AN INVESTIGATION OF THE COAL STORAGE AND HANDLING REQUIREMENTS OF MICHIGAN STATE COLLEGE FOR THE PERIOD 1955 - 1975

Thesis for the Degree of M. S.

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William Jack Sharp

1952

THESIS

SUPPLEMENTARY MATERIAL IN BACK OF BOOK

This is to certify that the

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(For G. W. Hobbs)

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AN INVESTIGATION OF THE COAL STORAGE AND HANDLING REQUIREMENTS OF MICHIGAN STATE COLLEGE FOR THE PERIOD 1955 - 1975

By

William Jack Sharp

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CHAPTER I

INTRODUCTION

The extent of the investigation herein outlined included the outside or field storage of coal and its preparation and handling from coal car and storage point to the Michigan State College South Campus Steam Generating Plant. Primary consideration was given to future requirements. Any investigation of future requirements must, of necessity, be predicated partly on historical facts and partly on enlightened prognostication.

The scope of the investigation included an analysis of the historical growth of Michigan State College in terms of total building cubage, and steam and electrical loads and the projection of such data for the determination of future coal consumption and hence of future coal storage requirements.

Comparison was made between various types of coal handling systems as to initial equipment cost, and operation and maintenance costs, wherever such cost figures were available. Equipment selection was then made in the light of such knowledge.

The design and layout of the selected system was then carried out according to the principles and methods of the conveyor manufacturing industry.

The author was aided in his undertaking by the valuable suggestions and literature of the many manufacturers of conveying equipment and much of the formulae and tables were extracted from "The Bartlett-Snow Belt Conveyor Handbook, Bulletin No. 88" through the courtesy of the C. O. Bartlett and Snow Co. Information was also obtained from other sources and these have been duly credited in the succeeding pages.

CHAPTER II

HISTORICAL BACKGROUND

An analysis of the rate of growth of steam and electric loads shown in Table I indicates an average total yearly increase of approximately, five percent. This figure shows some, though not close, correlation with the historical growth of (6.8 percent per year) of total cubage of building heated by steam from the power plant (see Table II).

Such building growth has naturally been reflected in the total steam requirements for all purposes. The discrepancy between the two figures is attributable to a combination of such factors as, an error in graphical analysis and a decrease in heating requirements per cubic foot of building with centralization of educational and other facilities.

An annual rate of building cubage increase of 6.8 percent of the preceeding year would result in an addition, by the year 1975, of over 220 million cubic feet of buildings to the existing 57.6 million cubic feet. This increase is equivalent to over ten building booms such as has been witnessed on this campus since the close of World War II.

Substitution of a 5 percent increase per year based on 1950 figures would result in a total building cubage equal to just over twice the present facilities. Such a figure appears to be more in line than the one previously quoted and will be used for purposes of calculation of coal handling and storage requirements.

TABLE I

RATES OF GROWTH FOR STEAM AND ELECTRIC LOADS CONSIDERED
BY THE COMMONWEALTH ASSOCIATES INCORPORATED [1]

1. Peak steam demand growth 5% per year.
2. Peak electric demand growth 5% per year.
3. 250 lb. steam load growth 5% per year.
4. Electric load growth 5% per year.
5. Relatively constant 5 lb. steam growth 1% per year.
6. Steam for feed water heating 1% of 5 lb. steam generated (by calculation).

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1. From the files of Mr. J. M. Campbell, Supt. Power Plants, Michigan State College, East Lansing, Michigan.

TABLE II

TOTAL CUBAGE OF BUILDINGS HEATED BY STEAM FROM THE POWER PLANTS
(From the files of Buildings and Utilities, M.S.C.)

Year	Volume in Cubic Feet at the end of the year	Year	Volume in Cubic Feet at the end of the year	Year	Volume in Cubic Feet at the end of the year
1871	261,118	1891	2,025,528	1911	4,572,823
1872	"	1892	"	1912	4,890,337
1873	"	1893	"	1913	"
1874	"	1894	"	1914	5,156,371
1875	"	1895	"	1915	"
1876	"	1896	"	1916	7,711,385
1877	"	1897	"	1917	"
1878	"	1898	"	1918	"
1879	"	1899	"	1919	"
1880	"	1900	2,204,728	1920	7,972,985
1881	480,427	1901	"	1921	8,487,285
1882	"	1902	2,482,728	1922	"
1883	"	1903	"	1923	8,554,105
1884	"	1904	2,591,452	1924	11,127,221
1885	"	1905	3,064,765	1925	"
1886	640,427	1906	"	1926	"
1887	"	1907	"	1927	12,908,332
1888	743,707	1908	3,152,161	1928	15,219,152
1889	868,969	1909	4,572,823	1929	"
1890	2,025,528	1910	4,572,823	1930	15,287,478

Year	Volume in Cubic Feet at the end of the year	Year	Volume in Cubic Feet at the end of the year
1931	16,271,722	1941	33,212,556
1932	17,489,684	1942	33,395,124
1933	"	1943	"
1934	"	1944	"
1935	"	1945	"
1936	17,757,724	1946	33,690,268
1937	18,721,314	1947	41,033,534
1938	20,457,464	1948	50,852,103
1939	21,651,372	1949	54,253,913
1940	33,030,370	1950	57,671,913

Annual rate of increase (average of 1880 through 1950) is equal to 6.8 percent of the preceeding year.* August 17,1951

* Derived by graphical analysis by engineers of the Buildings and Utilities Department of Michigan State College.

Coal consumption figures for the calendar year of 1950 as shown in Table III were used as the basis for calculation of coal requirements for the years 1955 through 1975.

All calculations for determination of the type and size of equipment were based on estimated requirements for the year 1975. A twenty year amortization period was selected as being representative of the legally approved depreciation rate and the useful life of power plant equipment of the type under consideration.[2] Coal consumption for the year 1975 was determined on the basis of a 5 percent increase per year and was based on coal consumed in the Michigan State College Steam Plants during the year 1950.

Existing coal handling facilities at the South Campus Plant were designed for an unloading capacity of fifty tons per hour. Observations have indicated that a minimum of one hour per day should be allowed for opening and closing of coal car pockets, switching of cars and miscellaneous unavoidable delays. Furthermore, tests have indicated that under the best operating conditions the existing equipment is unable to handle more than 35 tons of coal per hour. Neglecting such factors as delay in arrival of coal cars, bunching of cars, breakdown of equipment, normal equipment maintenance etc., calculations indicate that existing facilities will not adequately handle more than half the coal requirements for the year 1975. Should the rate of growth continue at the historical rate during the next few years the existing South Campus

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[2] F. T. Morse, Power Plant Engineering and Design, 3rd Ed., New York, D. Van Nostrand Company, 1942, p. 51.

TABLE III

NORTH AND SOUTH STEAM PLANTS LOAD FIGURES FOR 1950

	STEAM (pounds)		COAL (pounds)	
Month	S.C.P.	N.C.P.	S.C.P.	N.C.P.
Jan.	92,729,250	19,491,045	10,619,600	2,921,660
Feb.	82,100,174	18,983,722	9,458,728	2,486,000
March	80,686,250	25,175,325	9,194,975	3,047,200
April	94,515,000		10,467,000	
May	71,618,750		7,671,800	
June	53,066,250		5,598,600	
July	50,167,500		5,506,000	
Aug.	15,491,250	31,265,430	1,667,000	3,274,040
Sept.	20,836,250	34,776,630	2,156,800	3,767,360
Oct.	79,025,250		8,154,200	
Nov.	104,395,750		10,881,800	
Dec.	115,976,500		12,152,000	
TOTAL	860,608,174	129,692,152	93,528,503	15,496,280
GRAND TOTAL	990,300,326 lbs.		109,024,783 lbs.	

facilities will be indaequate to handle the growing load beyond the year 1953 without resorting to costly overtime work. In as much as growth in campus facilities has hiterto occurred in spurts (see Table II) it is possible that the necessity for overtime may be postponed a few years. It is interesting to note, however, that on December 8, 1950 the South Plant consumed 233 tons (see Table IV) against a loading capacity, to the bunkers, of 245 tons daily based on a 35 ton per hour and seven hour per day loading schedule. This permits only a sixty ton make up, during the entire week, for week-end use. It is quite evident that this is not sufficient to fill the bunkers for week-end use. Thus, the indication is that the South Campus Plant coal handling facilities are inadequate to meet normal winter requirements AT PRESENT.

The cost of maintenance, exclusive of labor costs, for the years 1948 to May 8, 1952 was approximately $7,300.00.[3]

By personal observation it is estimated that minor maintenance generally involved the service of one skilled man plus one unskilled man for not less than one hour. While major maintenance occupied the time of three to four skilled men plus two to four unskilled men for a minimum of four hours.

During the period that the author was employed at the South Campus Plant minor emergency maintenance on the coal handling system occurred five to six times a week. Though it was not too common, it was certainly not a rarity. Such frequent maintenance, when it did occur, generally occurred during the high load winter months.

[3] Obtained from the files of Mr. F. C. Filter, Engineer, South Campus Steam Generating Plant, Michigan State College.

TABLE IV

DAILY LOAD CHART, SOUTH CAMPUS STEAM GENERATING PLANT DECEMBER 1950

Date	Pounds of Coal	Pounds of Steam
1	429,800	4,048,750
2	373,600	3,554,000
3	356,000	3,357,500
4	437,400	4,076,250
5	427,400	4,048,750
6	421,200	4,031,250
7	433,300	4,060,020
8	467,000	4,400,000
9	411,800	4,072,500
10	383,400	3,707,500
11	432,400	3,996,250
12	417,400	3,761,250
13	417,000	3,998,750
14	412,000	3,965,500
15	376,400	3,743,750
16	370,000	3,546,750
17	356,200	3,510,000
18	374,000	3,655,000
19	371,200	3,638,750
20	361,600	3,557,500
21	379,000	3,621,250
22	349,200	3,393,750
23	328,200	3,215,000
24	342,600	3,273,750
25	367,600	3,498,750
26	409,800	3,956,250
27	430,000	4,128,750
28	421,200	3,982,500
29	388,800	3,708,750
30	369,000	3,425,000
31	338,400	3,162,500
Totals	12,152,000	115,976,500

The $7,300 maintenance cost, mentioned above, covered only those costs incurred on the plant Overbunker System[4] but exclusive of the Reciprocating Feeder and coal crusher. This is the section whose functions would be taken over by the proposed belt conveyor system.

A partial list of emergency maintenance on one eighty foot section of the South Plant coal handling facilities follows. This list omits emergency maintenance that could, even remotely, have resulted from avoidable causes and covers a period of only six months.

TABLE V

EMERGENCY ELEVATOR MAINTENANCE
A partial list*

Date	Cause of Breakdown	Damage
6-20-49	Elevator Plugged	Motor broken loose from moorings
6-21-49	Elevator Plugged	Motor broken loose from moorings
11-18-49	Broken Link	Fifty links broken
11-21-49	Broken Link	Links broken
11-26-49	Broken Link	Links broken
12-12-49	Elevator Plugged	Sheared Shear-pins

* It is within the author's knowledge that about half the minor maintenance work performed finds its way into the maintenance record

Figures 1, 2, 3, and 4 vividly illustrate the results of a few elevator break-downs that occurred during the past year.

[4] By Overbunker System here is meant the Reciprocating Feeder, Coal Crusher, Low Level Conveyor (45.5 feet), Elevator (80.5 feet) and Overbunker Conveyor (82 feet).

Fig. 1. Illustrates an Elevator Break-down
Caused by a Broken Link

Fig. 2. Illustrates an Elevator Break-down Caused by a Plugged System

Fig. 3. **Another Illustration of a Break-down Caused by a Plugged System**

Fig. 4. Illustrates the Tedious Method of Reclaiming Coal after Emergency Elevator Repairs

It is apparent therefore, that aside from future requirements there is a very pressing need for improved coal handling facilities at the South Campus Steam Plant.

CHAPTER III

PRESENTATION AND ANALYSIS OF DATA

A. TYPES OF SYSTEMS AVAILABLE

Having indicated the need for improved coal handling facilities it becomes necessary to describe the various types of systems that are manufactured and may conceivably be utilized by the South Campus Plant.

Figure 17 shows the general layout of the outdoor stock-pile in relation to the South Plant. As will be seen it is necessary for the contemplated system to be such as to enable unloading of coal cars to be undertaken in the vicinity of the stock pile and coal to be conveyed either to storage or to the steam plant, a distance of approximately 1200 feet. It should be noted that no matter which system is used the total length of all conveyors and the general layout will be approximately as illustrated.

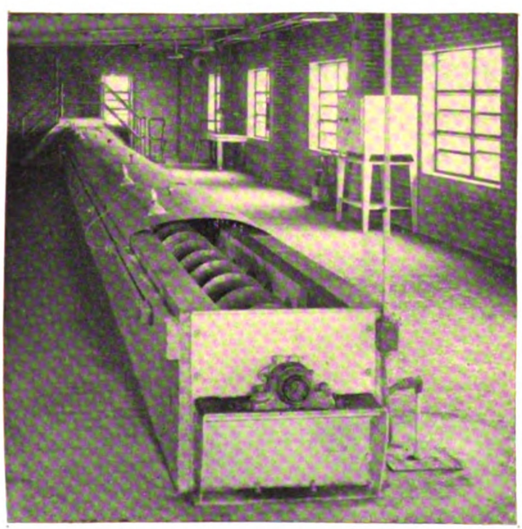
The types of systems which may be used, though not necessarily in this situation, are listed below. It should be noted that in the main there are two possibilities in each case listed. Coal may be conveyed from storage -- or unloading point -- (1) below ground level to the plant site and then elevated to the plant bunker level or, (2) coal may be elevated gradually from storage -- or unloading point -- to the plant bunker level without the use of an elevator.

Regardless as to whether the first or the second method of elevation is used with any particular installation costs of each will change little -- exclusive of costs of support and erection. Since the cost of the latter -- viz support and erection -- will be approximately the same for all elevated systems or for all ground level systems, cost comparison will be made for systems laid out as indicated in the illustration.

1. Screw Conveyor
2. Apron Conveyor
3. Pivoted Bucket - or V Bucket
4. Flight Conveyor
    a. Single Chain
    b. Double Chain
5. Belt Conveyor.

B. COMPARISON OF SYSTEMS

1. Screw Conveyors.

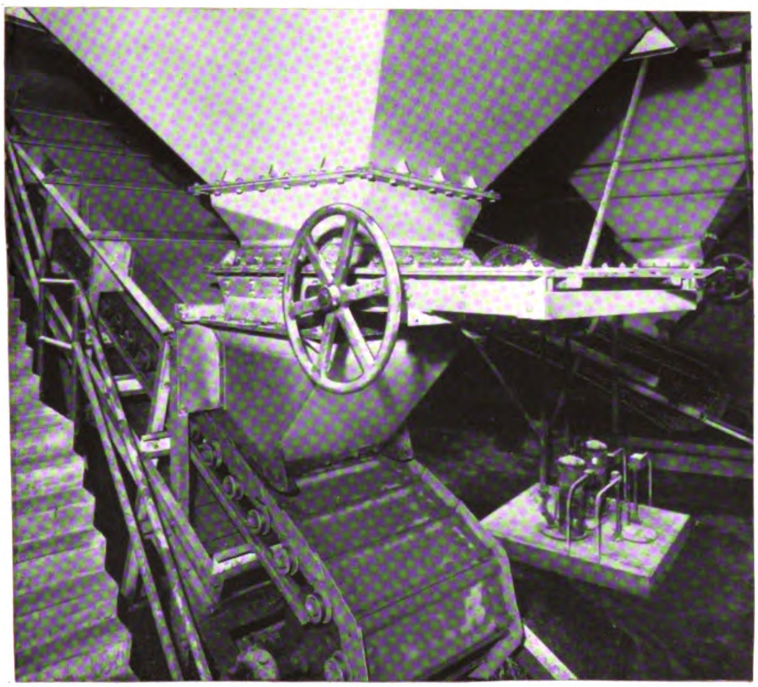


Link Belt Co.

Fig. 5. A Screw Conveyor

Screw conveyors are not suitable for any but the smallest capacity requirements and are not generally made in capacities above forty tons per hour.

2. Apron Conveyors.

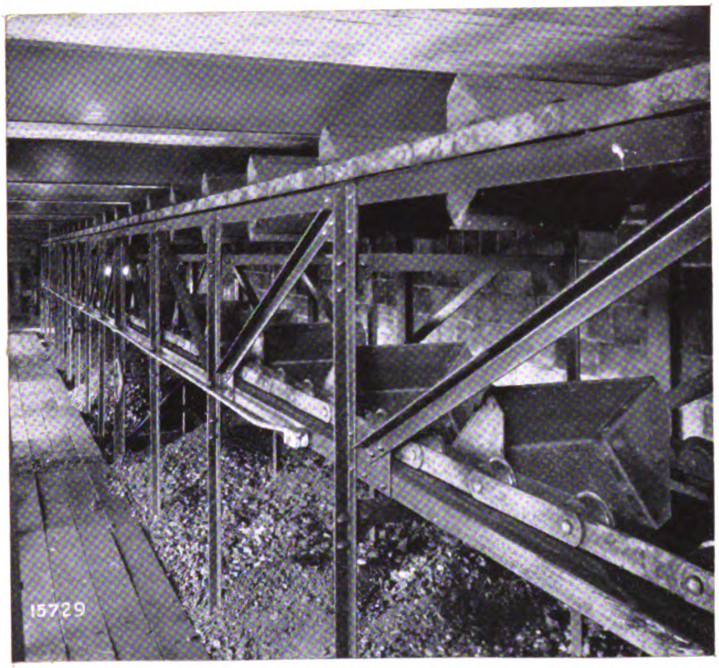


C.O. Bartlett and Snow Co.

Fig. 6. Illustrating a Typical Apron Conveyor and its Function as a Feeder

Apron conveyors are generally made for feeder duty rather than conveyor duty. Apron Conveyors are of heavy construction and require a relatively large horsepower input for the duty performed. About the only advantage of an Apron Conveyor lies in the large angle of incline at which it may be operated. Operation and maintenance costs for a large installation would be extremely high.

3. V. Bucket Elevator Conveyor.



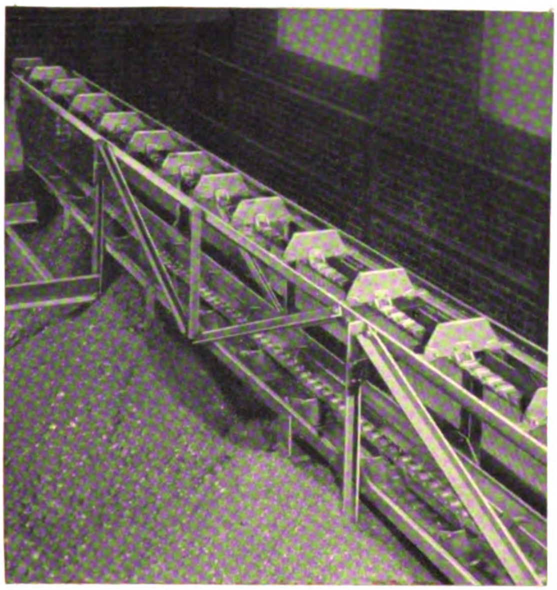
Jeffrey Manufacturing Co.

Fig. 7. Horizontal Run of a V. Bucket Elevator-Conveyor

This type of system is relatively expensive in first cost. According to conveyor tables this system requires only slightly less horsepower than does a flight conveyor under similar conditions. It is estimated that maintenance costs would approximate that for flight conveyors.

4. <u>Flight Conveyors.</u>

a. Single Strand



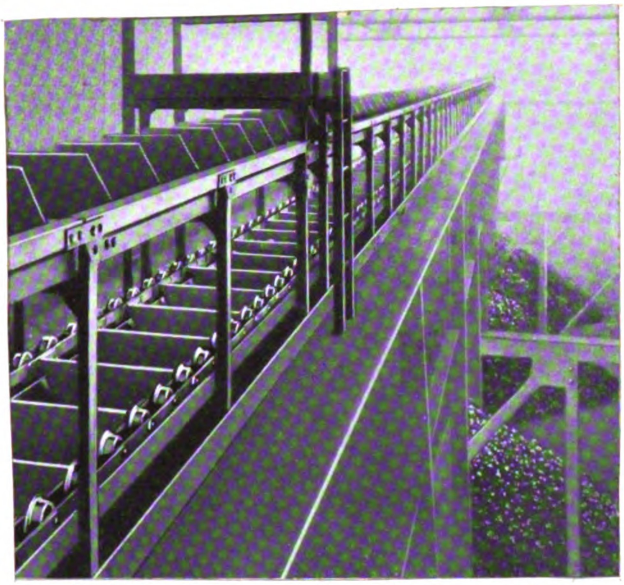
Link-Belt Co.

Fig. 8. A Simple Single Strand
Flight Conveyor

This type of conveyor is not generally made for capacities above sixty tons per hour.

b. Double Strand

Double Strand Flight Conveyors while capable of large output are, nevertheless, prodigious consumers of power. The main advantage of such a system lies in the extreme angle of inclination at which it may be operated. Inclinations up to 45^{o} are possible with Flight Conveyors.



Rex Chain Belt Co.

Fig. 9. A Rex Scraper-Flight Conveyor

The first cost is relatively low but the maintenance costs for such a system, while not as great as for Apron Conveyors, are nevertheless appreciably larger than for a belt conveyor system.

5. <u>Belt Conveyor Systems</u>.

It is genrally accepted that the cost of maintenance of such a system is less than that for any other type under similar conditions of operation, the consenous of opinion of the conveyor manufacturing industry being that maintenance costs of a belt conveyor system would be less than two-thirds the cost of maintaining a Flight Conveyor and less than half the cost of maintaining a Screw or Apron Conveyor system.

C.O. Bartlett-Snow Co.

Fig. 10. A Belt Conveyor Showing Tripper in Action

The initial cost of such a system is relatively high and would almost certainly amount to more than that for any other system.

Before a definite selection is made consideration must be given to the following factors:

1. Future requirements -- with regard to capacity.
2. Cost of maintenance..
3. Cost of operation.
4. Cost of installation -- initial cost.

<u>Future requirements</u>. Probable future requirements have previously been discussed in terms of future coal consumption per year up to and

including the year 1975. Table III indicates that the maximum coal consumption during any month of 1950 occurred in December when 12,152,000 pounds or 6,077 tons of coal were burned by both plants of which over 86 percent was burned in the South Campus Plant. Since any coal handling system should be capable of handling peak daily requirements it is necessary to determine such requirements. Table IV indicates that on December 8, 1950 a total of 467,000 pounds or 233.1 tons of coal were consumed. During this same month there were no less than thirteen days during which over 204 tons of coal were used per day. Therefore, the use of the peak figure of 233 tons per day for calculation purposes is fully warranted.

Using:

Five percent growth per year or 225 percent capacity requirement (not compounded) for 1975 based on 1950 consumption.

Maximum or peak daily coal consumption in December 1950 = 233 tons.

Then in December 1975 peak daily coal consumption would be:
233 X 2.25 or 525 tons.

and assuming a seven hour per day continuous operation schedule, then capacity required = 525/7 = 75.1 tons per hour.

In order to allow for such factors as necessary equipment maintenance, unforseen breakdowns, late delivery of coal cars, operation of the conveyors below their peak capacity and the necessity for making up for live storage used during the week-end:

Assume:

The conveyor is loaded to 75 percent of capacity. This is an accepted figure by conveyor manufacturers.

Then in order to meet daily requirements with a sufficient factor of safety conveyor capacity should be:

$$75.1/0.75 = 100.1 \text{ tons per hour,}$$

use 100 tons per hour for calculations.

A capacity requirement of 100 tons per hour immediately eliminates both screw conveyors and single strand flight conveyors. Apron conveyors will not be considered here since the primary purpose of such conveyors is to act as feeders wherever a sharp ascent is desired in a short distance. For this reason they are not at all economical as conveyors.

Cost of maintenance. While no certainty exists as to the exact cost of maintaining various systems it is generally accepted that belt conveyors require the least maintenance followed in order by skip hoists, flight and bucket conveyors and elevators, screw conveyors, and apron conveyors. A belt system is about half as costly to maintain as a flight or bucket system and a little more than one third as costly as a screw or apron type conveyor.

Cost of Operation. The cost of operation of any conveying system may be measured by the cost of two factors. The first, which is the direct labor cost involved, is relatively easy to determine and, generally speaking, would be approximately the same for the five systems mentioned. For this reason direct labor cost will not be considered in comparing operation costs. On the other hand the cost of running the systems with respect ot the power consumed will differe appreciably and will be dependent upon the horsepower required to drive the various systems and the length of time -- in hours -- during which the systems are operated. Table VI shows the horsepower required to drive the different systems, the total tonnage of coal that will need to be moved during the period 1955 to 1975, the total running hours of each system and the estimated initial, operating and maintenance costs.

It will be noted that initial costs have been given only for a belt conveyor system. The costs given for this system in this table include only those costs that are not peculiar to all the other systems. For example this table omits the initial cost of the crusher, double reciprocating feeder, motors, hoppers and gallery since these costs are common to all the systems.

Initial cost. If an allowance of an additional $10,000 is made for the initial cost of the Belt Conveyor system -- thus making a total cost of $44,733.00 exclusive of the cost of parts common to all systems as mentioned on page 25 and exclusive of installation costs -- it will be seen that so long as similar parts of the Pivoted Bucket or Flight Conveyor systems cost more than about $26,500 each then a belt conveyor system would be less costly in the long run. It is interesting to note that 179 feet of chains for the drag chain type of Flight Conveyor -- Underbunker Conveyor -- at the South Campus Plant were recently purchased for $1,061.47. On this basis the chains for 1472 feet of conveyor -- 3944 feet of chain -- would cost $23,300. The top, sides, and bottom plates and channels for such a conveyor would certainly be more expensive than the supporting frame of the belt conveyor idlers.[1]

1 Obtained from the files of Mr. F.C. Filter, Engineer, South Campus Steam Generating Plant, Michigan State College.

TABLE VI

COMPARATIVE COSTS

		Conveyor		
		Pivoted or V. Bucket	Flight, Double Strand	Belt
Total Length -- Feet		1472	1472	1472
Total Horsepower Required		188[a]	190[b]	40.46[c]
Total Coal (1955-1975) Tons		2,303,500	2,303,500	2,303,500
Capacity - T.p.h.		100	100	100
Running Time - Hrs.		23,035	23,035	23,035
H.P. Hours - 1955-1975		4,330,000	4,330,000	931,000
K.W. Hours - 1955-1975		3,230,000	3,270,000	694,000
Power Cost	Per K.W. Hr. - Assume	0.75¢	0.75¢	0.75¢
	Total (1955-1975)	$20,600	$20,850	$5,200
Maintenance Cost	Per Ton per 1000' (estimate)	0.75¢	0.75¢	0.40¢
	Total (1955-1975)	$25,370	$25,370	$13,500
Power and Maintenance Cost		$45,970	$46,220	$18,700
Initial Cost -- Partial				$34,733.00[d]

a. Fairfield Elevating and Conveying Machinery, Catalog No. 15, p. 129. This figure does not include allowance for each 90° turn nor drive losses.

b. Fairfield Elevating and Conveying Machinery, Catalog No. 15, pp. 93-97.

c. See Table XXII.

d. It should be noted that all but about $300.00 of take-up costs have been included here. For a breakdown of this figure see footnote Table XXIII.

It would certainly appear therefore that the sum of the initial, maintenance and operating costs of a belt conveyor system would be less than similar costs of other systems.

C. SELECTION AND DESIGN OF THE SYSTEM

Selection.

Having determined that a belt conveyor installation would be the cheapest of the various systems to operate and maintain it was decided that an installation of the type illustrated in Figure 17 or of a similar system underground, to the vicinity of the steam plant feeding into:

1. A V. Bucket Elevator-Conveyor which would elevate the coal to bunker level and convey it over the suspended bunkers in the plant or,
2. a Bucket Elevator feeding into a belt type Overbunker Conveyor or,
3. a Drag Chain Elevator of the type now in use at the South Plant or,
4. a Skip Hoist feeding into a belt type Overbunker Conveyor.

V. Bucket Elevator-Conveyor. This type of conveyor would require a minimum of 31.5 additional horsepower plus a large maintenance cost.[2] This horsepower is only slightly less than the total horsepower required for a complete belt installation 1472 feet long.

Bucket Elevator. A Bucket Elevator would require approximately 15.5 horsepower for an eighty foot elevation. However, such an elevator

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2 See Table XXIII

would result in uneven feeding of the belt type Overbunker Conveyor. This in turn would necessitate a much wider belt conveyor and result in uneconomical use of the belt. Bucket Elevator initial and maintenance costs are fairly high.

Drag Chain Elevator. No conclusive horsepower figures were available for such elevators. A similar elevator now in use at the South Plant requires a 25 horsepower motor. This Elevator is eighty feet long and is rated at fifty tons per hour. Tests, under most favorable conditions, have indicated that the coal handling system in the South Plant is unable to handle more than 35 tons per hour. In order to elevate one hundred tons per hour, therefore, a motor of not less than 35 horsepower would be needed. Furthermore it has already been shown that such an elevator requires considerable maintenance.

Skip Hoist. A Skip Hoist cannot be used without the use of some sort of hopper or outdoor storage bunker. Due to the intermittent nature of operation of a Skip Hoist and the large volume of the bucket the hopper would have to be of fairly large capacity.

A minimum of 18 horsepower would be required for a counterweighted Skip Hoist having a 100 ton per hour capacity.

Skip Hoists are not generally used for such service but are used to feed directly into large outdoor storage bunkers.

Belt Conveyor. A Belt Conveyor system as shown in Figure 17 would, therefore, be the most suitable and economical on a long term basis for the requirements of the South Campus Steam Generating Plant.

An illustrative example of design calculations for such a system will be found in subsequent pages.

Design of the System.

Troughed Belt Conveyors, Their Design and Operation.

Handling of coal is frequently reflected much too greatly in its cost but seldom adds anything to its value. Since outages of as little as a fraction of cent per ton assume quite large proportions over the life of even a small capacity conveyor, it is essential that the specifications of every installation be selected with the greatest possible precision.

Uniformity of Feed. Efficient, low cost operation of a belt conveyor requires the uniform loading of material onto the belt as nearly as possible at the exact rate the conveyor is calculated to handle. Under conditions of non uniform loading computations for capacity, power, etc., should be based on the peak load.

Maximum angles of incline. The material being handled and its action on the belt determine the maximum angle of incline at which inclined belt conveyors can be successfully operated without excessive slippage and rolling back of the material.

The calculations and design illustrated on the following pages have been based on the handling of run of mine coal which can be successfully elevated at 18^{o} to 20^{o} angles.

Size of lumps -- belt widths. The size of lumps and the percentage of lumps to fines is an important determining factor in the belt width. The larger the lumps or the greater the percentage of lumps to fines the wider the belt required. The relationship between maximum lump size and minimum belt width is shown in Table VII.

Belt speeds. In general, belt speeds should be such as to permit the use of as narrow a belt as possible without exceeding speeds that the service, and loading and discharging will allow. That combination of belt speed and width should be chosen that will permit the belt to operate under a full cross sectional load. Table VIII indicates normal maximum speeds for various widths of troughed belt conveyors for conditions to be met by the installation at the Michigan State College South Campus Steam Generating Plant.

Special Conditions

1. Run of mine coal is usually handled at speeds of less than 250 feet per minute, if excessive breakage in discharging the lumps is desired.
2. Conveyors used as feeders are generally operated at speeds below 100 feet per minute and give best results at speeds of from thirty to sixty feet per minute.
3. Conveyors with automatic trippers should be run at about 300 feet per minute to insure clean discharge of the material over the tripper head pulley.

TABLE VII

RECOMMENDED MINIMUM BELT WIDTH FOR TROUGHED BELT CONVEYORS HANDLING LUMPS OF VARIOUS SIZES

	Belt Width	18"	20"	24"
Maximum Size Lump	All Lump	3	3 1/2	4 1/2
	Lump Mixed with 90% Fines	5	7	9

TABLE VIII

RECOMMENDED NORMAL AND MAXIMUM SPEEDS FOR TROUGHED BELT CONVEYORS HANDLING VARIOUS MATERIALS

Material to Be Conveyed	RECOMMENDED MAXIMUM BELT SPEEDS (F.P.M.)		
	Width of Belt in Inches		
	18"	20"	24"
Normal Speeds (F.P.M.)	250	300	300
Small Non-Abrasive Sand, gravel, crushed coal, Fuller's earth, flue dust, soda ash, salt.	350	350	400

The following example has been selected from the preliminary calculations for a belt conveyor system. The accummulated results of these preliminary calculations may be found in Table XXII.

Upon the recommendation of Mr. W. H. Kuhn,[3] the belt speed of the Conveyor from Track Hopper was increased from 85 feet per minute to 225 feet per minute resulting in the use of a narrower belt. This is permissible because the reciprocating feeder smooths out the flow of coal to the belt. The belt speed from Crusher to Coal Pile was reduced from 300 feet per minute to 250 feet per minute in order to permit the coal to be brought up to speed more uniformly and so prevent excessive breakage. The belt width of the conveyor from crusher to suspended bunkers was increased to 24". This was done both, in the interests of uniformity and by the advice of Mr. Kuhn and Mr. John R. Hersey.[4] Since a tripper is used on this conveyor the belt speed was kept at 300 feet per minute. Mr. Hersey further recommended that pulley shaft sizes, though calculated correctly, be increased one half inch each in the diameter in the interests of future economy.

Table XXIII shows the final recommended specifications. Table XXII has been included merely to illustrate a few of the changes that may be made in order to realize economies of operation and maintenance.

It will be noted that certain horsepower figures have been omitted in these tables under the heading "Horsepower Required for the Belt Conveyor from Reclaim Hopper". Since this conveyor has no Reciprocating

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3 Sales Manager, Contract Division, The Fairfield Engineering Co., Marion, Ohio.

4 Sales Manager, The C. O. Bartlett and Snow Company, Cleveland, O.

Feeder it must act as a feeder itself. Therefore, the belt speed must be kept low. In order to minimize belt width under such conditions it is necessary to use skirt boards on the carrying side. The use of skirt boards raises a difficulty in horsepower calculations of this type in as much as the coefficient of friction of coal on steel is not known. Horsepower figures for such conveyors therefore can only be obtained by actual trial. The 7.5 horsepower figure shown in the tables was supplied by Mr. W. H. Kuhn.

Sample Design Calculations

Conveyor Section: From Crusher to suspended bunkers, (See Figure 11).

Length: 1035 feet: Along contour of belt.

Elevation: 55 feet or 17°.

Length of elevating section: 187 feet.

Length of horizontal section: 847 feet.

Weight of coal: 50 pounds per cubic foot.

Size of coal: Crushed to one inch.

<u>Capacities of troughed belt conveyors</u>. The capacity of a troughed belt conveyor is determined by its speed of travel in feet per minute, the amount of material that can be carried on the belt without spillage and the weight of the material that can be carried in pounds per cubic foot.

Tests have indicated that the effective cross sectional capacity of a belt 12 inches wide traveling at 100 feet per minute can be expressed as $3.2W^2$ where $W =$ belt width in inches and that the factor 3.2

gains gradually to 4.0 for sixty inch belts since the effective width of a belt increases, percentage-wise with increasing belt widths.

TABLE IX

VALUES OF "F" FOR VARIOUS BELT WIDTHS

Belt Width in Inches	"F" Factor	Belt Width in Inches	"F" Factor	Belt Width in Inches	"F" Factor
12	3.20	20	3.33	42	3.70
14	3.23	24	3.40	48	3.80
16	3.26	30	3.50	54	3.90
18	3.30	36	3.60	60	4.00

Thus:

Effective cross-sectional capacity of any belt traveling at 100 feet per minute = FW^2 cu. feet. Where F = the varying factor and W = belt width in inches.

Or effective cross-sectional area of any belt = $\frac{FW^2}{100}$ square feet.

Then:

$$\text{Belt capacity} = \frac{FW^2}{100} \times S \times M \times \frac{1}{2000} = \text{Tons per hour} = T$$

Where M = Weight of the material in pounds per cubic foot.
S = Belt speed in feet per minute.

Then where:

W = 20 inches ------ assume

M = 50 pounds per cubic foot ------ for coal

F = 3.33 from Table IX

= the cross-sectional capacity of a 20 inch belt.

T = 100 tons per hour ------ peak required capacity

S = belt speed in feet per minute ------ Find.

Since:

$$\frac{FW^2SM}{200,000} = T$$

$$S = \frac{T \times 200,000}{FW^2M}$$

$$= \frac{100 \times 200,000}{(3.33)x(20)^2 \times 50}$$

$$= 300 \text{ feet per minute.}$$

Power requirements. The total power requirement of a belt conveyor is represented by:

1. The power required to run the conveyor when empty.
2. The power required to convey the material horizontally.
3. The power required to elevate the material.
4. The additional power required when trippers are used.

Formula for the power required to run the conveyor when empty. The power required to run a belt conveyor when empty varies with -- the weight of the belt, the weight of the conveyor's moving parts, the coefficient of friction of the bearings and the speed of belt travel.

Using:

C = friction factor ------ See Table X.

Q = the dead weight of the moving parts of the equipment (including the belt) in pounds per foot of center to center distance ------ See Table XI.

L = the center to center distance in feet.

L_o = the length constant in feet ------ See Table X.

Then $Q(L + L_o)$ = total weight of the moving parts

$CQ(L + L_o)$ = pounds pull to overcome friction

$CQ(L + L_o) \times S$ = rate of work - in foot pounds pull per minute

and $\frac{CQ(L + L_o) \times S}{33,000}$ = horse power required to run conveyor when empty.

The "C" and "L_o" factors. The friction or "C" factor is dependent upon the type of bearings used and varies as indicated in Table X.

"L_o" represents the power absorbing factors that are present in any conveyor regardless of its length. Examples of such power losses are those due to head and tail pulleys, snub, bend, and take-up pulleys.

TABLE X

VALUES OF "C" AND "L_o"

Class of Equipment	Friction Factor "C"	Length Factor in Feet "L_o"
Plain Bearing Belt Conveyors	0.05	100
Average Type Anti-Friction Belt Conveyors	0.03	150
High Type Anti-Friction Belt Conveyors	0.022	200

Factor "Q". The value of "Q" is the weight of the belt and of the moving parts of the idlers per foot of conveyor length. It includes the weights of two lineal feet of belt and varies with different belt widths. The values for "Q" have been computed on the basis of the weight of the revolving parts of Bartlett-Snow Series 60 troughing and return idlers, using the spacings shown, and the weight of two lineal feet of belt of average specifications for the respective width conveyors.

TABLE XI

VALUE OF FACTOR "Q" FOR VARIOUS BELT WIDTHS

Belt Width	14	16	18	20	24	30	36	42	48	54	60
Value of "Q"	15	16	19	21	25	34	44	50	59	68	76

"Q" in the table above has been computed for the following conditions:

Weight Troughing Idler Rolls	35	37	39	41	45	52	58	64	70	76	82
Weight Return Idler Rolls	26	28	30	32	36	42	48	54	60	66	72
Spacing Troughing Idlers	5'0"	5'0"	4'6"	4'6"	4'0"	4'0"	3'6"	3'6"	3'6"	3'6"	3'6"
Spacing Return Idlers	10'0"	10'0"	10'0"	10'0"	10'0"	10'0"	9'0"	9'0"	9'0"	7'0"	7'0"
Weight-Two Feet of Belt	5.4	5.8	7.3	8.7	10.1	16.8	22.1	25.7	32.3	36.9	42.3

Due to the impossibility of determining the weight of the moving parts of idlers the values for "Q" used in the calculations have been taken from the above table although the spacing of the Troughing Idlers actually used are not as given above. However, the difference between the spacings used and those for which the values of "Q" have been calculated -- Table XI -- is not generally more than six inches. The figures for horsepower requirements thus arrived at are actually slightly on the safe side.

Belt Conveyor. From Crusher through overbunker.

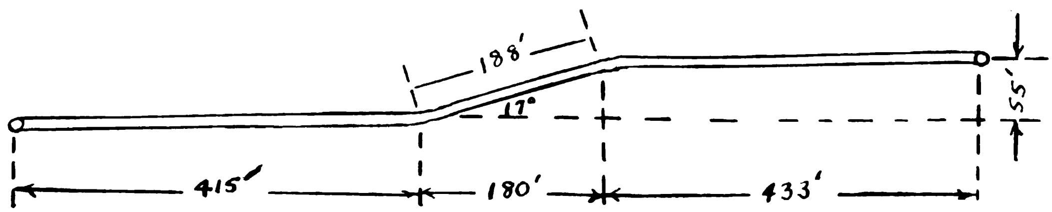

Fig. 11. Conveyor from Crusher to Bunkers

Formula for the Power Required to run the Conveyor when empty.

Conveyor belt width = 20 inches ------ See page 34.

Conveyor belt speed = 300 feet per minute ----- See page 34.

C = friction factor, See Table X, use high type antifriction belt conveyor

= 0.022

Q = the dead weight of the moving parts of the equipment (including the belt) in pounds per foot of center to center distance. See Table XI,

= 21 pounds per foot (of center to center distance).

L = center to center distance = 1035 feet.

L_o = 200 feet = the length constant. See Table X.

S = 300 feet per minute = belt speed. See page 35

Then: $Q(L + L_o)$ = the total weight of the moving parts.

$CQ(L + L_o)$ = pounds pull to overcome friction.

$CQ(L + L_o)S$ = rate of work in foot pounds pull per minute.

$\frac{CQ(L + L_o)S}{33,000}$ = horsepower required to run the conveyor when empty.

$$\frac{0.022 \times 21(1035 \quad 200)300}{33{,}000} = \text{HP required}$$

$$= 5.18 \text{ HP}$$

<u>Formula for the power required to convey the material horizontally.</u> The power required to convey the material horizontally varies with the total weight of the material that is on the belt, and the coefficient of friction of the bearings.

Using: C, L, L_o, and S, as in preceding formulas,

T = the tons of material handled per hour (at peak capacity),

then $2000T$ = pounds of material handled per hour,

$$\frac{2000T}{60} = \frac{100T}{3} = \text{pounds of material handled per minute}$$

$$\frac{100T}{3} \times \frac{1}{S} = \frac{100T}{3S} = \text{pounds of material handled per minute}$$

$$\frac{100T}{3S} \times (L + L_o) = \frac{100T(L + L_o)}{3S} = \text{total weight, in pounds, of the material on the belt}$$

$$\frac{100T(L + L_o)}{3S} \times C = \frac{100TC(L + L_o)}{3S} = \text{pounds pull to overcome friction}$$

$$\frac{100TC(L + L_o)}{3S} \times S = \text{rate of work, in foot pounds, pull per minute}$$

$$\frac{100TC(L + L_o)}{3 \times 33{,}000} = \frac{TC(L + L_o)}{990} = \text{the horsepower required to convey the material horizontally}$$

Therefore:

$$HP = \frac{100 \times 0.022(1035 + 200)}{990}$$

$$= 2.73$$

Formula for the power required to elevate the material (or the power generated in lowering it).

T = Tons handled per hour = 100 tons per hour

H = the net change in elevation in feet = 55 feet

then 2000T = pounds of material handled per hour

$\frac{2000T}{60} = \frac{100T}{3}$ = pounds of material handled per minute

$\frac{100TH}{3}$ = rate of work in foot pounds per minute

$\frac{100TH}{3 \times 33,000} = \frac{TH}{990}$ = the horsepower required for elevating the material (or that generated in lowering it)

Therefore: $HP = \frac{100 \times 55}{990} = 5.56$ HP

Horsepower required for conveyor belt tripper = 1.50[5] HP

Therefore: Total horsepower required for belt conveyor from the crusher to and including the overbunker conveyor

$= 5.18 + 2.73 + 5.56 + 1.50$

$= 14.97$ HP.

Belt tensions. In any belt conveyor in order to overcome friction, and move the belt and the material horizontally, on inclines, etc.; a difference of tension is needed in the belt on the two sides of the drive pulley. The tensions or pulls that require consideration are as follows:

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5 Mr. Hersey, John R. The C. O. Bartlett and Snow Co. Written Communication.

1. Effective Tension. This is the tension or "pull" resulting from the application of power to the drive pulley that moves the belt and the material.

2. Slack Side Tension, which is the tension or "pull" in the portion of the belt leaving the drive pulley that must be maintained to prevent slippage when power is applied to the drive pulley.

3. Belt Slope Tension - encountered only with inclined conveyors - which is the tension resulting from the weight of the belt pulling on the pulley at the top of the slope.

4. Maximum or Tight Side Tension. This is the greatest tension present in the belt and it determines the minimum strength of the belt that will be adequate for the given conditions.

Effective Tension. The Effective Tension, as described above, is designated in tension formulae as "E" and is computed when the horsepower requirement and the speed of belt travel are known.

If E = Effective Tension = pounds pull.

HP = 14.97 = the horsepower requirement of the conveyor

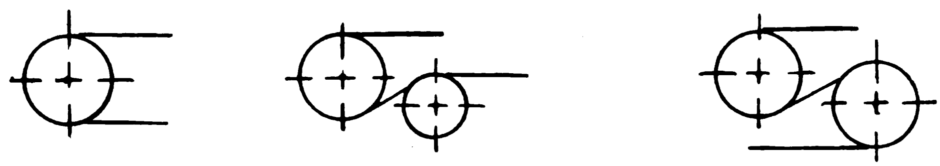
S = 300 feet per minute = belt speed

Then $\frac{HP \times 33{,}000}{S}$ = "E" ------ the Effective Tension

$$= \frac{14.97 \times 33{,}000}{300} = 1648 \text{ pounds pull} = \text{"E"}.$$

Slack Side Tension. The slack side tension, as described earlier, is designated in the formulae as "T_2" and varies with:

1. The arc of contact of the belt with the drive pulley. The arc of contact depends upon the type of drive arrangement - see illustration:

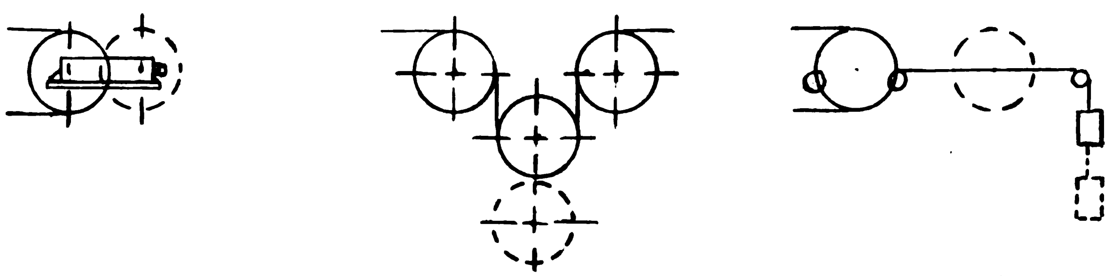


Plain Drive Snub Drive Tandem Drive

Fig. 12. Typical Drive Arrangements

2. The coefficient of friction between the belt and the pulley is equal to 0.30 for bare pulleys and 0.35 for lagged or rubber covered pulleys.

3. The take-up equipment that is used. There are two general types of take-ups -- automatic or gravity take-ups and screw or manual take-ups. See illustration below. Automatic take-ups constantly maintain the minimum required tension regardless of starting loads, belt stretch, changes in temperature, etc.; and are therefore preferred for all but the smallest conveyors. When screw take-ups are used, the adjustment is always made too tight to compensate in advance for belt stretch and other changing conditions which would otherwise necessitate the making of continual adjustments.



Screw Take-up Vertical Automatic Take- up Horizontal Automatic Take-up

Fig. 13. Typical Take-up Arrangements

Slack or initial tension which is present on both sides of the pulley does no actual work in moving either the belt or the material and should therefore be kept at the minimum that will permit the belt to be driven. Slack side tension required for a given conveyor will vary with the effective tension that is needed and the combination of drive and take-up arrangements that are selected.

Using HP, S, and E as before;

and K = the drive factor which varies according to the type of take-up and pulley used. See Table XII for Automatic take-up, Bare pulley (snubbed).

T_2 = the slack side tension - pounds.

then $\frac{HP \times 33,000}{S} \times K = T_2$

but $E = \frac{HP \times 33,000}{S}$

then $E \times K = T_2$

Therefore: $1648 \times 0.48 = T_2$

or $T_2 = 782$ pounds

Where E = 1648 pounds
K = 0.48 -- for bare pulley, snubbed.

Belt Slope Tension: Varies with the net change in vertical distance between the pulley at the top of the slope and that at the bottom of the slope.

Using:

H = the net change in elevation in feet = 55 feet

B* = 4.16 pounds per foot ---- weight of belt per lineal foot

then B x H = Belt Slope Tension -- or the pull of the belt on the pulley at the top of the slope.

* The C. O. Bartlett and Snow Co., Bulletin No. 88, p. 88.

TABLE XII

VALUES OF THE DRIVE FACTOR "K"

Arc of Contact	Screw Take-up				Automatic Take-up			
	Bare Pulley		Lagged Pulley		Bare Pulley		Lagged Pulley	
	1+K	K	1+K	K	1+K	K	1+K	K
180	1.97	.97	1.80	.80	1.64	.64	1.50	.50
200	1.85	.85	1.70	.70	1.54	.54	1.42	.42
210	1.80	.80	1.66	.66	1.50	.50	1.38	.38
215	1.78	.78	1.64	.64	1.48	.48	1.37	.37

B.P. = Bare Pulley
L.P. = Lagged Pulley
180° Arc of Contact

B.P.S. = Bare Pulley Snubbed
L.P.S. = Lagged Pulley Snubbed
215° Arc of Contact

$55 \times 4.16 = 229$ pounds

Maximum Tension. Maximum Tension is the greatest tension present in the belt. It represents the sum of the other tensions. Maximum or Tight Side Tension determines the minimum strength of the belt that will be adequate for the given conditions.

For horizontal conveyors: Slack side or initial tension is present on both sides of the drive pulley while the effective tension is present on one side only. Therefore, the maximum tension is equal to the algebraic sum of these two:

Then as before

Using: $HP = 14.97$

$S = 300$ feet per minute

$E = 1648$ pounds

$K = 0.48$ ------ drive factor

$T_2 = 782$ pounds

$T_1 =$ maximum tension ------ pounds

Since $T_2 = E \times K$

and $E = \dfrac{HP \times 33{,}000}{S}$

then $E + T_2 = \dfrac{HP \times 33{,}000}{S} + E \times K = T_1$

$$= \frac{HP \times 33{,}000}{S} + K\left(\frac{HP \times 33{,}000}{S}\right)$$

$$= \frac{HP \times 33{,}000\,(1 + K)}{S} = T_1$$

Therefore: $T_1 = \dfrac{14.97 \times 33{,}000(1 + 0.48)}{300}$

$= 2440$ pounds $=$ maximum tension.

For inclined conveyors having (1) a head end drive and a rise of less than 100 feet, or (2) a tail end drive and a rise of less than twenty-five feet, the belt slope tension involved is so small a factor in the final result that it can be disregarded. When the change in elevation exceeds these limits, the belt slope tension (B x H) must be added into the formula with E and T_2 to determine the maximum or T_1 tension.[6]

Selecting the Belt

Standard belts are fabricated of from three to twelve plies or layers of 28, 32, 36 or 42 ounce canvas duck, held together and fully enclosed by layers of rubber.

Selecting the number and weight of plies. Specification of a conveyor belt requires a consideration of the weight of duck and the number of plies that will:

1. Meet the requirements of maximum tension (T_1).
2. Support the material without excessive sagging between the idlers and withstand the impact of loading.
3. Permit the belt to be "troughed" by the idler rolls.

The number of plies that are needed to provide the strength required by the maximum tension can be computed from the following formula:

Using:

T_1 = 2440 pounds ------ as before

W = 20 inches ------ width of belt

D = 26 1/2 pounds per ply per inch of belt width for 28 ounce duck ------ See Table XIII

6 The Bartlett Snow Belt Conveyor Handbook, Bulletin No. 88, Prepared by Henry T. Bourne and Associates, Industrial Advertising, Cleveland. Published by the Caxton Company, Cleveland. p. 26.

N = the number of plies required

then

$$\frac{T_1}{D \times W} = N \quad \text{or} \quad N = \frac{2440}{26.5 \times 20} = 4.6$$

Use 5 plies.

TABLE XIII

VALUE OF "D" FOR VARIOUS WEIGHTS OF DUCK

Weight of Duck	28 oz	32 oz	36 oz	42 oz
Value of "D"	26.5	30	33	42

The minimum number of plies required to withstand the impact of loading and to support the material without excessive sagging between the idlers may be found from Table XIV.

The maximum number of plies that can be satisfactorily troughed to various widths of troughing idlers will be found in Table XIV.

Table XV gives the values of maximum tension "T_1"; effective tension "E"; and slack side tension "T_2"; for belts of various widths, weights of duck, number of plies, and having various drive and take-up arrangements. The tensions shown in this table have been computed using the values for factor "D" shown in Table XIII, and the values for "K" shown in Table XII for drive arrangements as follows:

BP = Bare Pulley 180° arc of contact

LP = Lagged Pulley 180° arc of contact

BPS = Bare Pulley Snubbed 215° arc of contact

LPS = Lagged Pulley Snubbed 215° arc of contact.

TABLE XIV

RECOMMENDED MINIMUM AND MAXIMUM NUMBERS OF PLIES FOR TROUGHED BELTS HANDLING VARIOUS MATERIALS

Belt Width W Inches	Minimum Plies to Support Load — Physical Characteristics of Material to be Handled							Maximum Plies for Troughing			
	Fine Coal, Sand Crushed Stone			Fine Ores, Lump Coal, Large Stone or Gravel							
	28 oz	32 oz	36 oz	28 oz	32 oz	36 oz	42 oz	28 oz	32 oz	36 oz	42 oz
18	4	4	4	5	4	-	-	6	5	4	-
20	4	4	4	5	4	-	-	6	5	5	-
24	4	4	4	5	5	4	4	7	6	6	6

TABLE XV

VALUES OF MAXIMUM TENSION "T_1"; EFFECTIVE TENSION "E"; AND SLACK SIDE TENSION "T_2" FOR BELTS OF VARIOUS WIDTHS, WEIGHTS OF DUCK, NUMBER OF PLIES, AND HAVING VARIOUS DRIVE AND TAKE-UP ARRANGEMENTS

Width of Belt Inches	Weight of Duck Pounds	No. of Plies	Maximum Belt Tension T_1		Effective "E" and Slack Side T_2 Tension for Various Drives					
					Screw Take-Up			Automatic Take-Up		
					L.P.S.	L.P. or B.P.S.	B.P.	L.P.S.	L.P. or B.P.S.	B.P.
20	28	4	2120	E	1293	1178	1076	1547	1413	1293
				T_2	827	942	1044	573	707	827
		5	2650	E	1616	1462	1345	1934	1766	1616
				T_2	1034	1178	1305	716	884	1034
		6	3180	E	1933	1767	1614	2321	2120	1933
				T_2	1247	1413	1566	859	1060	1247
	32	4	2400	E	1463	1333	1218	1752	1600	1463
				T_2	937	1067	1182	648	800	937
		5	3000	E	1830	1667	1523	2190	2000	1830
				T_2	1170	1333	1479	810	1000	1170
	36	4	2640	E	1610	1467	1340	1927	1760	1610
				T_2	1030	1173	1300	713	880	1030
		5	3300	E	2012	1833	1675	2409	2200	2012
				T_2	1288	1467	1625	891	1100	1288

<u>Belt Tension in Percent of Rating</u>. The percent of rated tension is utilized in determining carcass quality. It is obtained by dividing the required tension or "E" factor by the rated "E" tension shown in Table XV for the belt and terminal equipment that is to be used.

In the example illustrated:

1648 = "E" the required tension

1766 = "E" the rated tension of a 20 inch, five ply belt using a bare pulley snubbed drive and automatic take-up. See Table XV.

Therefore: Percent of rating $= \frac{1648}{1766} = 93.4$ percent

<u>Time Cycle</u>. The time cycle, or frequency at which the belt passes over the point of greatest tension is a factor in the selection of both carcass quality and cover thickness, and $= \frac{2L}{S}$

where L = conveyor length in feet

S = belt speed in feet per minute.

In the example illustrated:

Time cycle $= \frac{2(1035)}{300} = 6.91$ minutes

Thus with the following factors known or selected:

Tension rating = 93.4 percent

Time cycle = 6.91 minutes

Pulley Diameter in percent of normal = ------ use 100 percent

Then from Table XVI it will be seen that the belt carcass quality should be Carcass B.

Where symbols A, B, C, D refer to the following:

Carcass A ----- 20 to 40 pounds friction.

Carcass B ----- 16 to 19 pounds friction.

Carcass C ----- 12 to 15 pounds friction.

Carcass D ----- 12 to 15 pounds friction.

Cover A ----- 3,500 to 4,000 pound strength.

Cover B ----- 2,500 to 3,500 pound strength.

Cover C ----- 1,400 to 2,000 pound strength.

Cover D ----- 800 to 1,000 pound strength.

Pulley sizes. In order that maximum belt service may be obtained it is desirable to use pulleys of sufficient diameter to permit the belt to flex easily. Using pulleys of too small diameter for the weight of duck and number of plies in the belt may cause separation between the plies, or breaking of the fabric due to the added stresses set up in the outer plies as the belt bends around the pulleys.

Table XVII gives the "normal" diameters of pulleys that should be used with belts of various weights of duck and number of plies when the belts are stretched to the full tension of the duck. For "75 percent of normal size" pulleys, the diameters shown for the next fewer numbers of plies may be used and for "125 percent normal pulleys", the diameters shown for the next larger number of plies should be used. The size of pulleys selected should be consistent with the belt carcass quality taken from Table XVI.

TABLE XVI

RECOMMENDED CARCASS QUALITY FOR VARIOUS CONDITIONS OF FLEXING

$\frac{2L}{S}$ Factor or the Number of Minutes it Takes the Belt to Make one Complete Revolution	Tension 100% of Rating — Pulley Diameters in Percent of Normal		
	100%	125%	150%
.2	*	*	*
.4	*	*	A
.6	*	A	B
.8	*	A	B
1.0	*	A	C or D
1.5	*	B	C or D
2.0	A	B	C or D
3.0	A	C or D	C or D
4.0 and over	B	C or D	C or D

* Where no belt is indicated, a No. A belt may be used, but owing to the severity of flexing, a somewhat shorter period of service is to be expected. In these cases the use of a special skim coated carcass will provide additional flexing life.

TABLE XVII

NORMAL PULLEY DIAMETERS FOR BELT CONVEYORS

Number of Plies	28 Oz. and 32 Oz.			
	Tandem Drive	Head and Tripper	Tail and Take-up	Low Tension Snub
3	18	15	12	10
4	24	20	18	12
5	30	24	20	15
6	36	30	24	18
7	42	36	30	24
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

Head Pulley Diameter:

When

No. of Plies (belt) = 5
Weight of Duck = 28 oz.

Then

Head (and Tripper) Pulley diameter = 24 inches

See Table XVII for "100 percent Normal Pulley".

Selecting the Belt Cover Thickness. The recommended thickness of belt carrying side covers for various time cycles, kinds of material and various lump sizes are shown in Table XVIII. For the pulley side a 1/32 inch thick cover is recommended for the smaller belts, and a 1/16 inch thick cover for belts 36 inches wide or wider and/or seven plies or more in thickness -- or when abrasive conditions are encountered.

Thus with:

Time Cycle = 6.91 minutes

Cover Quality = B

Lump Size = 1/2 to 1 1/2 inches --- determined by the need of the plant and whether coal has been processed or not.

Then:

From Table XVIII, under "Moderately Abrasive Materials", it will be seen that a carrying side cover 3/32 inches thick is necessary.

Shaft Diameters. The slack side or "T_2" tension determines the amount of pull which must be developed by the take-up arrangement and is a factor in determining the diameter of the shafts required for the tail, take-up, snub and bend pulleys. See pages 41 - 44 for "T_2". The slack side tension may also be computed as the "T_2" tension shown in Table XV for the terminal equipment and belt that is to be used, multiplied by the percent of rated tension calculated on page 50.

From Table XIX may be found the shaft diameters that will be required to support various sizes of head pulleys for belt conveyors

TABLE XVIII

RECOMMENDED GAUGES AND QUALITIES OF CARRYING SIDE COVERS FOR BELT CONVEYORS HANDLING VARIOUS MATERIALS

$\frac{2L}{S}$ Factor or the Number of Minutes It Takes the Belt to Make One Complete Revolution.	Cover Quality Use the Same Qualities as were Selected for the Carcass.	Type of Materials: Moderately Abrasive Materials, Such as: Soda, Lime, Bituminous Coal, Loam Sand and Round Gravel, etc. — Lump Sizes: Dust to 1/4"	1/2" to 1 1/2"	2" to 5"	6" and over
4.0 and over	D	1/16	3/32	1/8	3/16
	C	1/16	3/32	1/8	3/16
	B	1/16	3/32	1/8	3/16
	A	1/16	3/32	1/8	3/16

TABLE XIX

SHAFT DIAMETERS FOR VARIOUS SIZES OF HEAD PULLEYS ON CONVEYORS HAVING VARIOUS DRIVE ARRANGEMENTS AND "E" FACTORS

24" Pulley						Shaft Size Inches
Screw Take-up			Automatic Take-up			
L.P.S.	L.P. or B.P.S.	B.P.	L.P.S.	L.P. or B.P.S.	B.P.	
540	500	460	630	590	540	1 15/16
1035	950	875	1200	1115	1035	2 7/16
1765	1625	1490	2040	1900	1765	2 15/16
2770	2540	2335	3210	3000	2770	3 7/16
4085	3790	3460	4750	4415	4085	3 15/16

TABLE XX

SHAFT DIAMETERS FOR TAIL, TAKE-UP, SNUB AND BEND PULLEYS ON CONVEYORS HAVING VARIOUS "T_2" FACTORS

Location of Shaft	Slack Side Or "T_2" Tension				
	Shaft Diameter Required				
	1 7/16	1 15/16	2 7/16	2 15/16	3 7/16
Tail and Take-up Pulleys	650	1300	2200	3600	4500
Snub and Bend Pulleys	900	1800	2800	4500	----

having various drive arrangements and calculated "E" factors.

Table XX shows the shaft diameters required for tail, take-up, snub and bend pulleys for conveyors having various calculated "T_2" factors.

Shaft Diameters for Head Pulleys:

Then where:

E = 1648 pounds

Pulley Diameter = 24 inches

Drive Arrangement = Bare pulley snubbed --- assume

Take-up type = Automatic.

From Table XIX it is found that a Head Shaft diameter of not less than 2 15/16 inches is necessary to meet the above conditions.

The shaft diameters for tail, take-up, snub and bend pulleys is determined in a similar manner from Table XX using the calculated Slack Side or "T_2" tension.

Pulley R.P.M. -- Motor Reductions

The revolutions per minute required for the pulley to produce a given speed of belt travel in F.P.M. varies with the diameter of drive pulley that is used and the speed of belt travel required and can be computed from the formula:

$$S \div \frac{\pi d}{12} = \text{R.P.M. required of pulley}$$

or $\frac{12S}{\pi d}$ = R.P.M. where d = drive pulley diameter in inches

S = Belt speed in F.P.M.

In the example illustrated:

where S = 300 F.P.M.

$d = 24$ inches

$$\frac{12 \times 300}{\pi \times 24} = 47.8 \text{ R.P.M. required of pulley.}$$

Idler Spacings

Spacing of carrying idlers is determined by such factors as, belt weight, weight of material per cubic foot, loading conditions.

The recommended spacing of carrying idlers for various belt widths and weights of materials will be found in Table XXI.

The following exceptions to the table should be given consideration:

1. Under Loading Chutes. The first idler below the loading chute should be located about six inches back of the lower edge of the chute bottom. To avoid any sagging of the belt, idlers under the skirt plates should be spaced at about half the specified distance for that weight of material and width of belt.

2. On Feeder. To overcome the tendency of the belt to sag between the idlers and to prevent lumps from wedging between the belt and the side plates of the chute, idlers under the loaded belt should be spaced of from 12 to 18 inch centers.

3. Return Idlers. Return idlers should be spaced on about ten foot centers.

4. One self-aligning troughing or return idler should be substituted for a standard idler for approximately every fifty feet of conveyor length.

TABLE XXI

RECOMMENDED MAXIMUM SPACINGS OF CARRYING IDLERS

Weight of Material Pounds Per Cubic Foot	Width of Belt in Inches		
	20	24	36
50	5'-0"	4'-6"	4'-6"

The Tripper

Due to the Tripper head-room requirements it will be necessary to run the new belt conveyor over the suspension bunkers in approximately the position of the existing overbunder conveyor. However, with the installation of the new system it will not be necessary to keep the present overbunker.

Figure 14 shows the manner in which a Fairfield Self Propelled Automatic Belt Tripper could be fitted into the new system. Only the outline of the outer casing and the idlers are shown.. There would be a minimum of two and a half inches of clearance above the casing. The illustrations in the Fairfield Bulletin No. 151 indicate that this would suffice for maintenance purposes. If additional head-room is needed for maintenance the tripper could be moved between the joists.

It will be seen that the Tripper would not run the entire length of the plant. However, it is not necessary that the Tripper should run nearer than ten feet from the North Wall in order that Number 1 bunker may be filled.

The existing Elevator would be left in position but the discharge chute changed as shown. Compare Figures 14 and 15. Changing the

A SECTIONAL VIEW of BUNKER ROOM SHOWING TRIPPER and REDESIGNED ELEVATOR

SCALE: 1" = 3'

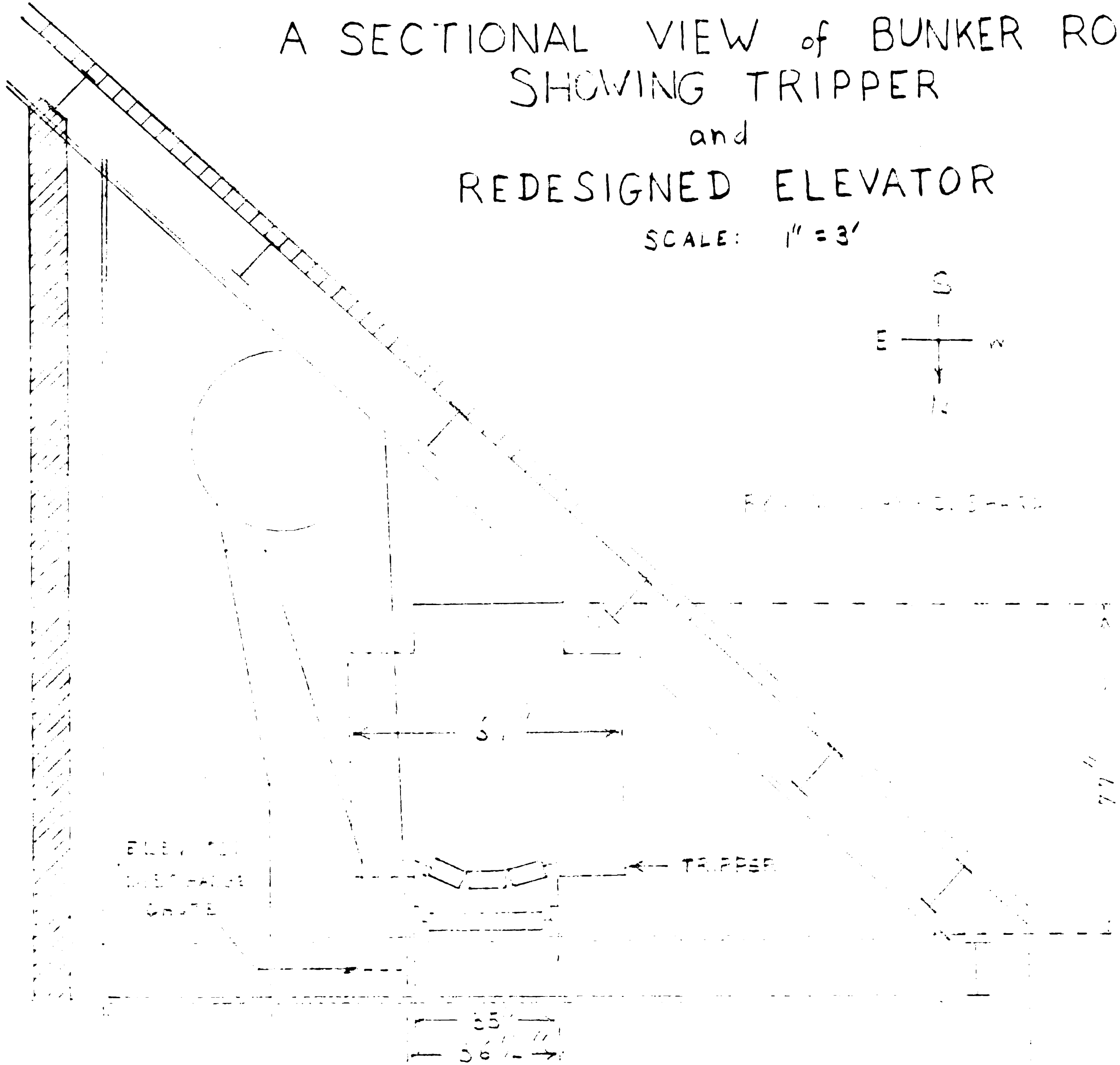
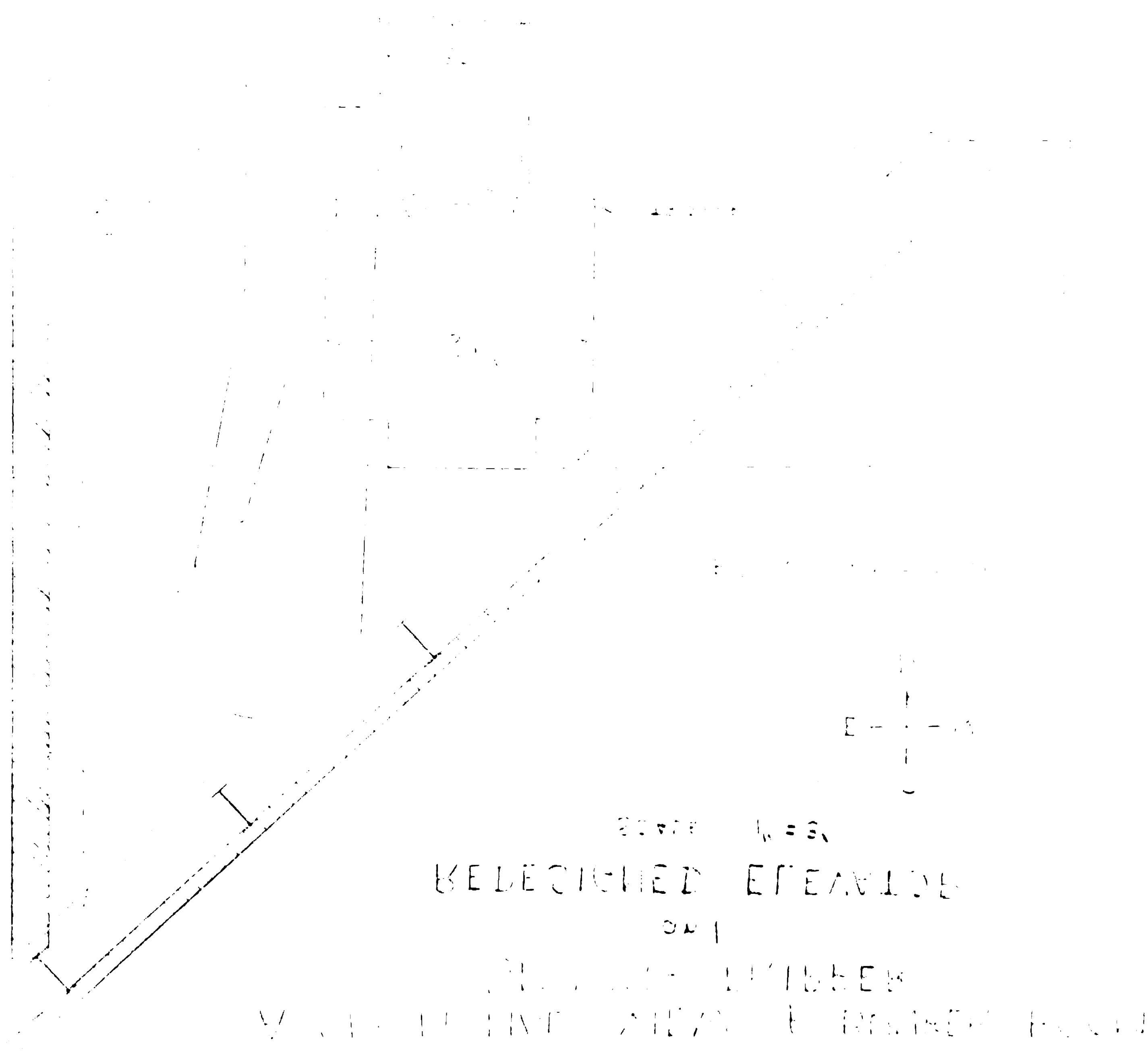


FIG. 14



REDESIGNED ELEVATOR

SECTIONAL VIEW of BUNKER ROOM SHOWING EXISTING ELEVATOR

SCALE: 1" = 3'

BY: WILLIAM J. SHARP

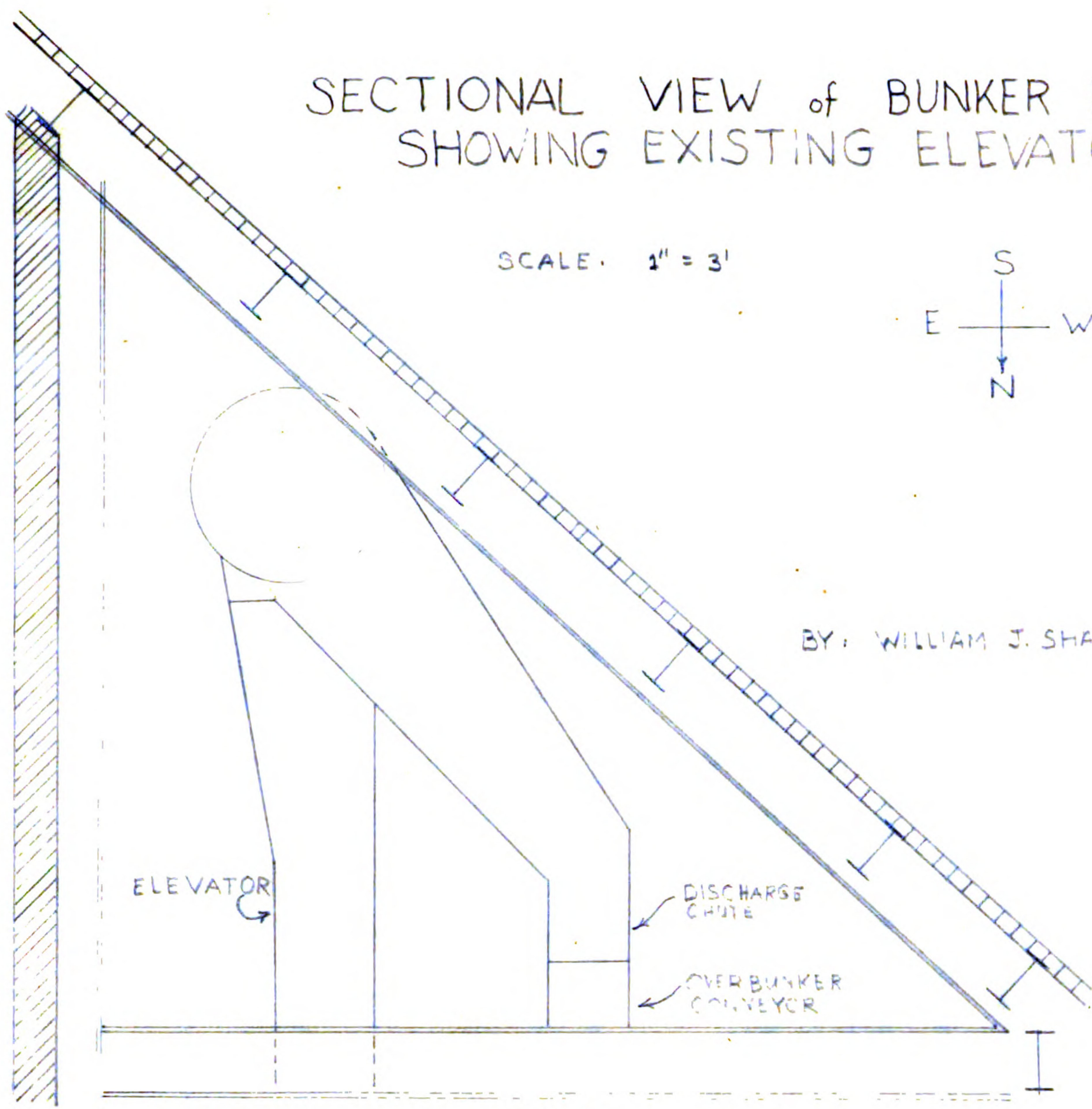


FIG. 15

Elevator casing would permit Number 1 Bunker to be loaded with test coal through the existing facilities. It would be necessary to run the belt conveyor itself to a point about one foot from the North Wall. Idler dimensional tables indicate that a 24 inch belt system has a maximum supporting frame width of 35 inches. As indicated in Figure 14 this would leave a clearance of 1 1/2 inches between belt conveyor casing and the elevator discharge chute. If more space is needed the discharge casing can be narrowed from the ten inches shown to about eight inches without trouble.

It will be necessary to raise the elevator motor and reduction gear by approximately one additional foot in order to permit the belt conveyor sufficient head room.

It is suggested that the drag chain overbunker when removed be used in the North Campus Steam Plant. This would help solve the problem of coal and water drip from the bunkers in that plant.

The Gallery

It is desirable to enclose all the outdoor sections of the belt conveyor in galleries. Galleries prevent deterioration of the rubber belt and conveyor equipment by rain and sunlight. Such a gallery needs only a single walkway on one side of the conveyor.

A peak roofed gallery though somewhat more costly than other types, is usually used where architectural appearance is of considerable importance.

Enclosed galleries of this type usually have precast concrete floors, no windows, corrugated steel, Galbestos or Transite sides and ceiling, small openings in the ends for the belt to pass through, and fireproof service doors. The only combustible in the gallery therefore is the conveyor belt and the coal being handled. These may be protected by automatic sprinklers mounted overhead. Head room is usually 6 feet 6 inches.

The Crusher

The type of cursher selected depends on capacity requirements, size of coal desired, size of coal purchased and present and future operating conditions.

The Fairfield line of crushers is listed for a basis of comparison as they are representative of the types available on the market. Comparisons have been made only on the basis of actual requirements of one inch crushed size, 100 tons per hour capacity using run of mine coal.

1. Ring Roll Type W.C. ---- Too small capacity.

2. Ring Roll Type S -- size 24. Similar to Type W.C. but of larger capacity. Horsepower required for conditions given -- 40 H.P. Price -- exclusive of motor and chute work -- $4,900.

3. Double Roll Type -- size 63. Horse power required for conditions given -- 40 H.P. Price -- exclusive of motor and chute work -- $6,000.

Both the Ring Roll and the Double Roll types are adjustable so that by permitting crushed coal size to be increased from one inch to 1 1/4 inches an additional twenty tons per hour capacity is obtainable. The Double Roll type results in less fines than does the Ring Roll type. However, in as much as the proposed system as a whole would undoubtedly result in less fines than does the Drag Chain system being used now, the Ring Roll Crusher would prove satisfactory.

Coal Storage

At the present rate of growth coal consumption between the months of October and April 1955 - 1956 would be approximately 49,600 tons. A reserve of only 10 percent would require a total coal storage of over 54,000 tons. This is approximately twice the amount of coal now in dead storage South of the new plant. Such a large storage requirement appears to obviate any possibility of concentrating purchasing of coal during the warmer months. It would seem advisable therefore to contimue purchasing on the present basis unless it is possible to acquire considerably more storage area than is now available.

The position of the storage pile as indicated in Figure 17 is only slightly different from the actual location. It is proposed here that the pile be broadened from eighty to one hundred and ten feet as shown so that the conveyor from the crusher to storage area may pass around the conveyor bringing coal from the coal pile to the crusher. Dead storage would then be increased from the present 25,000 tons to approximately 32,000 tons. Widening the storage pile would also make it possible to store coal on three sides of the reclaim hopper rather than to have this hopper placed at the Northeast corner as would otherwise be the case.

For purposes of distributing coal over the storage area and of reclaiming it back into the system one of the following methods may be used.

1. A Cable Drag System.

2. A Tractor-Scraper Team.

3. A bulldozer or a tractor-shovel.

Cable Drag System. The Cable Drag system is a relatively expensive method of distributing and reclaiming coal. An approximate cost for a Fairfield Cable Drag System is $30,000.00. Not only is this an expensive installation but there are many undesirable features inherent in the system among which are extreme lack of flexibility and a tendency to cause segregation of the coal thus increasing the possibility of spontaneous combustion. Generally such a system also requires two men to operate it.

Tractor-Scraper Team. This is an extremely flexible system and would be a very desirable unit for a larger installation.

Bulldozer, or a Tractor-Shovel. Either a bulldozer or a heavy model of a tractor-shovel would prove ideal for the requirements of the South Campus Plant.

Shakeouts

In general there are three methods -- exclusive of hand shovel and sledge hammer tactics -- by which cars may be rapidly unloaded.

1. By a Rotary Car Dumper

2. (Overhead) Car Shaker -- placed above the coal car

3. (Side) Car Shaker -- Hung on the side of the coal car.

Rotary Dumper. Rotary Dumpers are of very high capacity being able to unload from twenty to 45 open top cars per hour. These are expensive installations and the huge unloading capacity available would be wasted at this plant.

Overhead Shaker. These shakers are of moderate capacity and do a good job.

Price: $6,200.00 (approximate).

Side Shaker. As far as the author is concerned the reliability of these shakers is an unknown quantity. If satisfactory, it would be the shaker to purchase.

Price: $1,661.32.

Hoppers

Hoppers are built in varying sizes and styles. For a system having a coal handling capacity of 100 tons per hour a track hopper 14' x 30' having an 8 inch clear mesh built of 4" x 1/2" steel bars in one direction and 1 1/4 inch steel rods in the other direction is generally recommended. These hoppers have a capacity of approximately thirty tons of coal.[7]

A reclaim hopper measuring 14' x 18' covered by a grating of 8 inch square mesh and built of 6" x 1/2" bars and 1 1/2 inch diameter rods is recommended. This hopper has a capacity of approximately 17 tons.[7]

---

7 Mr. W. H. Kuhn, The Fairfield Engineering Company. Written Communication.

TABLE XXII

TRIAL SPECIFICATIONS

		From Track Hopper	From Reclaim Hopper	To Crusher	Crusher to Coal Pile	Crusher to Coal Bunker
Conveyor Length in Feet	Horizontal Portion	-	-	-	-	848
	Inclined Portion	106	28	110	193	187
	TOTAL	106	28	110	193	1035
Angle of Incline		5°	16.5°	16°	12.5°	17°
Elevation - Feet		10	8	30	42	55
Belt Width - Inches		36	36	20	20	20
Belt Speed - F.P.M.		85	30	300	300	300
Horse-power Required For:	Empty Conveyor	0.76	0.20	1.47	1.65	5.18
	Convey Material Horizontally	0.71	See p. 32	0.71	0.84	2.73
	Elevate Material	1.00	See p. 32	3.00	4.22	5.56
	Trippers	-	-	-	-	1.50
	TOTAL H.P.	2.87	7.50	5.18	6.71	14.97
Take-up - Type		Horizontal Automatic	Screw	Horizontal Automatic	Horizontal Automatic	Vertical Automatic
Drive Arrangement		B.P.	B.P.	B.P.	B.P.	B.P.S.
Belt	Ply	6	6	5	5	5
	Duck	28	28	28	28	28
	Carcass Quality	B	B	B	B	B
	Carrying Side Cover	1/8"	1/8"	3/32"	1/8"	3/32"
	Pulley Side Cover	1/16"	1/16"	1/32"	1/32"	1/32"
Pulley Diameter Inches	Head	24	24	24	24	24
	Tail or Take-up	20	20	20	20	20
	Snub or Bend	15	15	15	15	15

TABLE XXII Contd.

		From Track Hopper	From Reclaim Hopper	To Crusher	Crusher to Coal Pile	Crusher to Coal Bunker
Shaft Diameter Inches	Head	2 7/16	3 7/16	2 7/16	2 7/16	2 15/16
	Tail or Take-up	1 15/16	2 7/16	1 7/16	1 7/16	1 15/16
	Snub or Bend	1 7/16	1 15/16	1 7/16	1 7/16	1 7/16
Idler Spacing	Troughing	4' 6"	1' 6"	5' 0"	5' 0"	5' 0"
	Return	10'	10'	10'	10'	10'
Motor	Speed	1800	1800	1800	1800	1800
	Horsepower	2.68	7.50	5.59	7.25	16.17
Drive Pulley R.P.M.		9.02	3.18	57.29	57.29	57.29
Drive	Type	H.R.C.D.* OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**
	Reduction	194:1	548:1	30.51:1	30.51:1	30.51:1

* H.R.C.D. Herringbone reducer -- chain drive

** G.H.M.C.D. Geared Head Motor -- chain drive.

TABLE XXIII

FINAL SPECIFICATIONS

		From Track Hopper	From Reclaim Hopper	To Crusher	Crusher to Coal Pile	Crusher to Coal Bunker
Conveyor Length in Feet	Horizontal Portion	-	-	-	-	848
	Inclined Portion	106	28	110	193	187
	TOTAL	106	28	110	193	1035
Angle of Incline		5°	16.5°	16°	12.5°	17°
Elevation - Feet		10	8	30	42	55
Belt Width - Inches		24	36	24	24	24
Belt Speed - F.P.M.		225	30	250	250	300
Horse-power Required For:	Empty Conveyor	1.15	0.20	1.34	1.63	6.18
	Convey Material Horizontally	0.72	See p. 32	0.71	0.87	2.76
	Elevate Material	1.00	See p. 32	3.00	4.22	5.60
	Trippers	-	-	-	-	1.50
	TOTAL H.P.	2.87	7.5	5.05	6.72	16.04
Take-up - Type		Horizontal Automatic	Screw	Horizontal Automatic	Horizontal Automatic	Vertical Automatic
Drive Arrangement		B.P.	B.P.	B.P.	B.P.	B.P.S.
Belt	Ply	5	6	5	5	5
	Duck	28	28	28	28	28
	Carcass Quality	B	B	B	B	B
	Carrying Side Cover	1/8"	1/8"	1/8"	1/8"	1/8"
	Pulley Side Cover	1/32"	1/16"	1/32"	1/32"	1/32"
Pulley Diameter Inches	Head	24	24	24	24	24
	Tail or Take-up	20	20	20	20	20
	Snub or Bend	15	15	15	15	15

TABLE XXIII Contd.

		From Track Hopper	From Reclaim Hopper	To Crusher	Crusher to Coal Pile	Crusher to Coal Bunker
Shaft Diameter Inches	Head	2 7/16	3 15/16	2 15/16	2 15/16	3 7/16
	Tail or Take-up	1 15/16	2 15/16	1 15/16	1 15/16	2 7/16
	Snub or Bend	1 15/16	2 7/16	1 15/16	1 15/16	1 15/16
Idler Spacing	Troughing	4' 6"	1' 6"	4' 6"	4' 6"	4' 6"
	Return	10'	10'	10'	10'	10'
Motor	Speed - R.P.M.	1800	1800	1800	1800	1800
	Horsepower	3.10	7.50	5.45	7.26	17.15
Drive	Pulley R.P.M.	36.8	3.18	39.78	39.78	47.74
Drive	Type	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**	H.R.C.D.*OR G.H.M.C.D.**
	Reduction	48.82:1	548:1	43.8:1	43.8:1	36.65:1

* H.R.C.D. Herringbone reducer -- chain drive.
** G.H.M.C.D. Geared Head Motor -- chain drive.

TABLE XXIV

BILL OF MATERIALS — PARTIAL

	Belt Conveyor					Miscell-aneous Costs	Sub-Total Costs
	From 1 Track Hopper	From Reclaim Hopper	To Crusher	Crusher to Coal Pile	Crusher to Bunkers		
Belting	$1138.00	$524.00	$1335.00	$1178.00	$12,540.00	-	$16,815.00*
Brush-Belt Cleaning	293.00	365.00	293.00	293.00	293.00	-	1,537.00*
Car Shaker						$6,200.00	6,200.00
Crusher-less motor and chute						4,900.00	4,900.00
Feeder-double recip.							
Holdbacks	150.00	325.00	150.00	150.00	150.00	-	925.00*
Idlers	877.30	637.00	877.30	1475.40	8,061.00	-	11,928.40*
Motors-Conveyor	117.00	180.00	180.00	180.00	362.00	-	1,019.00
Motors-Crusher						666.00	666.00
Motors-Feeder						138.00	138.00
Pillow Blocks	119.90	279.20	119.90	119.90	266.40	-	905.30
Pulleys	157.50	210.00	157.50	157.50	273.50	-	908.50
Take-ups	290.00	72.40	290.00	290.00	215.00	-	1,202.40*
Tripper						2,626.00	2,626.00*
Pulley Shafting	12.00	22.00	12.00	12.00	32.00		90.00
						TOTAL	49,860.60

* Refer to footnote "d" Table VI.

SUMMARY AND CONCLUSIONS

TABLE XXV

HISTORICAL GROWTH AND FUTURE EXPANSION AT
MICHIGAN STATE COLLEGE

Data	Coal Tons	Year	Building Cubage Cu. Ft.	Data
None	--	1871	261,118	Actual
Actual	14,210	1927	12,908,332	Actual
Actual	54,600	1950	57,671,913	Actual
Estimate	122,500	1975	129,300,000	Estimate

TABLE XXVI

COAL USED AND UNLOADED AT THE
SOUTH CAMPUS TEAM PLANT

Date 1950	Coal Used Tons	Maximum conveying capacity at 7 hours per day and 35 tons per hour
Dec. 8	233	245*

* Optimistic yet still does not permit making up for week-end consumption without overtime.

The figures in Tables XXV and XXVI point out the need for expanded and improved coal handling facilities at the South Campus Steam Plant.

A study of the requirements and approximate total costs of various systems indicates quite definitely the many advantages of a belt system over other types.

While it is difficult to determine total costs of each type of system it is sufficient to compare the maintenance and operation costs of other systems with similar costs of a belt conveyor installation and the costs of that portion of each system where appreciable differences would exist. From such comparisons it is obvious that the proposed installation would be the most satisfactory.

Conveyor manufacturers are in general agreement that belt conveyors give more trouble free service than any other conveyor that could possibly be suitable for the requirements of this plant.

The system proposed for the South Plant would be laid out as shown in Figures 16 and 17 and would operate generally in the following manner:

Unloading would take place over the double track hoppers illustrated. Cars would be shaken out by an overhead shaker and the coal fed from the track hoppers by a double reciprocating plate feeder to a 24 inch belt conveyor. This conveyor, traveling at 225 feet per minute would carry coal to another 24 inch belt running at right angles at a speed of 250 feet per minute. This conveyor feedsthe crusher.

Coal may be processed through the crusher or by-passed. If by-passed, the coal is carried on a 24 inch belt conveyor to the storage pile. Crushed coal is carried on a 24 inch belt conveyor, operating at 300 feet per minute, to the plant suspended bunkers. An automatic self-propelled belt tripper operates over the bunkers discharging coal from the conveyor into the bunkers.

When it is desired to reclaim coal from the storage pile a bull-dozer or tractor-scraper would be used to keep the reclaim hopper full. Coal is fed from this hopper to a 36 inch belt conveyor acting as a feeder. This belt has skirt boards on the carrying side. Coal is fed from this belt to the 24 inch conveyor, previously mentioned, which elevates the coal to the crusher.

SUGGESTIONS FOR FURTHER STUDIES

It is suggested that a further study be made of the possibility of moving the storage pile under discussion about 400 feet northward. Allowing for an extension northward of the double bank of railroad tracks would permit a coal pile about 60 to 70 feet wide. Lack of width could be made up by a southward extension of the storage area. This should materially reduce initial cost.

A further study should be made of the possibility of using an individual car unloader in conjunction with a small portable belt conveyor. Car unloaders can be used on top of rails or in undertrack pits. Such a combination, together with the system already proposed would result in excellent flexibility besides materially reducing the work of the bulldozer by unloading coal at various points on the coal pile. By raising unloading capacity such a system would also permit pruchasing of coal during the warm months only, without the necessity of increasing the capacity of the entire belt conveying system.

The author would estimate that the cost of a suitable car unloader and portable belt conveyor to be about $4,000.00.

BIBLIOGRAPHY

1. Bauerle, R. written communication, January 15,1952.

2. Brill, L.E. written communication, January 16,1952.

3. _____. written communication, May 1,1952.

4. Central Station Coal Handling Equipment, prepared by the C. O. Bartlett and Snow Company, Cleveland: Bulletin No. 103, 1951, 17 pp.

5. Coal and Ashes Handling Machinery for Power Plants and Boiler Houses, prepared by the Jeffrey Manufacturing Company, Columbus: Catalog No. 778A, 60 pp.

6. Coal and Ash Handling Equipment, prepared by the Fairfield Engineering Company, Marion, Ohio: Catalog No. 436, 56 pp.

7. Directory of Link-Belt Company, Chicago: Book No. 1953-E, 1950, 48 pp.

8. Economic Coal Storage with Allis-Chalmers Tractors, prepared by the Allis Chalmers Manufacturing Company, Milwaukee, 8 pp.

9. Fairfield Elevating and Conveying Machinery, prepared by Fairfield Engineering Company, Marion, Ohio: Catalog No. 151, 1951, 256 pp.

10. Hersey, John R. written communication, January 18,1952.

11. ______. written communication, April 23, 1952.

12. Jeffrey Belt Conveyors, prepared by the Jeffrey Manufacturing Company, Columbus: Catalog No. 785, 160 pp.

13. Kuhn, W. H. written communication, November 14,1951.

14. ____. written communication, January 18,1952.

15. ____. written communication, April, 26,1952.

16. Link-Belt Equipment for Power Plants, prepared by Link-Belt Company, Chicago: Book No. 2410, 1951, 41pp.

17. Morse, Frederick T. Power Plant Engineering and Design. 2nd ed., 5th printing, New York: D. van Nostrand Company, 1948, 703 pp.

18. National Car Shaker Bulletin and Price List, prepared by National Conveyor and Supply Company, Chicago, 4 pp.

19. Paige, G. A. written communication, January 23, 1952.

20. Radcliffe, Porter E. written communication, January 18, 1952.

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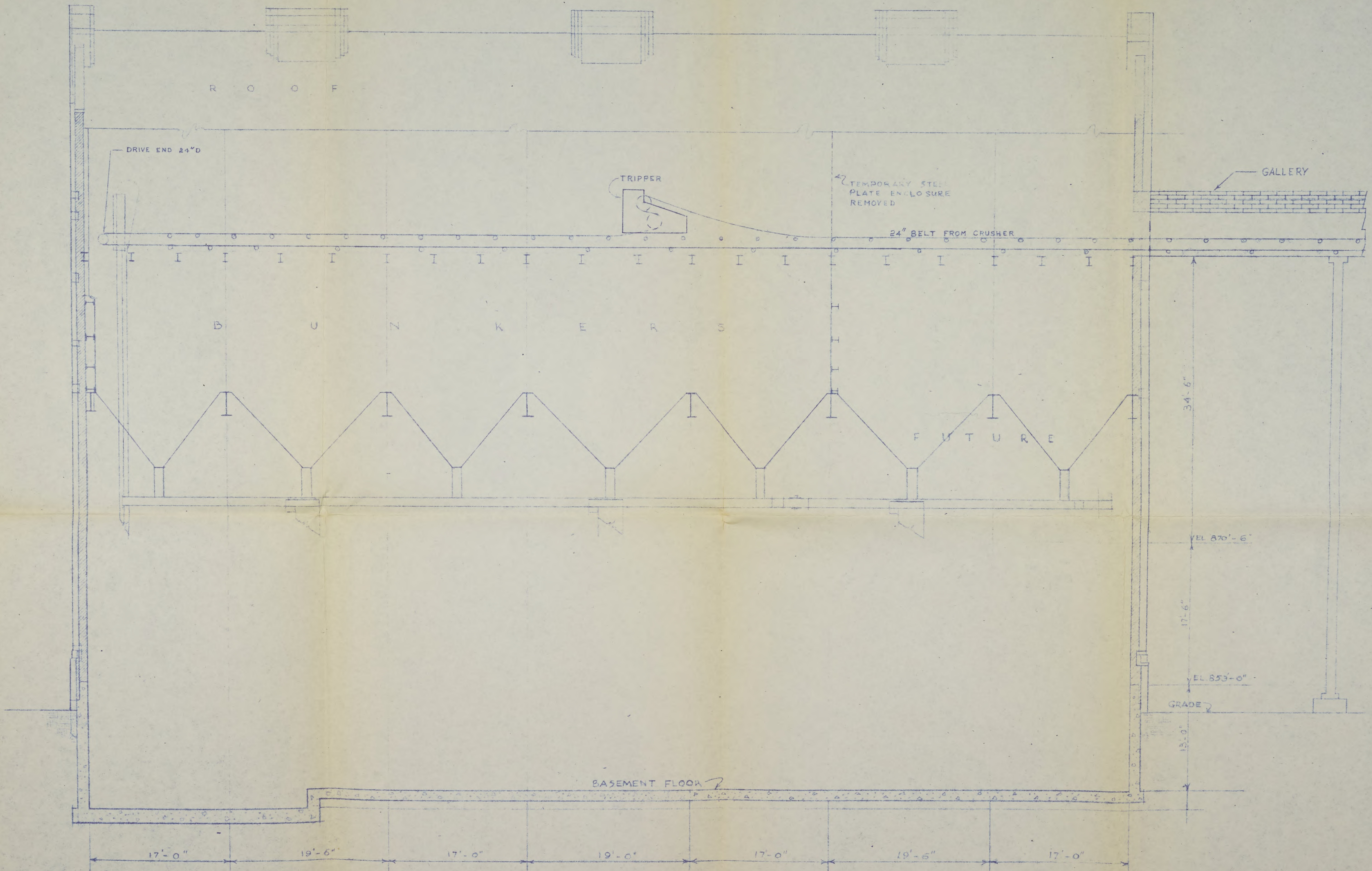
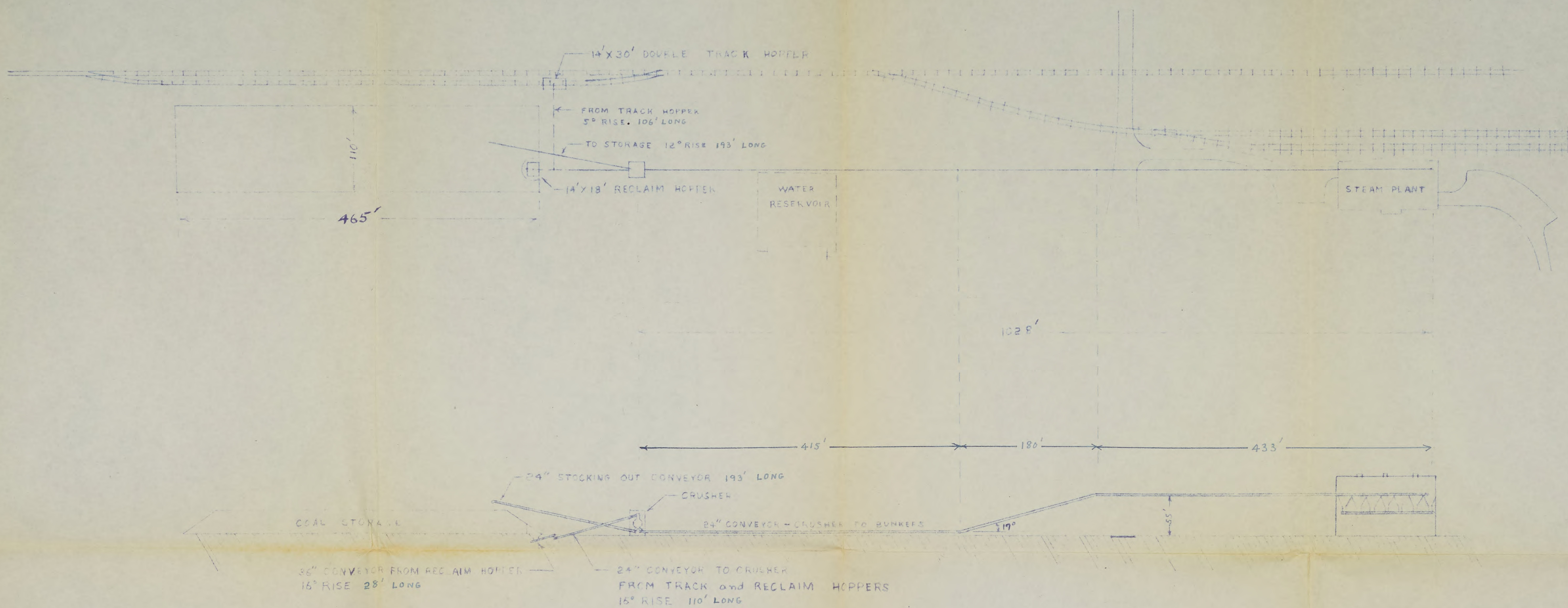
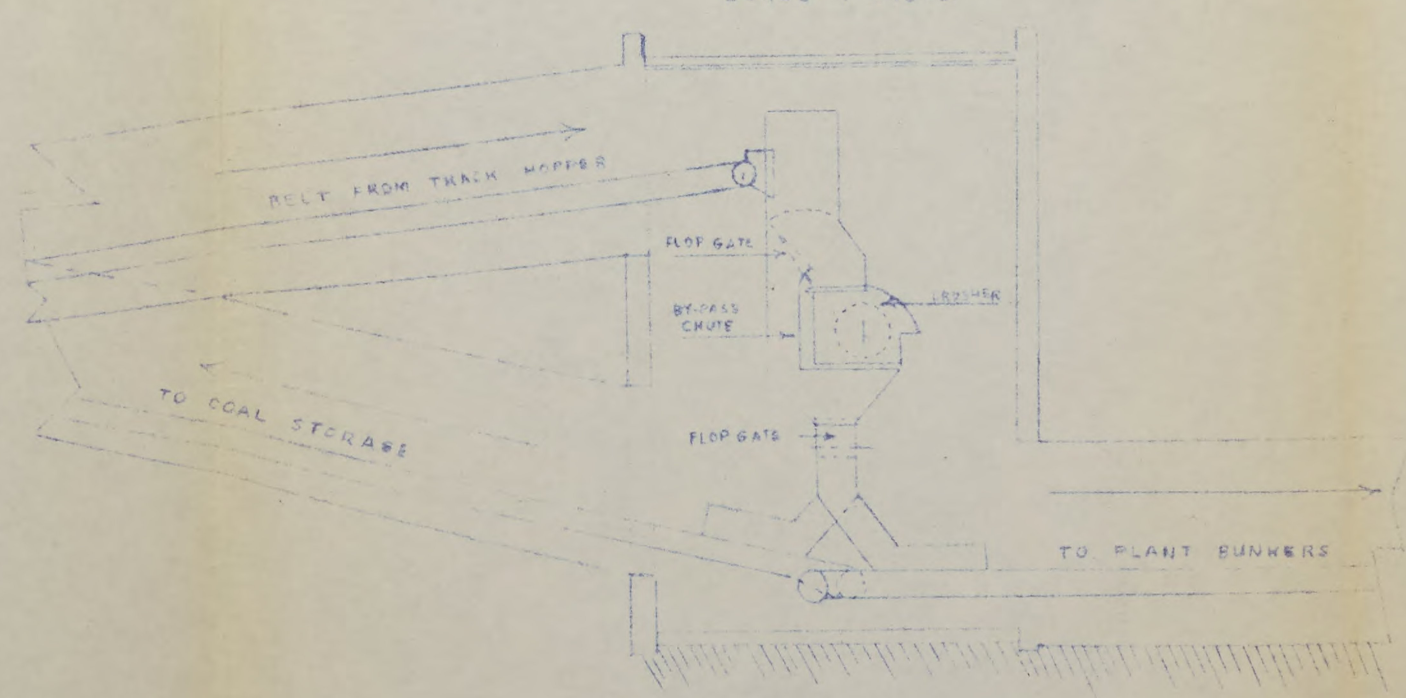


LONGITUDINAL SECTION SHOWING
COAL HANDLING EQUIPMENT
SCALE 1/8 = 1-0

SOUTH CAMPUS STEAM GENERATION PLANT MICHIGAN STATE COLLEGE … E. LANSING			
ELEVATION BELT CONVEYOR SYSTEM			
WILLIAM J SHARP GRADUATE ENGINEER			
DR: Wm. J. Sharp	FIG. 16	Scale: 1" = 8'	Date: 1952



CUT-AWAY OF
CRUSHER HOUSE
SCALE 1" = 10'-0"



SOUTH CAMPUS
STEAM GENERATION PLANT
MICHIGAN STATE COLLEGE . . . EAST LANSING

WILLIAM J SHARP
GRADUATE ENGINEER

PROPOSED COAL HANDLING SYSTEM

DR	Wm. J. Sharp	SCALE: 1" = 100'-0"	DATE: May 1952
CK		FIG. 17	
APP'D			

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