DESIGN OF A COAL HANDLING SYSTEM FOR A GAS PLANT.

---

by

ALFRED IDDLES

***

A Thesis submitted to the Faculty of the Michigan Agricultural College for the Degree of M.E.

East Lansing, Michigan.

May 1917.

THESIS

CONTENTS.

****

The following Thesis is a consideration of the problem of handling gas coal at a certain Gas Plant, with the operation of which the writer was at one time connected. The plant is used for the manufacture of illuminating gas for a city of forty-two thousand population(1914). The gas produced is mixed coal and carbureted water gas of 600 B.t.u. and 15 candle power.

The original installation put into service some thirty years ago made water gas only. When it became evident that coal gas was cheaper to produce, two coal gas benches were installed and found to be satisfactory. Then four more benches were installed and the old water gas plant was abandoned . As the demand increased, coal gas benches were added until the present (1914) installation of eleven benches of six retorts,each 14"x 28"x 9', was complete. About 1910 the load became so variable that it seemed advisable to install a water gas machine to carry the peak loads. A 7'-6" United Gas Improvement Co. water gas machine with scrubber and wash box was installed.

This equipment gave a maximum capacity of 1,250,000 cubic feet per 24 hours with continual operation of the water gas machine and medium quality yield. The coal gas benches were run on four hour heats and the usual charge per retort was 300 lbs. This gives a daily coal consumption of 71 tons for gas making purposes. It was customary to use the same kind of coal for bench fuel at an average con-

sumption , including waste of about 325 lbs. of fuel per ton of coal carbonized. This sums up to 11 tons of bench fuel per 24 hours. Total coal consumption per 24 hours was then 82 tons of 2000 lbs. each.

This coal was usually 3/4 lump West Virginia gas coal, tho occasionally Youghiogheny coal was purchased. It was delivered by the rail-road in all kinds of cars on the company's siding,as shown on drawing No. 1. Ordinarily it was possible to get the coal delivered in bottom dump cars. Coal for immediate use could be dumped from the bottom of the cars onto a brick pavement at the south end of the retort house(marked coal dock). When so unloaded it was possible for the stokers to get their supply by shovelling.from the ground pavement into the charging wagons. It was necessary to have one man on each shift to trim the coal in the car, and to clean up and close the pockets. Figured on a basis of charging all of the stokers' time to stoking and none to coal unloading(as was customary in that by the works management) it cost only $2.50 per 50 tons to unload or five cents per ton. It was impossible however to unload,even 20% of the total coal in this manner, because of the irregularity with which thw shipments arrived. It was common for ten to fifteen cars to come at one time, and then none for a week. To obviate payment of demurrage charges it was necessary to unload this coal in to the coal sheds adjoining the retort house on the east

and on the west.This was done by shovelling from the cars into wheel barrows placed on plank runways on top of the cars. The coal was wheeled into the shed and dumped. One man on the wheel barrow and two to shovel from the car in the barrow were necessary. This method averaged a cost of 25 ¢ per ton to unload.

During a period of two weeks to two months each year it was to be expected that coal shipments might be held up entirely. This necessitated taking the daily coal supply from the stock pile. The stock pile,containing about 3000 tons was located several hundred feet west of the retort house,with structures intervening(see drawing No. 1). The price of stocking coal in that pile by means of men and wheel barrows averaged 30¢ per ton. To reclaim that coal by means of horse drawn wagons and men, handling by hand and delivering to the front of the retort house averaged a cost of $1.25 per ton.

On the average during a year's time twenty per cent of the coal would be unloaded direct from the cars at a cost of 5¢; 10% would be stocked and reclaimed from the large pile at a total cost of $1.25 per ton; and 70% would be taken from the coal sheds at a cost of 25¢ per ton.

During the year then the following would be spent for handling coal from the cars to the charging wagon,-

365 days x 82 tons		29,930 tons per year.
20%	5986 tons @ 5¢ per ton	$299.30
10%	2993 tons @ $1.55 " "	4629.15

70%	20850 tons @ 25¢	5212.50
	Total per year	$10140.95

This ampunt varied somewhat but there was always the possibility of the arrival of such conditions as existed in the winter of 1916-1917, when all of the stock pile was used up, tho during the preceding summer there had been an unusually large one. The actual average cost then to unload coal was 33.88¢ per ton. The costs as outlined above were for the year 1914, when the cost of labor was $2.00 and $2.25 per day for common labor, and $2.50 for a wagon driver, and $1.50 per day for a team of horses. Since 1914 the labor conditions have suffered considerable change. Now common labor receives $2.50 to $2.75 per 9 ½ hour day and the stokers $3.00 per 11 hour day. In spite of the high wages laborers are scarce and difficult to control. The stokers refuse to handle coal from different unloading places, and object to going out of doors in the winter time. With all it seems very desirable to lessen the hand labor required, both because of high cost, and because of the possibility of strikes and the discontinuance of operation. With labor costs about 25% higher in 1917 than in 1914 the yearly cost to unload coal required in 1914 would be $12 675 or 42.3¢ per ton.

In 1912 the daily send out averaged 500,000 cu.ft. in the summer and 700,000 cu.ft. per 24 hours in the winter. Since then the increased use of gas for industrial purposes

and the normal increase due to growth in population has given an average daily sendout of 1,000,000 in 1914 and 1,500,000 cu. ft. in 1916. In Feburary 1917 the sendout was around 2,000,000 cu.ft. per 24 hours. These figures plotted as in Fig. 1. indicate a load of about 3,000,000 cu.ft. per day in 1918. It is difficult to prophesy what it will be in 1920. If the rate of increase remains constant the sendout will be 4,500,000 cu. ft. per day. The population is increasing so rapidly that the building operations, including installation of gas services, have not kept pace. Hence it is reasonable to assume , that the gas sold will increase at the present rate and possibly faster. The population in 1916 was estimated at 65000 or 70000. See Fig. 2 for increase in population in recent years. The capacity of the plant showed signs of needing an increase as far back as 1913. Certain plans were then being formulated to replace some of the then present equipment with more modern and efficient types, and to enlarge the works capacity to care for the probable future needs as outlined above. It was planned to install in the very near future a new water gas machine to run in connection with the one already in use; and also to put in the necessary additional scrubbing and condensing apparatus. A new holder of 1,000,000 cu.ft. capacity was contracted for erection in 1915. A new retort house of inclined oven retorts was proposed to replace the old house of stop end retorts, six per

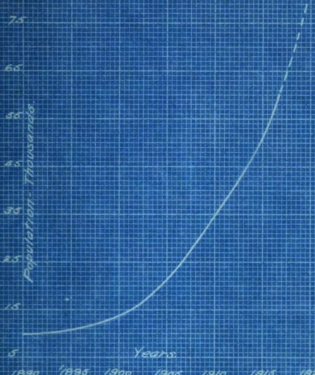

FIG. 1.
CURVE
Showing
INCREASE IN POPULATION

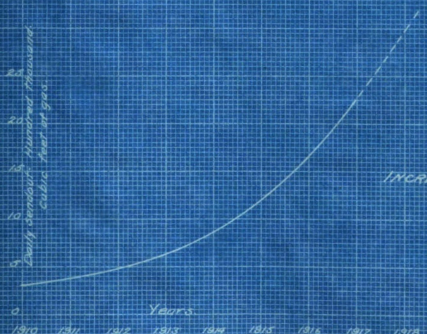

FIG. 2.
CURVE
Showing
INCREASE IN OUT-PUT
OF PLANT

bench. This installation would bring the coal gas capacity of the plant to 2,750,000 cu.ft. daily, 2/3 of this to be installed now and 1/3 later(see drawing No. 2).. With a yield of 5.00 cu.ft. of gas per lb. of coal this would demand 275 tons of coal per 24 hours. If coal is used for furnace fuel, there will be 41 more tons required, or a possible total of 316 tons per 24 hours. To handle this coal by the old-time hand methods would have cost $122.00 per day or $44,530 per year, a cost which is obviously prohibitive. Hence the necessity for a coal handling system.

Referring to drawing No. 2, the extensions already planned are shown in diagram. These are the new purifying boxes to care for the new output capacity; the new water gas machine; and the new boiler to furnish steam for it. The new governor and booster room is shown and will remove those articles from the basement of the office, where they have been a source of danger. South of this is the new condenser and exhauster room. The proposed new retort house is shown just east of the 300,000 cu.ft. holder

Assuming that the working hours in such industrial plants will soon be on an eight hour day basis, it becomes advisable to be able to unload, crush and store in bunkers for use in the retort house at least one day's supply in the working time of eight hours. It will be also wise to have coal handling capacity sufficient to unload reserve coal and place it in the stock pile. In my judgement there

should be a coal storage of at least 200 tons in connection with the retort house, preferably an overhead bunker, because the oven retorts are charged at the top end by gravity from travelling weighing larries; also it should be possible to unload and stock 6 to 7 carloads per day besides the daily consumption. This makes 13 carloads per day to be handled, or about 650tons ,to handle which, a capacity of about 80 tons per hour will be necessary. In case of excessive demand above this amount, the resort to overtime or to two shifts would solve the problem.

To furnish two months reserve coal in the stock pile it would be necessary to store 20,000 tons.

Then the problem reduced to its simplest terms consists of designing a systemtthat will (1) stock about 20,000 tons of coal at the rate of 325 tons per day, and reclaim it at the same rate when needed; and (2) that will at the same time unload, crush, and deliver to overhead bunkers 325 tons per day for current use. This system should do its work with a minimum of total cost and be so designed that future growth will be possible.

The second requirement will be taken up first. From the nature of the ovens, which are inclined and charged from the top it seems advisable to build an overhead hopper type of coal bunker. The coke storage space is between the retort house and the river, and therefore

the ovens ought to be so placed that the discharging side of the oven stack will be on the north. The plan is to convey the coke to quenching pockets and then to the east end of the oven stack, and from there transfer by travelling crane and buckets,either to a crusher and screens,or to the yard storage of run of oven coke. The charging side of the ovens is then on the south so that the coal bunker must be there also. (A consideration relative to future extension is taken up later). The charges will be distributed thruout the day at sufficient,intervals, so that the quality of gas will not vary too greatly. Hence the coal bunker ought to hold enough coal to last from the end of one eight hour day to the beginning of the next, or an 18 hour supply equal to 200 tons. For this purpose I have chosen an elevated hopper type bunker made of steel and lined with concrete to protect the steel from corrosion. See drawing No. 3 for size and refer to specifications for further details.

The coal for use in the ovens must pass an 1½" screen, and since it is not always economical nor possible to buy this size at the mine, nor wise because of breakage and consequent waste, it is therefore necessary to install a coal crusher. The coal can be bought to be delivered in hopper bottom cars which will permit of unloading by gravity into a track hopper.

To handle the coal for daily consumption then the following equipment must be provided for a capacity of 40 to 50 tons per hour,-

a track hopper,

feeder,

crusher,

conveyor elevator,

coal bunker.

These pieces of apparatus will handle the coal with the least amount of hand labor and with minimum cost for maintenance.

In the future if additional capacity is needed a new stack of ovens will be necessary. It is impossible to extend the present oven stack,because it borders the roadway on one end and the larger holder on the other. Hence this coal handling apparatus is designed for the maximum capacity of this oven stack,including the one third more to be added to that now being built. Later on I have taken up the matter of additional ovens and the coal handling plant for them.

LAYOUT OF SYSTEM.

The only available location for railroad side track for delivery of coal to the north side of the oven stack, and for shipment of coke is between the river and the 300, 000 cu. ft. holder. All other ways of approach are estopped by buildings already in place. By reference to drawing No. 2 it is apparant that it is possible to bring a track from the main line of the Grand Trunk Railway along the river , northof the holder and up to the north side of the oven stack. This track will traverse the large triangular open space west of the holder and provide yard storage space for coal stock. This property was owned by the Railway Co. in 1913 but has recently been purchased by the Gas Co.

This track will then be brot to and over a track hopper on the north side of the oven stack, and extended beyond as far as possible to provide switching space for empty cars. In the future another stack of ovens might well be provided for. The proposed location for this stack is shown in heavy dash lines on drawing No.4. The charging side of this future stack will face the charging side of the present stack, and make a firingaisle running east and west between the two stacks. The coal for the new stack can be brot in on the same track and unloaded by a similar arrangement. To provide space for this possible future installation the present track hopper and

bunker have been located to the west of the center of the oven stack. The new installation can be placed adjacent to it and just east of the center line. The general lay-out is shown on drawings No. 3 and 4, and is described in the specifications.

To handle from cars to stock pile a daily amount of 325 tons of coal, or to be able to reclaim the same amount, will require a capacity of 40 tons per hour. The cheapest method both in first cost and in operation to handle such coal(3/4 lump) to and from open storage on the ground is by means of the locomotive crane and grab bucket. For this purpose a 20 ton eight wheel truck steam locomotive crane with 55ft. radius and 2 yd. bucket has been selected. A system for track arrangement is shown on drawing No.4 , whereby practically all of the open ground space will be available for coal storage and within reach of the crane. A concrete pit has been located so that coal f from hopper cars can be unloaded by gravity and dug from the pit by the grab bucket. All places in the yard cannot be reached by the crane, when taking coal from the coal pit, without the construction of too many pits, and so it is planned that for storage in such places the grab bucket will take coal directly from the cars. When the cars are nearly empty they can be pushed over the pit and dumped to completely empty them. The locomotive crane

will also be of special value to move cars in the yard, and thus be independent of the Railway yard men. Drawings No.4 and 5 indicate the track arrangement, location of the coal pit and a typical cross section of the storage yard, showing depth of coal piles, the track distances, and relative location of crane and coal pit. Drawing No.5 shows details of construction for the coal pit. For a description of the apparatus and its installation see the specifications.

For future growth it will be possible to place the tracks on low trestles and thus make possible higher storage piles. If this is done, and the reclaiming speed is to be increased, it will be necessary to have either a second locomotive crane, or a larger one, or to operate the one during two shifts. If deeper piles are used, it probably would be advisable to separate the yard into unit pockets by concrete retaining walls, so that in case of spontaneous combustion the fire could be isolated and the condition remedied.

SPECIFICATIONS

Specifications for a Coal Handling System of 650 Tons per 24 hours Capacity to be installed for the ------Gas Co.

GENERAL DESCRIPTION.

These specifications with the accompanying drawings and plans contemplate the complete installation of coal handling machinery and all fixtures and structures necessary or desirable for the proper and economical handling of coal to be used by the Gas Co. The part of the gas plant which will use the coal consists of an installation of 15 inclined ovens, located as shown on drawing No. 2 , and furnished and erected by The Gas Machinery Co. of Cleveland, Ohio.

The ovens will use a maximum of 325 tons of coal per 24 hours for fuel and gas coal combined. The coal will be delivered by the Grand Trunk Railway on a side track adjacent to the stack of ovens or to the yard for storage.

The storage is to provide for a stock pile of 22,000 tons, stored on the ground in uncovered piles. Coal for immediate use is to be dumped from hopper bottom railway cars(either direct from the mines or loaded locally from the storage pile) into track hoppers. From these hoppers the coal is to be conveyed by an inclined apron conveyor into a coal crusher which will reduce the size to that suitable for charging in the ovens. From the crusher the coal will pass by gravity into a pivoted buck-

et elevator and conveyor, and be taken up over and across the top of the ovens and delivered into the storage bin. From there the coall will pass by gravity into travelling weighing larries and thence into the inclined ovens in charges of about 5,500 lbs. The apparatus herein specified will take the coal from railway cars and deliver it to storage bin over the ovens. The travelling weighing larrie is not included in these specifications.

The coal in storage piles is to be handled with a locomotive crane from cars or from track pits. This crane will also be used as a switching engine in the yard.

The concrete foundations, walls and excavations are to be made by the Owners according to detailed plans furnished by the contractor for the apparatus.

RAILWAY SERVICE

There is a railway siding available for bringing in material and supplies. The location of this track is shown on drawing No.2.

MATERIAL

All material is to be new and of first class and is to be furnished by the contractor except, as noted, for concrete work. The material is to be erected in a workman-like manner and to the satisfaction of the consulting engineer.

ELECTRIC CURRENT

110 volt, 3 phase, 60 cycle electric current is available for power, and all machinery is to be run by that means.

TESTS

When the system is completely installed, the contractor is to put it into operation and superintend its operation for one week , or as long as necessary, making all necessary adjustments and alterations until completely satisfactory.

DRAWINGS

As a part of these specifications there are submitted five drawings which show the general layout and location of present and future structures in relation to the coal handling system. These general layouts and dimensions are to be followed.

The contractor shall submit detailed and shop drawings for the inspection and sanction of the consulting engineer befor goingahead with the work; and shall leave with him two complete copies of the drawings finally used.

PAINTING

All steel and iron work is to be painted in the shop with one coat of red lead in oil and aftererection with two coats of graphite and oil. No paint shall be applied over rust spots or scale . All such imperfections shall

be removed before painting.

DETAILS OF CONSTRUCTION.

TRACK HOPPER

The track hopper to be installed on the north side of the oven stack shall be a 12'x 12' steel hopper, either Link Belt Co.'s . or equal. This hopper shall be installed complete including rails and rail supports, except excavation and concrete work.

APRON CONVEYOR

The apron conveyor and feeder shall be a 9" pitch, 30" wide, Link Belt Co's., No. ES-63 or equal, with a capacity to handle with ease 40 tons per hour, set so that the maximum depth of excavation shall not be greater than shown on the drawing, and so that the distance of rail siding from the oven stack shall be approximately as shown. This conveyor is to be installed complete with a driving motor, which motor will also drive the crusher, set adjacent, if desirable. The conveyor shall have side boards to prevent spilling of coal, and shall be provided with adjustable bearings at one end to care for slack in the chains.

COAL CRUSHER

The crusher shall be of the two roll type with spring release of rolls for large pieces of foreign matter.

The rolls shall be 28" diameter x 24" wide, and with a capacity to crush 40 tons per hour of 3/4 lump gas coal to pass an 1 ¼" screen. The crusher shall be Link Belt Co's. Type "A", or equal. The feeding hopper and outlet chute of the crusher shall be made of 1/4 " steel plate securely riveted and properly supported. The crusher is to be driven, preferably by the motor which drives the apron feeder.

ELEVATOR AND CONVEYOR

The elevator and conveyor shall be of the pivoted bucket type, 24"x 24" size, and a so called "Peck Carrier" manufactured by the Link Belt Co., with a capacity at a moderate speed, of 40 tons per hour. This conveyor is to receive the coal from the crusher on the lower run, elevate it high enough to clear the top of the ovens, convey it over the oven top, and discharge into the top of the hopper type storage bin. The bin is 35ft. long. The conveyor is to deliver the coal eight feet above the top of the bin, so that the coal will pass by gravity to both ends and to the middle of the bin. There shall be a stationary tripper over the storage bin to cause the coal to be dumped into the chutes, which are provided to guide it to all parts of the bin. All necessary sprocket wheels, idlers, guides and driving mechanisms shall be provided, together with an electric motor at the driving corner. This motor shall be furnished with distant control located

on the charging floor as shall be directed by the Owners. All steel frame work and housing for the conveyor shall be provided. The conveyor shall be amply protected from the weather, especially from ice and snow, and shall be equipped with stairs and ladders conveniently located for inspection and repairs. In brief, a standard Peck Carrier is called for, installed as may be recommended by the Link Belt Co. of Chicago, Ill.

EXCAVATIONS AND FOUNDATIONS

As soon as possible after taking the contract the contractor shall furnish the Owners with detailed plans and instructions for excavating and for placing the foundations for every piece of apparatus and structure.

STORAGE BIN

The storage bin shall be of the hopper type, made of 3/8 " steel plate properly riveted and lined on the inside with reinforced concrete 3 1/2 inches thick. It shall be about 35 ft. long, 15 ft. wide and about 17 ft. deep, and shall hold 200 tons when heaped full of gas coal crushed to pass an 1 1/4 " screen. The bottom of the delivery spout must be 40 ft. above the grade line of the railway side track or top of the track hopper. The bin shall be supported on steel columns the clearance dimensions for which are shown on drawing No.3. The north row of support-

ing columns will rest on special cross girders over the tops of the ovens, as provided for and shown on drawings of the ovens by the Gas Machinery Co.The bin shall be covered with a suitable roof as shown on drawing No.3. The concrete lining shall be placed by the contractor and shall be made of well mixed concrete of the following proportions,- Portland cement, 1 part, sharp sand 2 1/2 parts and broken stone not larger than 3/4" in diameter 5 parts.

LOCOMOTIVE CRANE

The locomotive crane shall be a Link Belt Co!s. (or equal) standard steam locomotive crane, with an eight wheel truck, standard railway gage of 4'-8 1/2", 55 ft. radius and 2 yard grab bucket for use in handling coal. The minimum clearance height of bucket at 50 ft. radius when fully loaded shall be 22 ft. This crane shall be self propelling and provided with standard couplers on each end, so that it can be used to handle railway cars in the yard. It shall be fully housed to protect the operator in the winter time.

GRADING. COAL PIT. TRACK LAYING

The Owners will do all grading and filling; will construct the concrete coal pit for the yard storage system, and be responsible for the laying of all railway tracks.

COVERING OVER CONVEYOR AND CRUSHER.

The contractor shall provide a reinforced concrete covering over all apparatus between the track hopper and the oven stack. This covering shall be strong enough and suitable for general floor use and be a proper protection from the weather for the apparatus beneath.

Special construction to be done by the Owners.

The concrete digging pit for coal in the storage yard is shown on drawing No.5. It should be constructed of well mixed concrete of the following proportions,- Portland cement 1 part, clean sharp sand 2 parts and medium aggregate 4 parts.

The I beam supports for the railway track should be set level and true and according to the instructions of the railway track foreman. The I beams rest on the walls of the coal pit for support and are incased in concrete to prevent corrosion. The digging pit is surrounded on three sides by a wall two feet above grade line to prevent the inclusion of foreign matter with the coal and to prevent accidents to the operators.

The storage yard has been filled in until it is practically level. The Owners will arrange with the Railway Co. for the laying of the necessary tracks thruout the yard and for any necessary grading. The track should be well laid and of substantial weight, say rails of about 80 lbs. per yard.

When filling the storage yard the outer edges should be filled first and then the space toward the center, provided it is planned to completely fill the yard. When completely full only the principal yard track would be left uncovered with coal. Over this track the coal for daily use and any shipments of coke can be passed. If only a

part of the storage space is to be filled then the circular storage track should be used. Coal dumped into the digging pit can easily be handled from cars to the storage pile by the locomotive crane. And when reclaimation is necessary it is most easily accomplished from the circular pile.

The Circular Track System of storing coal, as outlined on drawing No. 4, has been patented by the Link Belt Co. of Chicago, Ill. and the Owners will make arrangement with that Company for the right to use it in this layout.

ESTIMATED COST.

The estimated cost of the equipment, as outlined and listed in the specifications, completely installed is as follows,-

FOR STORAGE

Locomotive crane ----------	$15 000.00
Concrete digging pit in yard------	500.00
Railway track thruout the yard,80% charged to coal handling and half of that to storage yard, -------	1 000.00
Total direct	$16 500.00
Engineering expense -------10%--	1 650.00
Total----	$18 150.00

FOR COAL HANDLING, DAILY

Track hopper and pit by ovens --	$1 000.00
Coal crusher----------	2 000.00
Apron feeder ----------	3 000.00
Hopper type storage bin --------	4 000.00
Pivoted bucket elevator and carrier	8 000.00
Railway track, half of total to coal	1 000.00
Total -	$20 000.00
Engineering expense --10%------	2 000.00
Total	$22 000.00
Total cost of installation for both storage and daily use ----------	$40 150.00

ESTIMATED COST TO OPERATE

DAILY COAL DIRECT FROM RAILWAY

Net operating cost for bucket carrier	2.4¢/ton
To operate the coal handling system for daily supply will require 1 man @ $2.75/ day or----------	.084¢ "
Total investment, exclusive of bucket carrier, is $14 000.00. If 15% is charged for depreciation, interest and repairs that gives $2 100.00 per year or-----	1.782¢ "
Total cost to handle, per ton ------	4.246 ¢

COAL TO STORAGE

Total investment ----------$18 150.00	
15% for fixed charges---$2 720.00/ year	
On an assumed amount of 50 000 tons per year to storage this equals -------	5.45 ¢/ ton
1 man @ $3.50 per day	
1 man @ $2.75 per day	
$6.25 fpr 350 tons --------	1.85 ¢/ton
Fuel cost, 50 h.p. ----------	1.00 ¢ "
Total cost per ton to place in storage--	8.30 ¢ "

It will cost about the same to reclaim from the storage pile and deliver to the ovens. When coal is stored in the yard and later used in the ovens twice

this amount must be added to the cost to handle at the oven stack or a total amount, per ton of ----20.84¢

If more than the assumed 50 000 tons per year be put in and out of storage the cost per ton would decrease somewhat. For instance if 100 000 tons were to be handled per year the cost would be about 5.53 ¢ per ton as against 8.30¢ for the smaller amount.

THE END

Patents: 5 Drawings