed at the mine so gasoline could be purchased in tank lots. This tank also had to be dug and installed near the railroad track so the gasoline locomotives could be refueled each day. This tank had to be placed near the dinkey shed so the locomotives could be run out of the shed to the tank and filled. A gasoline storage tank with a capacity of one thousand gallons was installed east of the curved track across the hopper and approximately one hundred twenty-five
feet southwest of the west side of the coal hopper. The hole for the tank was excavated six feet deep, the tank installed and a gasoline service gauge with hose installed with connection to the tank. The locomotives can very readily be refueled each morning with gasoline, oil and grease as the gasoline tank and the oil house are so close to the dinkey shed, and they can be very easily refueled as they leave the dinkey shed on their first trip, past the gasoline tank to the pit.

General office building.

In the operation of a strip mine of any size, it is necessary that a suitable office be provided for the mine superintendent and the man who has charge of the loading of the cars and their billing. This man is called the "top" boss and has charge of the office under the mine superintendent, of course, and handles all clerical work pertaining to the loading and billing of coal cars, the selling of custom coal and getting out the payrolls for the mine and attending to the superintendency of work around the tipple and other buildings, when the mine superintendent is not there. The office building is used to store all the office equipment needed in the operation of the mine and is occupied by the top boss and the mine superintendent, and because of the amount of work carried on at a mine, a building of suitable proportions and adaptability had to be built for Mine No. 15.

At the time construction work began at the tipple site of Mine No. 15, the only building standing near the site was an old two room shack, located about thirty feet south of the southwest edge of the coal hopper. This house was in very poor condition, but could be very easily repaired and made suitable for occupancy.
There was a porch on the east side of the shack facing the road, but this porch was also in very poor condition. This house was purchased from it's owner and renovated into a very nice looking office building. The building is twenty-eight feet long by sixteen feet wide, the longer side paralleling the north-south road, east of the house. The building, before being repaired, was unpainted, the roof leaked, the porch was about ready to fall in and it was unfinished inside. Several carpenters were put to work on this old building, the outside walls being covered with eight inch new siding, the siding being extended to the ground level to cover up the old rock foundation of the building, several old window sashes were replaced with new ones, the porch was braced and new lumber placed where needed. A loading dock was built on the west side of the building facing the other buildings, several new windows were built in the walls where needed, the house reshingled where needed and the entire building given two coats of a gray paint that changed the whole general appearance of the building. The walls of the inside of the building were covered with sheet rock, shelves were built in the north room to keep bolts and miscellaneous articles in, while the south or front room was fitted up with suitable office equipment, needed to carry on the work. The renovated office building is very nice looking and will no doubt last several years, although if it proves unserviceable later, it will be torn down and an office building constructed of tile, built so it will harmonize with the appearance of the other buildings, the other buildings all having been constructed of clay tile with red mortar.
XXIII. General features of mine yard in general.

The general appearance of the mine yard buildings with respect to each other is very pleasing. The tipple and hopper are built as one unit, the covering for the drag conveyor of the tipple extending over a portion of the hopper as a shed, causing the tipple and hopper to look very large and formidable because of the size of the two structures. The combined dinkey shed-work shop, oil house and sand house are located at the most strategic locations, with respect to good usage and because they are built of the same material of clay tile, they add to the esthetic beauty of the place. The mine yard presents a pleasing, as well as a very business-like appearance, the tipple, yard tracks, hopper, "dinkey shed", oil and sand houses and the mine office all having been built out of the best material and equipment and with the best of workmanship. The mine yard has been cleaned of all debris and all the low places in the yard are being brought to a uniform grade by filling in the yard with "sulphurs" from the coal, this operation extending over quite a time, as there is not much sulphur in this coal seam.

The mine yard around the office has been planted with blue grass and a picket fence painted white, has been built on the property line on the west side of the road in front of the office, extending from the north side of Spur Track No. 17 north to the south edge of the main yard tracks east of the tipple. An opening was left in this fence for the tracks over the coal hopper and a cattle guard placed in this opening. An arched gate was built in the fence at a distance of three hundred feet north of Spur No. 17.
The various structures, tracks and other esthetic features comprising the mine yard of The Pittsburg & Midway Coal Mining Company's Mine No. 15, presents a most efficient and pleasing appearance to the layman, but to the man familiar with the operation of mining and preparing coal, it represents the last word in the proper preparation of coal.

XXIV. Beginning operation of stripping shovel.

The large stripping shovel had been erected with it's caterpillars paralleling the coal outcrop, so that when the erection had been completed it would be in a position to begin stripping and advance without turning the caterpillars around. The shovel was erected on soft coal or on the coal outcrop; there being approximately fifteen feet of overburden at the point of erection. After everything on the shovel had been properly fitted, it dug northwest on approximately a six percent grade down to the coal. The coal at this point was found to be much softer than could be used so additional drill holes were put down ahead of the shovel and in this manner the shovel dug on the edge of the good hard coal. It had been planned to dig north of the erection site, but because of the poor coal, the stripping was carried to the west (See Map No. E-2-10). Additional hand drillings were put down ahead of the stripping shovel as it progressed north along the crop line. In this manner, the shovel always dug on good coal, the preliminary drillings on the cropline previously drilled not being spaced close enough to dig to accurately.

The first pit dug in a strip mine is called a "box" pit, because there is solid overburden on each side of the
shovel and it seems hemmed in when digging in the first pit. The difficulties experienced in the first pit dug by the 385-B shovel was that it had much difficulty in placing the overburden far enough away so it would have enough room for additional dirt. This made digging very slow and, because of the difficulty in getting enough space to place the overburden, there were quite a number of slides or cave-ins while digging the first pit. The shovel was never caught in one of these slide-ins, although it would have been if great care hand not have been exercised by the shovel operator or "runner". The total yardage moved by the shovel in digging the "box" pit was ninety-eight thousand one hundred cubic yards, this yardage being moved in twenty-nine digging shifts, using only one shift or an average of thirty-three hundred cubic yards per digging shift, which was very good considering the fact that nearly thirty hours time was lost in cleaning up slide-ins and cleaning the clay out of the dipper.

XXV. Summary of operation of the different equipment used in operating the mine as a unit.

The method of moving the overburden on each successive pit is identical with the operation of the first or "box" pit, except that it is much easier to move dirt after the "box" pit has been dug, as the overburden is then cast into the pit from which the coal has been taken out, while the earth from the "box" pit must be deposited on the natural ground line, there being more difficulty in getting space to deposit the material from the box pit.

Because of the fact that haulage is carried on the high wall or natural surface and not on the coal seam itself,
where a berm would be needed to carry the track, it decreases
the angle of swing of the stripping shovel to a marked degree,
and increases the time actually employed in digging. It has
been found practical in reducing the angle of swing of the
stripping shovel to stack the first dirt from the cut in a
pilot wall near the toe of the spoil behind, this pilot wall
taking the natural repose of dirt. Before the shovel moves up,
two or three buckets are taken on the inside of the pilot wall,
giving it a reclining angle of approximately 3 to 1, the re-
main ing dirt going behind this pilot wall and taking the natural
line of repose. This method of stripping the overburden puts
more dirt nearer the shovel, decreases the angle of swing of the
shovel and gives more cubic yards of dirt moved per month.

Each pit is kept absolutely dry by installing electric
pumps at the proper places in the pit. These pumps are Ingersoll-
Rand pumps and have a six inch intake and four inch discharge.
Each pump is equipped with enough pipe so that any water in the
strip pit can be discharged over the highwall into small surface
ditches that carry the water to the larger ditches and then to
the creek.

The overburden is stripped off the coal seam by the
stripping shovel. Two men using shovels aid the shovel by
keeping the dirt cleaned up the stripping face so the shovel
dipper can pick it up. This leaves the coal seam very well
cleaned of all dirt and any other dirt or loose dead carbonaceous
material is removed from the coal seam by the use of the 30 HP
Caterpillar Tractor, equipped with a backfiller, or blade. This
blade is mounted on the front end of the tractor and can be raised
or lowered or adjusted to any angle. The tractor equipped with this blade, shoves all loose particles off the coal toward the edge of the spoil bank, leaving the coal nearly cleaned of all foreign material. When the caterpillar tractor with the back-filler has completed its task, the coal is then thoroughly cleaned by another tractor equipped with a revolving broom that sweeps the coal thoroughly clean. These cleaning operations leave the coal in as perfect condition to load as it seems possible to attain.

The coal seam, having been cleaned thoroughly of all dirt, is now drilled at ten foot intervals across the strip pit. Each strip pit is dug approximately 65 feet wide. These holes are drilled in the coal seam with the Ingersoll-Rand jack-hammers and can be very quickly drilled as the drill quickly penetrates the coal seam, the thickness of which averages twenty-two inches. These holes are sometimes filled with FFF powder and electrically set off by one shot, or are set off individually by placing in each hole after it is drilled a "squib" or charge of black powder and then electrically setting off the charge. Enough holes are drilled and discharged so the coal can be readily loaded by the 50-B electric loader into the skip of the 50-B bank machine. The bucket of the loader has a capacity of two cubic yards while the skip capacity of the bank machine is seven cubic yards. A track is laid on the high wall, paralleling each pit excavated, so the coal can be hauled from the pit face to the tipple. Each of the two gasoline locomotives haul three of the 35-ton capacity automatic bottom dump cars filled with coal. After each train load of coal is dumped into the coal hopper, it is brought back to the pit face opposite the place the loader is loading the coal.
The loader fills the skip of the bank machine that is setting on the coal seam and it, in turn, raises the skip full of coal and swings over to the high wall, depositing the coal into the 35-ton coal cars. If the skip was filled to it's full capacity each time, it would take only five full loads to fill the coal cars, but as the loader has a two cubic yard bucket, only three full buckets are placed in each skip, or about six yards. Seven loads of the skips are placed in each carload, or approximately forty-two cubic yards, each car being filled to overflowing and stacked several feet above the top of the car. As an illustration of how much is placed in each coal car, seven car loads were placed in the coal hopper and seven Missouri-Kansas-Texas railroad coal cars were filled ready to ship to the customer. This loading is carried on identically at each successive pit, the track on the highwall being dragged away from the pit face the width of the pit after the coal is loaded out of that pit and realigned. The track is dragged away from each pit to it's new location near the next pit, by using the 30 HP caterpillar tractor, that very easily pulls the track over a little at a time by hooking on to different points along the track. The track is dragged over as one unit, this simplifying very much the task of track building.

After the three coal cars of each "trip" or train load is filled, the coal is hauled to the coal hopper, the main east and west track used to Spur Track No. 17, depending on the point at which the loading is progressing, the closest track being used in every case. The coal is hauled over Spur Track No. 17 and over the curved track to the coal hopper, where the contents of each coal car is dumped into the hopper as the projecting rod from the bottom doors of the cars strikes the automatic door opening devices, this
causing the doors in the bottom of each car to open and it's contents to be dumped into the hopper. Three full car loads can be dumped from either track over the hopper, and two from the other track after the three have been unloaded from the first track, the total capacity of the hopper being five car-loads, or one hundred and seventy-five tons. As the coal falls into the mouth or bottom of the hopper, it falls upon the reciprocating feeder which is inclined on a pitch of six inches in it's total length and which works on an eccentric that jerks it back and forth, then causing the coal on top of the reciprocating feeder to be discharged onto the drag conveyor just underneath the end of the reciprocating feeder (See Drawing No. K-3-11). This reciprocating feeder, as previously said, works on an eccentric that is turned driven by a 15 HP., 1200 R.P.M. motor. Connected to the motor and driven by it is a No. 4 G Reeves variable speed transmission. The advantages of using the Reeves Transmission over any other type of speed control are as follows:

(1) The transmission of power is positive at all speeds, there being no slippage.
(2) An infinite number of speeds are provided - any speed whatsoever that the drag conveyor is desired to run - can be provided.
(3) When set, the speed remains constant and does not vary with fluctuating loads placed on it.
(4) It automatically locks in place at any desired speed setting.
(5) The power consumption is directly proportionate to the speeds.
(6) Practically no maintenance is required.
(7) Adaptable to all types of machinery requiring speed control.
It may be driven in either direction.

The speeds may be changed while the machine is running. It is not necessary to stop production to effect the speed regulation.

The speeds may be changed at the machine or at remote positions.

It is equipped with force-feed system of lubrication.

It is highly efficient.

A wider ratio of variation is provided - as high as 16 to 1 if desired.

It may be installed without appreciably increasing the power consumption.

Reeves Transmissions are now being used extensively in mining operations, but prior to a few years ago when Mr. K. A. Spencer, in charge of engineering for the Pittsburg & Midway Coal Mining Company, installed the first Reeves Transmission at the company's Mine #10 several years hence, they were not in use.

The coal is discharged from the reciprocating feeder through a 2 3/4 foot x 4 foot opening, or mouth, onto a revolving flight conveyor 54 inches in width. This flight conveyor is composed of many sections of elliptical steel that make up the area that the coal is discharged on, each of these steel sections being designed so, once the coal is deposited on it, it will be held at that point and carried to the top of the flight conveyor where it is discharged, either through the coal crusher or onto the shaker screens. The flight conveyor is driven by a 50 HP. 1200 R.P.M. motor, a motor as large as this being necessary, as the distance from the bottom of the flight conveyor to the top is 186 feet. The coal, having been discharged onto the double shaker screen, is oscillated back and forth on an eccentric
driven by a Tex Rope Drive. This causes the coal to move down the shaker screen, which is inclined on an angle, the coal being graded into sizes as it passes over the different sized openings in the screens. The chutes from the shaker screens are arranged so the different sizes of coal can, either be loaded directly into the coal cars underneath, or be loaded onto loading booms into the coal cars. The lump, nut, mine run, railroad and egg size coal is loaded into the cars with the aid of loading booms, each being driven by a 5 HP., 1200 R.P.M. motor. The loading booms are raised or lowered into the car by the use of automatic electric hoists attached to the loading end. The purpose of the loading booms are to load the coal into the cars without any breakage of the coal, this loading proceeds uniformly as each car, as it is filled gradually from end to end, is lowered down the 2.5 percent railroad grade under the tipple, by the aid of the car retarders. These car retarders permit the cars to be lowered gradually down the grade under the tipple, insuring even loading and simplifying the handling of the cars. The coal cars, before having been brought down under the tipple to be loaded, had been "spotted" or hauled and placed on the "tail" or empty storage track by one of the railroad locomotives, it having used the runaround track to go by the tipple and place the number of empty cars needed for the day on the empty storage track.

As the machinery in the tipple is running and the coal is being loaded into the coal cars, any foreign matter in the coal such as "sulphur", slate, etc. is picked off the loading booms by several men stationed at each boom, whose only duty is to watch the coal as it passes by them and to pick out the sulphur
and other foreign material and place these into an opening that discharges onto the sulphur conveyor. This conveyor conveys the sulphur to a point over the sulphur track under the tipple where it is discharged into a rotating Bradford Breaker. This breaker is lined inside with angle irons around its cylindrical inner surface which causes the sulphur pieces to be knocked against the sides of the walls so that any coal on the sulphur will be knocked loose and fall through the openings in the cylinder and into a container where a cup hoist driven by motor, raises the slack from the sulphur up and deposits it back onto the drag conveyor that in turn, deposits it on the shaker and then it is screened into the slack car.

The waste sulphur goes out the end of the rotating breaker and falls into a side dump sulphur car, which, when filled is hauled to the worked out strip pit and dumped into the pit.

The cars loaded with coal are lowered to the coal storage tracks by one man operating the breaker as it goes down the grade by gravity. The cars are then ready to be shipped to the coal buyer, this being handled by the sales force. Each day the number of cars and initial are called into the Pittsburg office where they are billed out to the purchaser, the coal having been sold by the sales department, located at any one of the following places: Omaha, Nebraska, Henryetta, Oklahoma, Wichita, Kansas, Joplin, Missouri or Kansas City, Missouri.

XXVI. Future development of the mine.

The future development of Mine No. 15 will, in some ways, depend upon the trend of coal prices. If a much better price for coal is obtained, there is no doubt but what much more coal acreage at Mineral can be stripped west of the line on
Map No. E-2-12, designated as the maximum digging line. However, if the price of coal remains constant, all of the coal in the east one-half of Section 4 will be worked out and the south spur track continued south into Section 9, all of the coal then being worked out of Section 9. The coal having been worked out of the east one-half of Section 4 and all of Section 9, the coal can then be taken out of the west one-half of Section 4. To recover the coal from Section 8, it will be necessary to construct a spur track extending south of the tipple into Section 8. The present location of Cherry Creek will have to be relocated, changing its channel west back of the maximum digging line, and paralleling the Missouri-Kansas-Texas Railroad track on the east side to the trestle over Cherry Creek. The location of the creek west of the trestle will not be changed, as it lays on the coal outcrop at this point.

Relocating Cherry Creek in Section 8, will enable the mining company to begin stripping at the east side of Section 8, west of the road (the north-south could not be vacated) and stripped west to the relocated location of Cherry Creek, this insuring that the recoverable coal in Section 8 will be recovered. A ditch large enough to carry a drainage area of eighteen hundred acres will be needed, thus if the average depth of excavation is five feet, the average width of the ditch will be fifty-six feet, an area of waterway of two hundred and eighty square feet being needed.

All of southwest quarter of Section 8, east of the maximum digging line, will be stripped as well as that portion east of the maximum digging line in the northwest quarter of
Section 17. Additional acreage to the southwest will no doubt be stripped and hauled to the present tipple location.

The general future outlook of Mine No. 15 of the Pittsburg and Midway Coal Mining Company is very gratifying, basing future expectations on the way the mine has been developed to date and the amount of coal that has been loaded up to the date of writing this report. The different equipment seems to blend harmoniously into the trend of operations, each phase of the mining operation seeming to team and fit in very well with the other. The sizes of the different units all seem to be just what the mining operators wanted to get the maximum tonnage expected from the mine. The mine has loaded as high as thirty-five railroad cars a day on many days, this making a daily tonnage of seventeen hundred fifty tons a day, which is very good considering the thickness of the coal seam. The tipple has had no difficulty at all in handling all the coal hauled and loaded through it, while the capacity of the coal hopper is more than adequate for the present amount of coal loaded into it.

Considering every phase of the mining operations of Mine No. 15, the stripping, loading, hauling, pumping and preparation of the coal and the loading of the coal into cars for shipment, the mine is the best equipped modern strip coal mine in this mining district. Considering the quality and tonnage of good coal available at this mine, the Pittsburg & Midway Coal Mining Company expects Mine No. 15 to be the best coal producing mine working on any seam of coal in the district, with the exception of mines working on the Weir-Pittsburg seam of coal whose thickness is thirty-six inches, as compared with twenty-two inches at Mine No. 15.
XXVIII. Summary.

Coal stripping operations have utilized all sorts of equipment since the first coal mines were operated using strip methods. Early work was carried on by what was commonly called hand methods, that is, by plowing and removing the overburden by means of scrapers without the use of steam or electric shovels. The cost of these operations was so great, when animal and human labor was employed, that such methods could not be used where heavy overburden was encountered.

Coal mining, using stripping methods, has advanced to the use of such modern equipment in every phase of the development and operation of the mine, that it can truthfully be said that strip mining is really a science.

The use of machinery on a large scale in strip mining has decreased the cost of mining, labor having decreased to a minimum.

Every unit used in the development and operation of a strip mine is built to blend in with the other mining operations. If one unit is weak and does not perform satisfactorily, that unit is replaced by one capable of doing the work.

Electrical power has supplanted the use of steam in driving the huge shovels used in strip mining. The supplanting of the use of steam by electrically driven shovels, has been caused by (1) the fact that it is cheaper to use the electricity, (2) there are fewer delays and therefore more stripping time available, because of the lack of delays in refueling with coal (3) there is more uniformity in loading and (4) boiler trouble is eliminated, caused by using poor water.
Every strip mine uses more or less modern equipment, but the Pittsburg & Midway Coal Mining Company, in installing their Mine No. 15, has seemingly reached its goal to efficiency in the mining and preparation of coal. Every effort has been made to install mining equipment in the pit and machinery in the tipple, that would prepare the coal in the most efficient and satisfactory manner possible, thereby insuring their customers that they will receive coal from this mine that is absolutely free from all foreign material, such as "sulphurs" and clay impurities.

The Pittsburg & Midway Coal Mining Company's Mine No. 15 has been successfully operated since it was opened and has been furnishing its customers with a very high grade of coal. The different mining units used in operating the mine have been functioning very well together, and have come up to the standard expected to them. However, time will prove whether some one unit will prove wanting in some phase, and if such is the case, that unit will have to be replaced and supplanted by another unit capable of keeping in stride with the other operating units.

In writing this thesis, I have desired to give the reader a working knowledge of how a modern coal strip mine is developed and operated, using the most modern stripping methods available. I hope, by reading this thesis and with the assistance of the photographs and maps accompanying it, the reader will have become more or less familiar with the development and operation of a modern coal strip mine.

Respectfully submitted,

Henry C. Widmer
In writing this thesis on "The Development and Operation of a Strip Coal Mine using Modern Methods", references have been made to a discussion of the Engineering Bulletin No. 13 of the University of Kansas, the subject of the discussion being "The Occurrence and Production of Kansas Coal", and its author, Professor C. M. Young, Head of Mining and Engineering Department of Kansas University. This bulletin was published in March 1925.

References were also made to a report given at Pittsburgh, Pennsylvania in 1929 by Mr. K. A. Spencer, in Charge of Engineering for the Pittsburg & Midway Coal Mining Company. The subject of this report was "The Problem in handling Twenty-five feet to Fifty feet Strip Mining in the Kansas and Missouri Field."
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