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Coal washing

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C O A L   W A S H I N G.

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A

THESIS

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HISTORICAL.

The rapid growth of the coal washing industry in the United States during the past few years is characteristic of the general tendency toward more economical and efficient utilization of the natural resources, the washing of coal being a process of enrichment of one of the most necessary and widely used raw products. This industry is of great importance to the men engaged in mining of coal as well as to the community at large, and since it makes possible the use of originally poor coals, [redacted] it conserves one of the natural resources absolutely essential for the progress of the human race.

The coal washing industry is comparatively young. Crude methods of coal dressing are known to have been used in the early days of coal mining. Quite primitive were those methods, and they were but little related to the modern stages in the developments of the industry.

It is thought that the more or less systematic washing of coal was originated in Silesia and Prussia, and it may be said that in the former state scientific methods, such as are used today, were applied on a large scale for the first time during the early sixties. In the German Empire those years were marked by an extensive building of railroads, which made available for the principal markets, coal mined in the remote districts, also by an industrial crisis and the development of coking industry, which created general demand for the coal of high quality. Conditions were such as to favor extensive application of the coal washing scheme invented not long before by Lührig. Since then coal washing methods have been constantly improved. Toward the end of the last century difficulties that had been encountered in drying of coals, clarification of wash waters, etc. were removed, and at the present time German methods of coal washing are distinctly those of coal enrichment.

English coals are high grade and very favorably situated as regards transportation. The early attempts at enrichment were confined entirely to screening. A patent for a screen was issued in 1849, but developments were very slow until 1884, when the jigging systems, already largely used in Germany, were introduced; from that time the English and German systems have been developed along parallel lines.

In Belgium and France the development has been similar to that in Germany.

In the U.S. there are large areas of high grade coal, and washing was not so essential to the development of the metallurgical industries as was the case in Europe.

Coal was first washed in the U.S. in 1870 at Alpsville, Pa., the plant was built by a Prussian engineer named John J. Endres who had been employed in the government collieries in Germany. During 1871-1872 Endres built other plants at Hazelwood and Hollidaysburg, Pa., and Joliet, Ill. All these plants were jigging plants, but during the same period a few more or less successful plants using trough washers were erected.

About 1878 the Eureka Co. buily a Stutz jig plant at Helena, Alabama, this plant is said to have run successfully for several years but information regarding it is meager. No further developments were made until the early '90's when the demand for better coke, and especially coke with a low sulphur content for iron blast furnaces, forced the coke producers to wash their coal, and several large plants using jigs were erected.

In 1891 the "Robinson Washer" was first practically applied and later the "Stewart" and "American New Century" systems were introduced, and not only coal intended for metallurgical coke but nut coal and slack intended for domestic and steam purposes is now very generally washed.

In Illinois, coal washing was first attempted in 1872 as a preliminary to coke making; it is probable, however, that most of the plants now operating in that state wash their coal for steam and domestic purposes. In Kansas, Missouri and Oklahoma the industry is very young and is confined entirely to washing coal for domestic and steam purposes. The few plants in Colorado and New Mexico wash coal exclusively for metallurgical coke. The most promising field for coal washing development in the U.S. today in West Virginia and Kentucky where the immense deposits of coking coal, on which the pig iron industry must depend more and more, requires some enrichment preparatory to coking.

In the U.S. the coal washing industry is in its infancy and great developments are to be expected in view of the depletion of the high grade coals, and the constantly increasing demand for better coke, as well as a better quality of domestic and steam coals.

THE IMPURITIES OF COAL.

The object of coal washing is of course to reduce the percentage of impurities in the coal, chiefly sulphur and ash, and the process is invariably one based on the difference in specific gravity between the coal and the impurities. When the sulphur exists as large crystal aggregates, hand picking and screening is always used before the washing process is applied.

Sulphur is very detrimental to coke that is to be used for metallurgical purposes; it is also objectionable for domestic use owing to bad odors, tarnishing effect, etc. Under certain circumstances it attacks the grate bars and other iron work. Sulphur is perhaps the most troublesome impurity and only when it is present as distinct crystals [illegible]" of iron sulphide (Pyrite or Marcasite) can it be separated by a process dependent upon specific gravity.

Sulphur exists in coal in three forms: (1) Iron Sulphide, FeS_2, (2) the sulphates of the metals of the alkaline earths, chiefly Gypsum, $CaSO_4 \cdot 5H_2O$ and (3) "Organic" sulphur or sulphur originally present in the woody material from which the coal was formed. Iron Sulphide (Pyrite and Marcasite) is the form in which the bulk of the sulphur in coal is found, this is shown by numerous analyses in which the close relation of sulphur to iron is strikingly brought out, to illustrate this a few analyses taken from Haas are given below. (See Vol. 2A, 1908. West Virginia Geologic Survey)

No of Coal.	Total Sulphur.	Total Iron.
1	.80	.452
2	1.63	.922
3	2.03	1.070
4	2.49	1.307
5	2.52	1.239
6	2.56	1.142
7	3.14	1.569
8	3.26	1.788
9	3.54	1.948
10	3.68	1.849

The size of the crystals and crystal aggregates varies between wide limits with different coals; in some cases very fine and disseminated throughout the coal mass, but more usually occurring as masses of crystals weighing up to several hundred pounds. Often the crystals occur as flaky layers filling the bedding planes of the coal. The size and shape of the Pyrite particles has great influence on the effectiveness of the coal washing operation, the fine flaky Pyrite being quite difficult to remove.

Gypsum ($CaSO_4$ $5H_2O$) is present in varying quantities in all coals but usually its amount is small compared to Iron Pyrites. It occurs principally as flakes in the bedding planes of the coal and is largely removed by any process that removes the iron sulphide. Associated with the Gypsum are smaller and unimportant amounts of Calcite, Dolomite, and more rarely Barite. Some sulphur undoubtedly existed in the vegetable material from which the coal was derived, but it seems probable that the greatest part of sulphur in coal was introduced by circulating ground waters, which always carry more or less metallic sulphates in solution, notably iron sulphate, **and as carbonaceous material under certian conditions is very strongly reducing,** the sulphides were formed from the sulphates, **Gypsum was likely directly percipitated** by the reaction of the iron sulphate and Calcium Carbonate.

Ash is inert, incombustible, non-volatile mineral matter existing in coals, (1) as a slaty laminae between the coal beds, (2) as disseminated oxides principally of Silicon and Aluminum. It is understood that presence of ash reduces the value of the coal accordingly; moreover the presence of ash may have an undesirable effect on the behavior of the combustible material of coal. Clinkering of coals which is caused by the ash they contain may be mentioned here. It has no direct bearing upon the combustion of the coal, but it reduces the capacity and efficiency of a furnace by making it necessary to hold the doors open longer when cleaning the fire, in addition, fusible ash, by solidifying between the grate bars, diminishes the quantity of air passing into the furnace. The fusing of ash is a direct fluxing of the ash constituents and can usually be predicted if the analysis of the ash and the calorific value of the fuel be known.

The success or failure of a washing scheme sometimes depends upon the extent to which removal of ash can be commercially carried out. Such extent depending upon the conditions of the market in general and the possibility of improving the coking properties of the coal, in particular. It is evident then that from the commercial standpoint the removal of the ash is to be considered in a very general way in-so-much as the factors that may influence such considerations are numerous and change from time to time and from place to place.

The behavior of ash when subjected to high temperatures is of great importance in this respect as coals running high in infusible ash may be more desirable than those with low but fusible ash content.

A theory of the nature of ash based upon a study of West Virginia coals has been advanced by Mr. Frank Haas#, to quote; ". . . . larger part of ash is made up of Silica and Alumina, this together with alkalies are what we choose to call the original impurities in coal. They are probably the mineral portion of the original woody fibre and the result of the decomposed Feldspar. . . these four compounds are again combined into a silicate of Alumina and alkalies forming an insoluble and stable compound." Mr. Haas distinguishes "original" impurities from secondary or "migratory" impurities which as the name implies is a foreign portion of the coal having been carried into the coal bogs from adjacent formations. To quote further, ". . . there is but slight variation in the original impurity, which approximates 4 % and is of uniform composition . . . any additional impurity is of the migratory group, which decidedly variable in composition. To the secondary group of impurities is chargeable the fusibility of the ash with resulting clinkers".

It could be then justly assumed that the portion of ash which comes under the head of "original" impurities is associated with the coals more intimately than that of "migratory" origin, and probably removal of the latter in a washing process will take place before that of the former, thus giving definite idea of

#Vol. 2A, 1908 W.Va. Gealogical Survey.

the nature of the material to be dealt with.

While coal washing practice deals entirely with mechanical means for the removal of ash, better understanding of its nature could be of great service in devising washing schemes. Assuming that Mr. Haas' theory could be applied to all coals, it becomes apparent that in the light of such a theory the interpretation of preliminary tests would be more complete.

Coal washing involves exactly the same principles as does Ore Dressing except that in coal the valuable portion (coal) is lighter than the impurities, whereas in Ore Dressing the reverse is usually true.

Water concentration schemes are used exclusively for Coal Dressing and, as is the case in Ore Dressing, the coal must be crushed fine enough to free the impurities and then sized to such an extent that the free or hindered settling ratios, as the case may be, will admit of separation by water currents. This sizing is usually less exact than that required in Ore Dressing because of the usually greater difference in specific gravity between the coal and the impurities. Coal screening is done on a variety of machines, revolving, shaking and gyrating screens being the most important.

The subject of coal crushing lies entirely outside the province of this thesis, but it is well to state that the size to which crushing is to be carried and the laws governing the production of fines are identical with those of Ore Dressing, and the crushing machines, (Rolls, Swing Hammer Pulverizers, etc) differ only in details of design.

Ordinary bituminous coal has a specific gravity of 1.25 to 1.35, that of clean shale is about 2.3, but that of the highly carbonaceous shales is much less. Pyrite has a specific gravity of 4.95 to 5.91 so its separation requires no very close sizing.

The extent to which sizing must be carried must be determined in each individual case by actual tests, a discussion of which is given in another part of this thesis.

COAL WASHING SYSTEMS.

The following classification of coal washing systems is here proposed not with the expectation that it will be found complete but to aid in a better understanding of the descriptive matter.

I. JIGGING SYSTEMS.

1. Systems employing sizing before jigging.
   - a- New Century.
   - b- Stewart.
   - c- Schüchtermann & Kremer.
2. Systems employing sizing after or before jigging.
   - a- Humboldt.
3. Systems employing sizing after jigging.
   - a- Baum.

II. HYDRAULIC CLASSIFIER SYSTEMS.

- a- Jeffery Robinson.

III. Trough Washers.

- a- Scaife.

IV. Bumping Tables.

- a- New Century.

DESCRIPTION OF COAL WASHING SYSTEMS.

NEW CENTURY SYSTEM.

This system employs sizing before jigging, the peculiarities being in the very different design of jiggs used on various coals and sizes of the same coal. A heavy double plunger jig is used on the larger sizes and where the difference in specific gravity beyween the coal and bone is small the well known differential motion obtained by a cam is used. (See Plate I). The peculiarity of the jigs is the unique rotary valve or "draw" for removing the material from the bed. (See Plate 2).

This valve consists of a rotating part with four vanes which fits practically water tight in a cast iron case, the number of revolutions and hence the quantity of material drawn can be very accurately regulated.

These jigs use short quick strokes and have proven very effective for small sizes, Material that was all crushed thru 1/16 inch having been successfully handled. A list of this company's jigs is appended, showing the range of sizes handled. These jigs are all of the movable plunger type, and only in the valve and minor mechanical features do they differ from the "Luhrig" jig.

Number of Machine.	Kind of Motion	Adaption to Size of Coal
900 B	Eccentric	3" to 4 1/2"
900 A	Eccentric	3" down
600	Eccentric	3/4" down
500	Eccentric	3/4" down (for low ash)
700	Eccentric	Slack
"Double Anthracite" .	Cam	3" down.

The two flow sheets (Plates 3 and 4) represent typical practice of this company.

STEWART SYSTEM.

This system differs [redacted] from the New Century only in that it employs movable sieve jigs (See Plate 6). It is most successful on the larger sizes of coals, and is in extensive use. The suction on the bed is very great and to obviate this to some extent the "Pittsburg" modification has been designed. This consists of a closed box, with valves opening inwards, which is attached to the eccentrics, the screen forming the top of the box; on the upward stroke, therefore no suction takes place (see Plate 5).

SCHÜCTERMANN AND KREMER SYSTEM.

Screening results in three sizes;
(1) fine coal 0 -10 mm. (2) nut coal 10-25 mm.
(3) Coarse nut 25-80m.m.

Those products are then seperatly jigged on machines for each size. As a rule, feldspar bed is used when jigging fine product.

Piston, two-compartment jigs are used. The product of the first sieve consists of clean refuse, while that of the second consists of refuse material intimately connected with the coal. This product represents practically true middlings and is retreated.

Jigs for fine coal have two or four sieves. When fines run high in Pyrite a third sieve, placed at the feed end, is being generally employed. This sieve slopes toward the center of the jig and carries a pipe for the periodical removal of the accumulated Pyrite.
Some data relating to the "Shüchterman & Kremer "jigs" is tabulated below.

	Jig. for the Nut and Larger Sizes.	Jig. for Fine Sizes; Feldspar Bed.
Sieve Surface in m.m.	1800 long 800-1400 wide	4 sieves, 1200x700
Size of Openings in M.M.	3.5 - 5.0	12 x 12 m.m.
Ratio of the Surface of the Sieve to that of the Piston.	About 1 : 2	1 : 2.8
Length of Stroke in m.m.	100 - 300	30 - 40
Number of Strokes per minute.	50 - 55	150
Capacity per hr. in Metric Tons.	12 - 15	15 - 20
Power in H.P.	1/2	1 - 1.5
Water Consumption in per min.	0.8 - 1.0	0.9 - 1.0

The flow sheet (Plate No. 7) illustrates the typical practice of this system.

THE HUMBOLDT SYSTEM.

Three distinct types of washeries are manufactured by the firm of Humboldt. Their design as regards the stage of the process at which sizing shall be employed depends entirely upon the character of the coal to be treated.

(1) Complete sizing before jigging for coal with small difference in specific gravity between

the clean coal and the impurities.
(2) Incomplete sizing before jigging for the coal with a greater difference in specific gravity.
(3) Jigging precedes sizing for the coals with considerable difference in specific gravity.

Following is a description of a typical Humboldt washery at work at the Dahlbush coal mine based upon data published in Glückauf, No. 14, 1911.

The washery is designed to treat 100 tons per hour. About 50% of the washed coal is intended for coking. Specifications for the first class coke call for a maximum of 5.5% ash, and less than 1% salt. Coal as delivered to the washery contains 15 -22% ash and 2-3% Salt. The character of the impurities carried by the coal makes separation an exceedingly difficult process. Salt is readily dissolved by the wash waters thereby increasing its specific gravity, while the other impurities have the property of decomposing into thin flakes and are practically inseparable from the clean coal by jigging.

It has been found, however, that fine coal and dust (0 - 2 m.m.) are especially rich in impurities, and that after their removal, reduction of the impurities left in the coal is comparatively easy.

The flow sheet of this washery (Plate No. 8.) indicates the main stages of the process.

THE BAUM SYSTEM.

"First wash and then classify", is the official slogan of the Baum Company. It is claimed that this system was first to employ the process involving sizing of the jigged product. In fact, the reputation of the system is based upon the successful application of that process, and at the present time all washeries are designed by this firm in accordance with this principle.

The importance of sizing for successful separation of coal from its impurities by jigging is discussed elsewhere in this paper. It hardly can be doubted that sizing improves operation of jigs, and it would seem that in jigging coals, whose specific gravity differs but slightly from that of impurities, preliminary sizing is absolutely essential.

Commercial jigging of such coals, without subjecting them to preliminary sizing, seems to be possible due to such factors, as difficulties encountered in sizing (moist conditions of run-of-mine and better preservation of the unsized product, while it is being jigged. These factors are apt to be of such an importance as to make Baum's process very successful, notably in those cases when difference in specific gravity of coal and bone is considerable.

Another distinguishing feature of Baum's system is the employment of pneumatic jigs both for large and small sizes.

One of the principal advantages of such a jig is the complete elimination of suction. As the inlet valve is closed with the simultaneous opening of the escape valve, diminution of pressure in the air compartment is gradual and quite slow, and accordingly, the returning water runs slow at the beginning, its velocity gradually increasing.

The narrow limits of regulation of the pneumatic jigs is, perhaps, one of their most serious drawbacks. Since the inlet valve remains closed while the water is in motion, the number as well as the length of pulsations is limited, fifty pulsations per minute being the maximum.

For a sketch of the Baum jig see Plate No. 9. The upper portion of the jig is developed into two compartments. (a) hutch and (b) air.

Admission and exhaust of compressed air is is regulated by means of a cylindrical valve, (v) in Fig. 3, which is operated by an eccentric, (e). When valve is in its lower position, the air enters compartment, (c) and drives water in, (a) upward; as the valve is raised, air escapes, and water returns to its former position.

Clean coal is discharged at the end opposite to that of feed. Refuse is discharged partly through chambers, (D) Fig. 2, and partly as hutch product. It is carried away by a spiral conveyor, (s) running along the entire length at the bottom of the jig. The Discharge through, (d) is regulated by gates, (g). The Valve, (h), placed at the top of discharge chambers, regulates the pressure of air in these chambers; the character of the refuse (whether clean or an intermediate product), is thus controlled by means of this valve.

A Baum jig with 9.5 sq. meters of sieve surface has a capacity of 150 tons per hour.

The flow sheet of the Grimberg-Monopol Washery, (Plate No. 10) illustrates typical practice of the Baum System.

THE JEFFREY-ROBINSON SYSTEM.

In this system the separation of coal from its impurities is done by means of a continuous rising current of water.

The washer (Plate No. 11) consists of an inverted steel cone with a refuse chamber, operated by a rack and pinion, together with a central shaft carrying projecting arms and stirring blades. The coal passes into center ring at the upper portion of the washer. Water enters through the housing (F) and passes into the washer through perforations. The coal is kept in a constant state of agitation; as it sinks it is met by an upward current of water. Clean coal is discharged as overflow, while the refuse is accumulating in chamber, (J) at the bottom of the washer. Discharge of refuse is operated by means of valves, (V).

Advantages claimed for this system are, simplicity, and low cost of installation and operation.

The comparatively rare application of classifiers for washing coals is explained by the fact that such devices give satisfactory results with only few coals, (the difference in specific gravity of coal and its impurities must be rather sharp), and that there is no intermediate product formed.

It seems quite reasonable that water classification will be of some importance sooner or later as a treatment preliminary to jigging. In fact, some of the British washeries employ classification in a spitzkasten before jigging their coal.

Spitzkastens are also known to be in use as washers of coal, that is, classification by carrying current of water. They are employed instead of jigging, and it is supposed they can be employed for this purpose with more or less success in some rare and specific cases.

THE SCAIFE TROUGH WASHER.

This washer is simple in construction. Coal and water are fed in at one end of the inclined trough and meet riffles in flowing down it. The slate and bone collect behind these riffles and in the Scaife machine are periodically removed automatically; the machine is cheap but has a low efficiency.

BUMPING OR RECIPROCATING TABLES.

These operate on exactly the same principle as do ore concentrating tables; they are usually longer, however, and the riffles extend close to the end. The peculiarity of the American New Century table is the small tubes in riffle bottoms which remove the small pyrite and slate and vastly increase the efficiency and capacity of the table. (Plate No. 12)

AN ACTUAL TEST.

An actual laboratory test was made on a slack from Southern Illinois to determine if it could be washed and thereby converted into a high grade steam or domestic coal. All the slack passed a 1/2 inch screen and the percentage of fines was quite large. A screen analysis was first made, which showed nothing of great value except that by screening out the dust the quality of the product would be improved. The float and sink tests were conducted under conditions as nearly uniform as possible, the number of tests was not sufficiently large but gave a good idea of the nature of the impurities. The laboratory tests on jigs, were as carefully carried out as possible and the results are considered reliable. An attempt was made to run a sample of the coal on the "Dunham" Table but it was wholly unsuccessful.

The original coal was quite lustrous with good cubical cleavage. Some gypsum flakes occurred in the fractures with considerable flaky pyrite, a good many "balls" or aggregates of pyrite crystals usually of small size also occurred.

ANALYSIS OF ORIGINAL COAL.

Moisture . . . . 3.2 %

Ash . . . . [illegible]

Sulphur 3.7

Vol. Matter 11.3

Fixed Carbon . . . . [illegible] (by difference)

All coal was crushed through 1/2 inch and a screen analysis made to determine the distribution of ash and sulphur in the various sizes.

On 4 mesh - Percent of Total . . . 41%

Ash . . . . [illegible]8

Sulphur . . . . [illegible]3

On 4-8 mesh-Percent. of total . . . 25%

Ash 10

Sulphur 2.5

On 8-12 mesh-Percent. of total . . 11%

Ash 10

Sulphur 2.6

On 12-16 mesh-Percent. of Total . . 7%

Ash 7.6

Sulphur 3.2

On 16-20 mesh- Percent. of Total . . 3.2%

Ash 6.0

Sulphur 3.5

On 20-30 mesh -	Percent. of Total . . .	4.2%
	Ash	35
	Sulphur	4.68
Under 30 mesh -	Percent. of Total . .	8.6%
	Ash	18.1
	Sulphur	5.3

This shows that the pyrite and slate break generally finer than the coal and that a method of simply screening out the fines would very much improve this slack.

The next step was to try several "float and sink" tests as described elsewhere in this paper. The solution used was zinc chloride in a 5" x 12" anatomical jar, a weighed sample of the coal was placed therein and allowed to stand a few hours, the float was then carefully skimmed off, and the sink collected by filtration; both were washed with slightly acidulated water to free them from the solution, dried and weighed.

Sp. Gr. of solution 1.433.

Percent. of sink . . .20%

Percent. of Float. . 80%

Analysis of Float.

Ash . . . . [illegible].8%

Sulphur 1.3%

Analysis of Sink.

Ash 43.2%

Sulphur 5.63%

Sp. Gr. of Solution . . .1.34.

Percent. of Sink . . 32%

Percent. of Float . 68%

Analysis of Sink.

Ash 31.2%

Sulphur 4.8%

Analysis of Float.

Ash 7.1%

Sulphur 1.12%

This shows that in order to get a thoroughly good product from this coal, a large amount of discard must be made and unless this discard could be used under the plant boilers it is doubtful if it would be profitable to wash.

A small sample (about 20#) was run on the small Vezin Jig (Cut No. 7).

21% of the total was drawn off as bed and hutch product, only the clean coal however was analyzed.

Analysis of Clean Coal.

Sulphur	2.21%
Ash	8.40%

The small jig was run at 75 R.P.M. with a 5/16 inch stroke, using a 20-mesh screen.

This result corresponds well to the float and sink test, about 0.9% more sulphur being shown, probably due to fines washed over by the pulsating current.

Then 20# of feed was put over the two cell Hartz Jig (Cut 7) in the ore dressing laboratory, on the first bed about 1 inch of Galena was placed on the sieve, making in effect a feldspar jig. Quite a few slimes were carried over the tail board and but little hutch was obtained.

Percentage of Clean Coal.	60%
Percentage of Beds	35%
Percentage of Hutch	02%
Percentage Losses	03%

Analysis of Clean Coal.

Ash	8.00%
Sulphur	2.38%

245# of feed were put over the same jig as before using a coal bed, but few slimes seemed to come over and considerable hutch was made.

Clean Coal	74%
First bed	8%
Second bed	8%
Hutch	7.5%
Losses	2.5%

Analysis of Coal.

Ash	6.5%
Sulphur	1.89%

These are by far the best results obtained and indicate that the coal can be much improved by jigging in fairly coarse sizes up to 1 inch over two compartment jigs, The difference in specific gravity between the coal and impurities is considerable and sizing below 3/4 or 1 inch is necessary.

An attempt was made to run some coal on the "Dunham" table in the ore dressing laboratory, but no separation at all could be made, it seems that sizing would be absolutely necessary in this case, also a table with a gentler stroke and riffles with wider spacing would be advantageous.

Calorific determinations were made on the original coal and on the coals cleaned in the various ways. An "Emerson" Fuel Calorimeter was used in these determinations.

Original Coal . . . . 12,600 B.T.U.

Clean Coal from Vezin Jig . . . . 12,696 B.T.U.

Clean Coal from Hartz Jig . . (Feldspar Bed) . . 12,690 B.T.U.

Clean Coal from Hartz Jig (Coal Bed) . . . . 12,900.

WASHERY CONTROL AND PRELIMINARY TESTS.

No standard systems of control or testing have been devised; the 'Float and Sink' test is the usual preliminary and is most favored for control. It consists of separating the coal and bone by means of solutions of high specific gravity, $CaCl_2$ and ZnCl being the salts ordinarily used.

The maximum specific gravity obtainable with $CaCl_2$ is 1.43 which is not sufficient to separate some coals. With ZnCl, however, specific gravities of 2.00 may be obtained with cold solutions. Unfortunately neither of these solutions is cheap enough to permit its use as a separating medium on a commercial scale.

The apparatus may be simple or elaborate as conditions determine. The authors of this paper used a glass jar about 12" high and 5" diameter, and skimmed off the float with a wire-cloth skimmer. This method gives fair results but the separation is nevery very complete. Several machines for securing the quick and complete separation of the sink and float have been designed the most popular one of which is described in Mines and Minerals for 1909. - (July)

Preliminary tests are of two general kinds: (1) on coking coal where the size crushed to is fixed only by the consideration of securing the best and cleanest product and (2) Domestic or Steam coal propositions where the size is fixed by purely commercial considerations.

In the first case samples of coal crushed to 1 1/2 - 1 1/4 - 1 - 3/4 - 5/8 - 1/2 - 3/8 - 1/4 and 1/8 inches are usually taken and each size tested in about six solutions of varying specific gravity, the 'float' of each test being analized for Sulphur and Ash. On domestic coals as the size is fixed one set of six tests in the 'float and sink' solution is usually considered sufficient.

In control work tests in the specific gravity solution are made at stated intervals on both the washed coal and the refuse as well as on the raw coal. Some good coal is always lost in the refuse and the calculation of its percentage when its amount has been determined by the float and sink tests is a matter of much interest.

Some engineers calculate this loss in terms of percentage of Raw Coal, but it is brought out by Delamater* that the most correct method is to

*Mines & Minerals Feb 1902 .

calculate this loss as a percentage of the "good" coal in the raw coal as determined by a float and sink test, the specific gravity of the solution being exactly the same in each test, however. He gives the following formulae for calculating this percentage.

Let X = percent. of good coal lost in refuse.

b = " " raw " float (good coal)

i = " " refuse produced by the plant.

J = " " " Float, (good coal).

M = Ji = Percent. of float coal in the refuse in terms of Raw Coal.

Then $X = \frac{Ji}{b} = \frac{M}{b}$

The Float and Sink test is usually considered as 100% efficient, but such may not be the case. Chemical reactions between the coal constituents and the solution may take place, or soluble constituents may be leached from the coal. Thus it would seem that the time that the coal remained in the test bath was an important matter. It has been suggested that the coal acting on Zinc Chloride solution causes a precipitation of basic Zinc Chloride which increases the ash content.

Also a reaction between Zinc Chloride and Pyrite may take place whereby some Sulphur goes into solution, thus decreasing the actual amount of sulphur present and to some extent vitating the test.

Coal Age, Jan. 29, 1912, gives a description of a scheme for obtaining a curve showing the inevitable loss in washing a coal containing X% of ash. The apparatus for separating the coal and bone is a small special hand jig instead of the usual float and sink solution. The assumption on which the development of the curve is based is:

Y = yield of coal from washing operations.

X = ash content of washed coal.

the Y = f(x).

A method of washery control by the analysis of the ash has been proposed, but the concensus of opinion is that it is too costly and lacks flexibility. (see E. & M.J., Aug. 29, 1908).

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New Century.

Differential Motion Jig.

Plate - 1 -

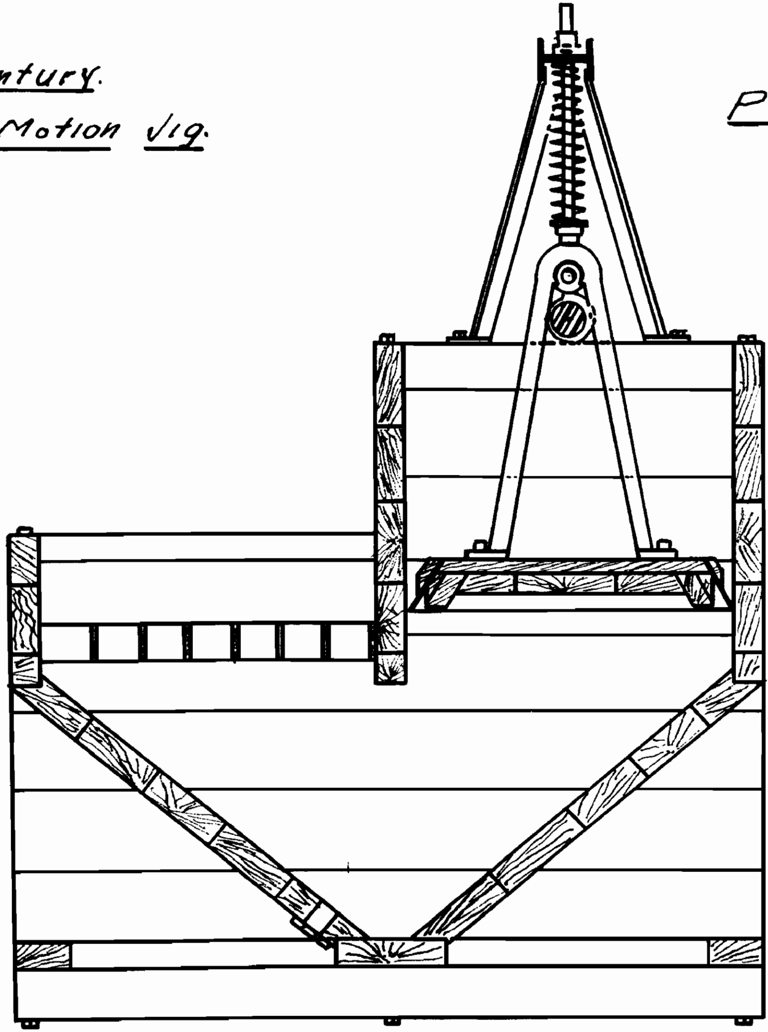
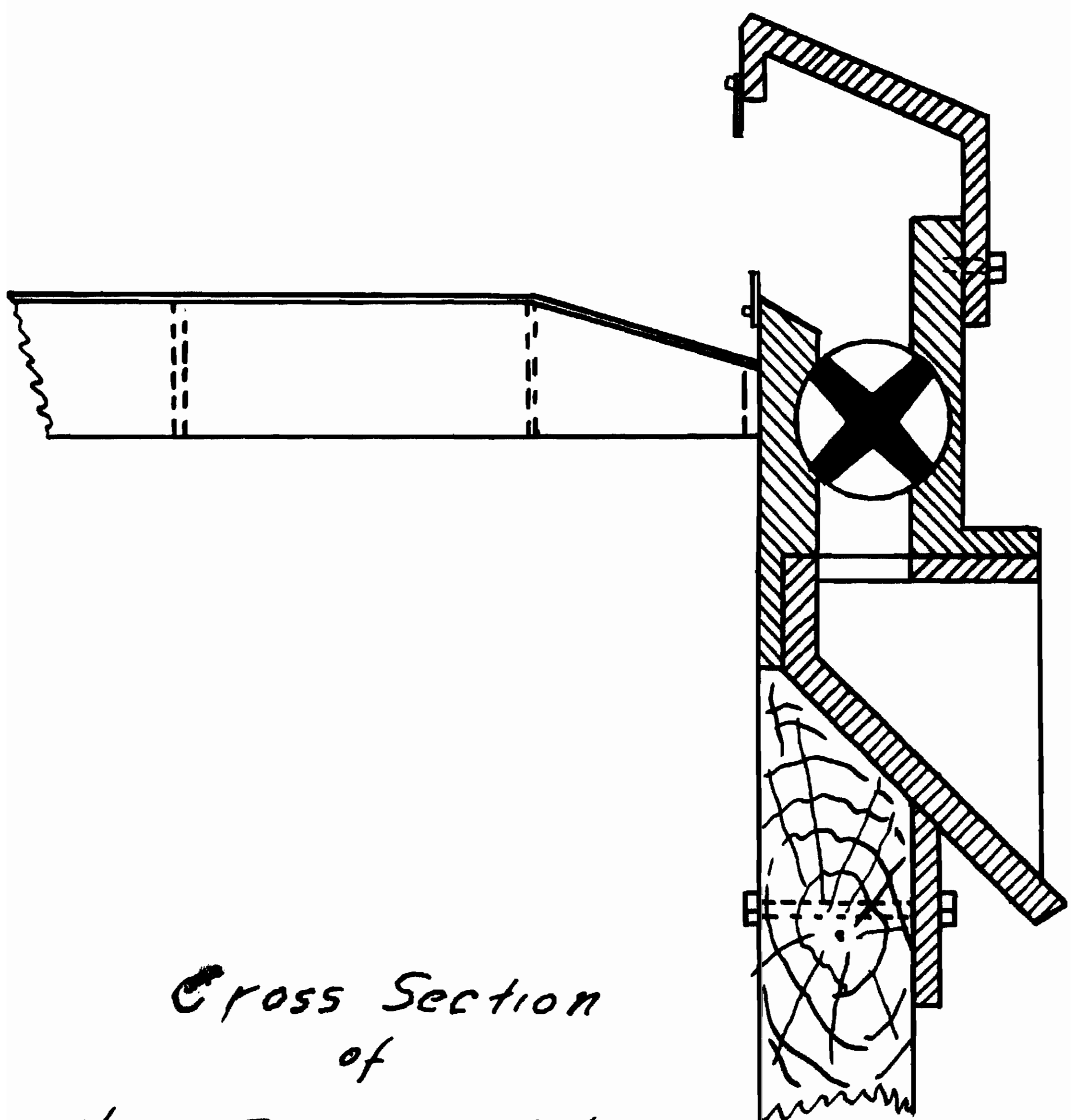
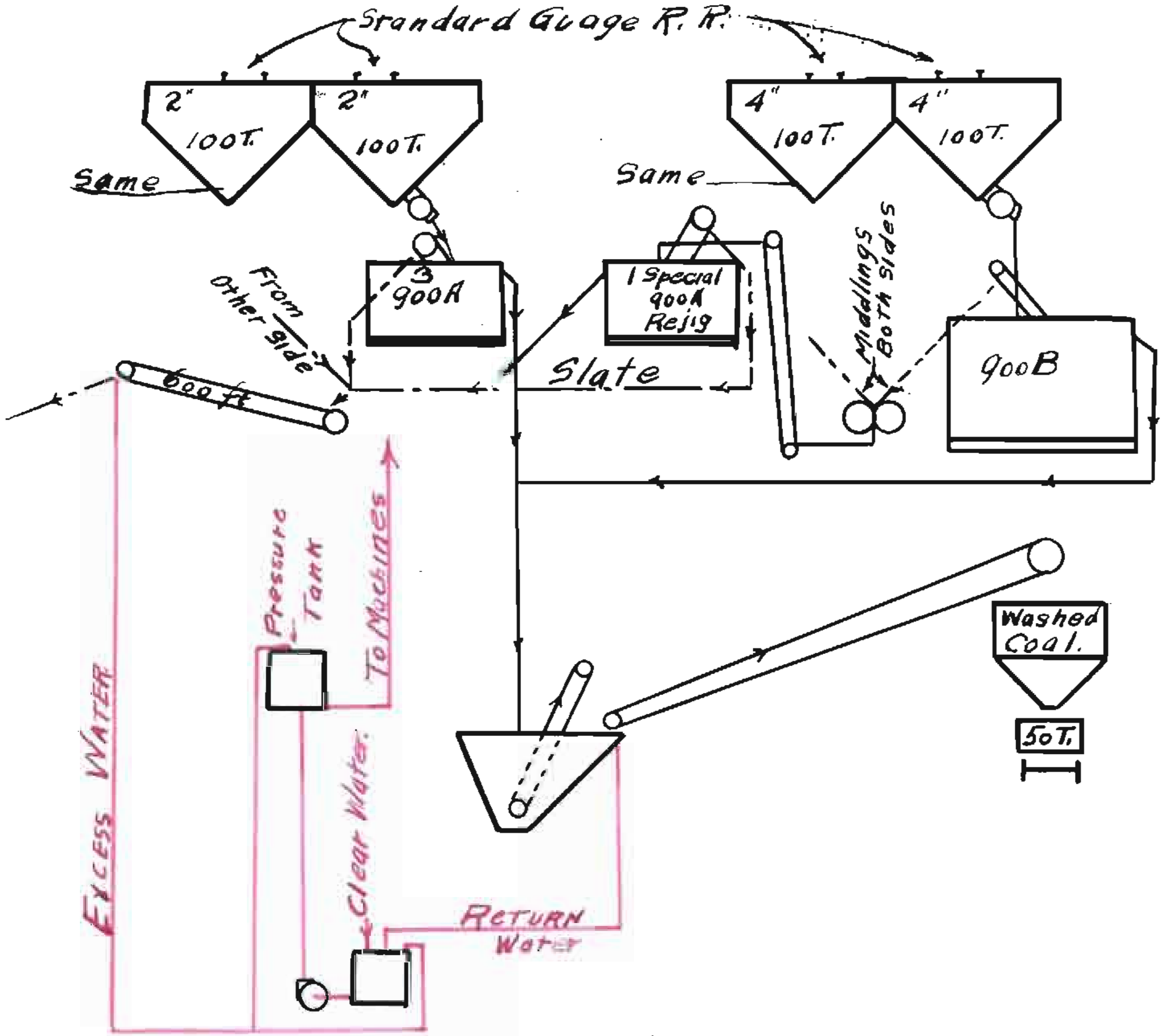


Plate. - No 2 -



Cross Section
of
New Century Valve

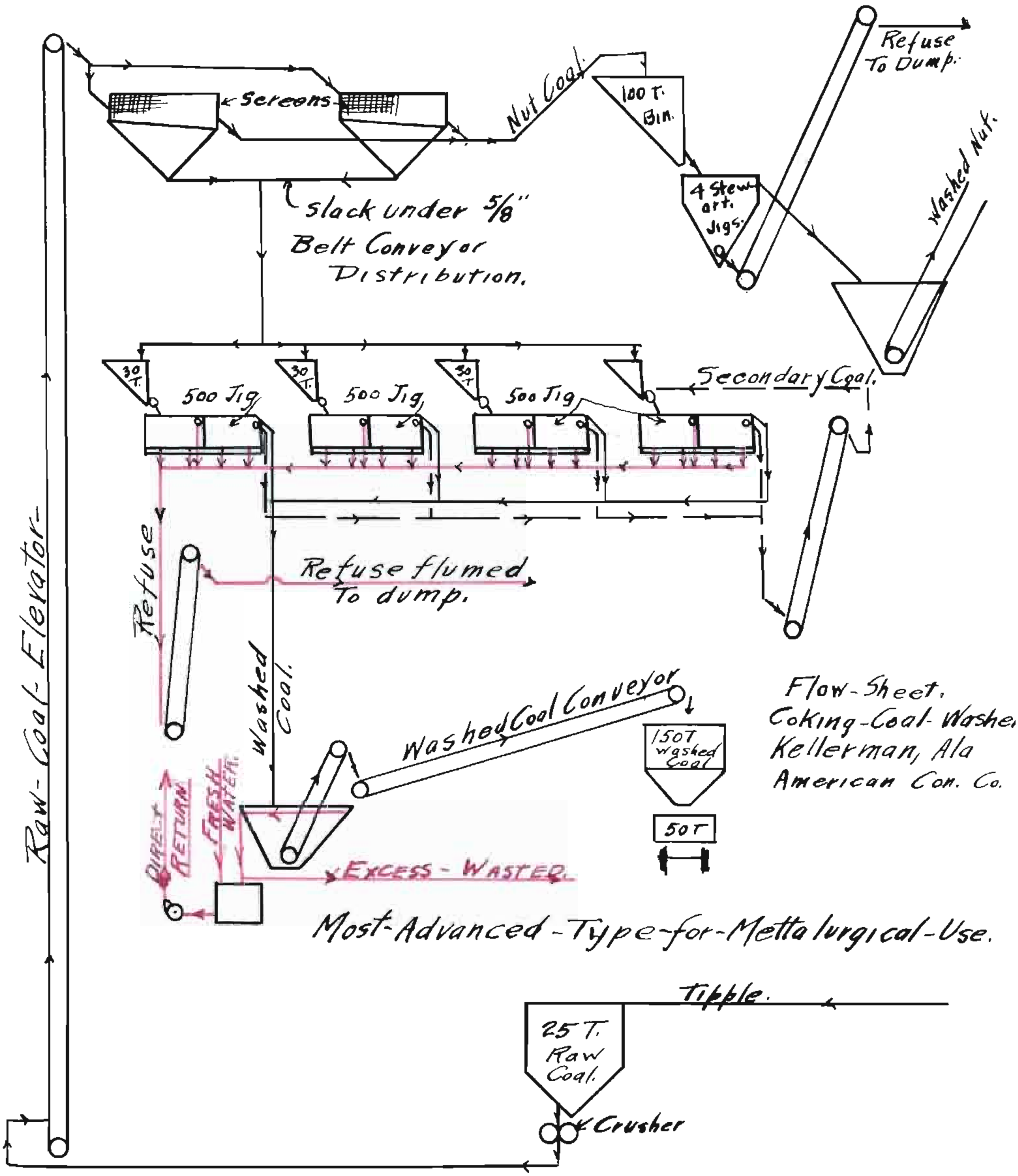
Plate No 3.



- Flow Sheet. -
Acmar Washer

Treatment-both-Sides-Identical-Capy 250T. hourly
-Most-advanced-type-for-Ordinary-Fuel.
American Concentrator Co.

Plate No 4.



Screens
Nut Coal
100 T. Bin.
Refuse To Dump.
4 Stewart Jigs.
Washed Nut.
slack under 5/8"
Belt Conveyor Distribution.
30 T.
30 T.
30 T.
500 Jig
500 Jig
500 Jig
Secondary Coal.
Refuse
Refuse flumed To dump.
Washed Coal.
Washed Coal Conveyor
150 T washed Coal
50 T
Flow-Sheet.
Coking-Coal-Washe
Kellerman, Ala
American Con. Co.
DIRECT RETURN
FRESH WATER
EXCESS - WASTED.
Most-Advanced-Type-for-Mettalurgical-Use.
Raw-Coal-Elevator-
Tipple.
25 T. Raw Coal.
Crusher

Plate 5.

Movable sieve of the "Pittsburg" Jig.

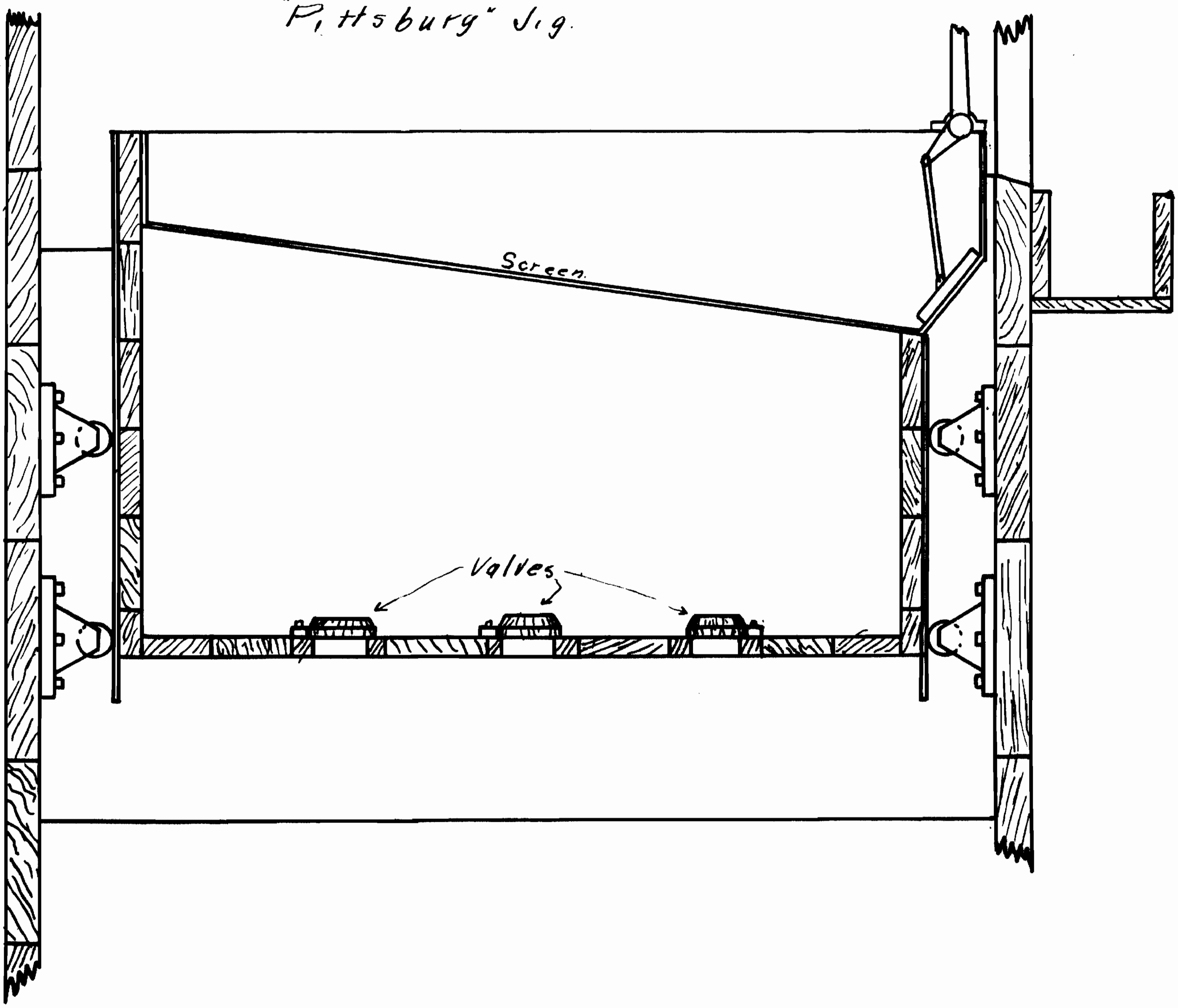


Plate 6.

The Stewart Jig.

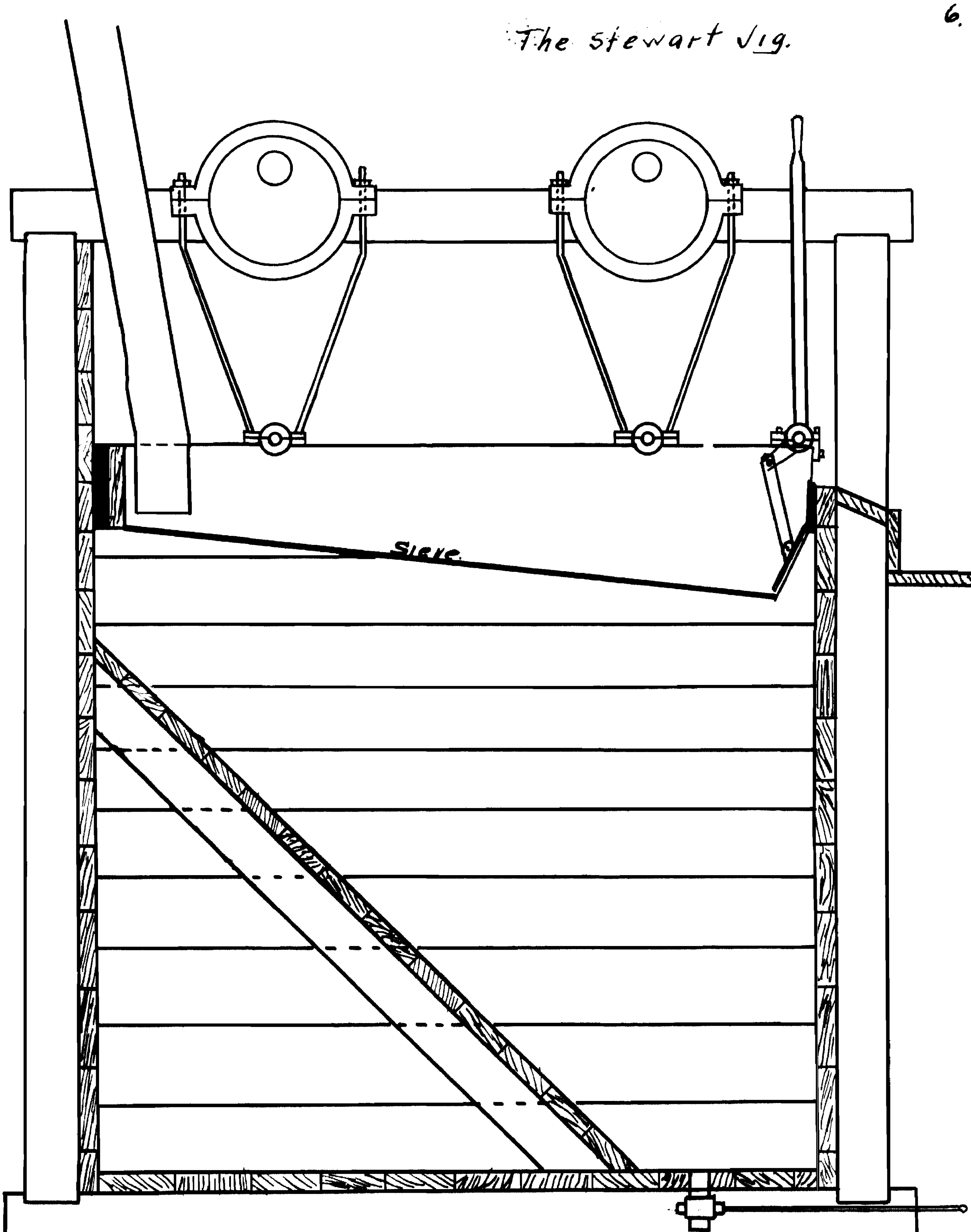


PLATE No 7

Flow Sheet
of
The Dorstfeld Coal Washery
(Schüchtermann & Kremer System)

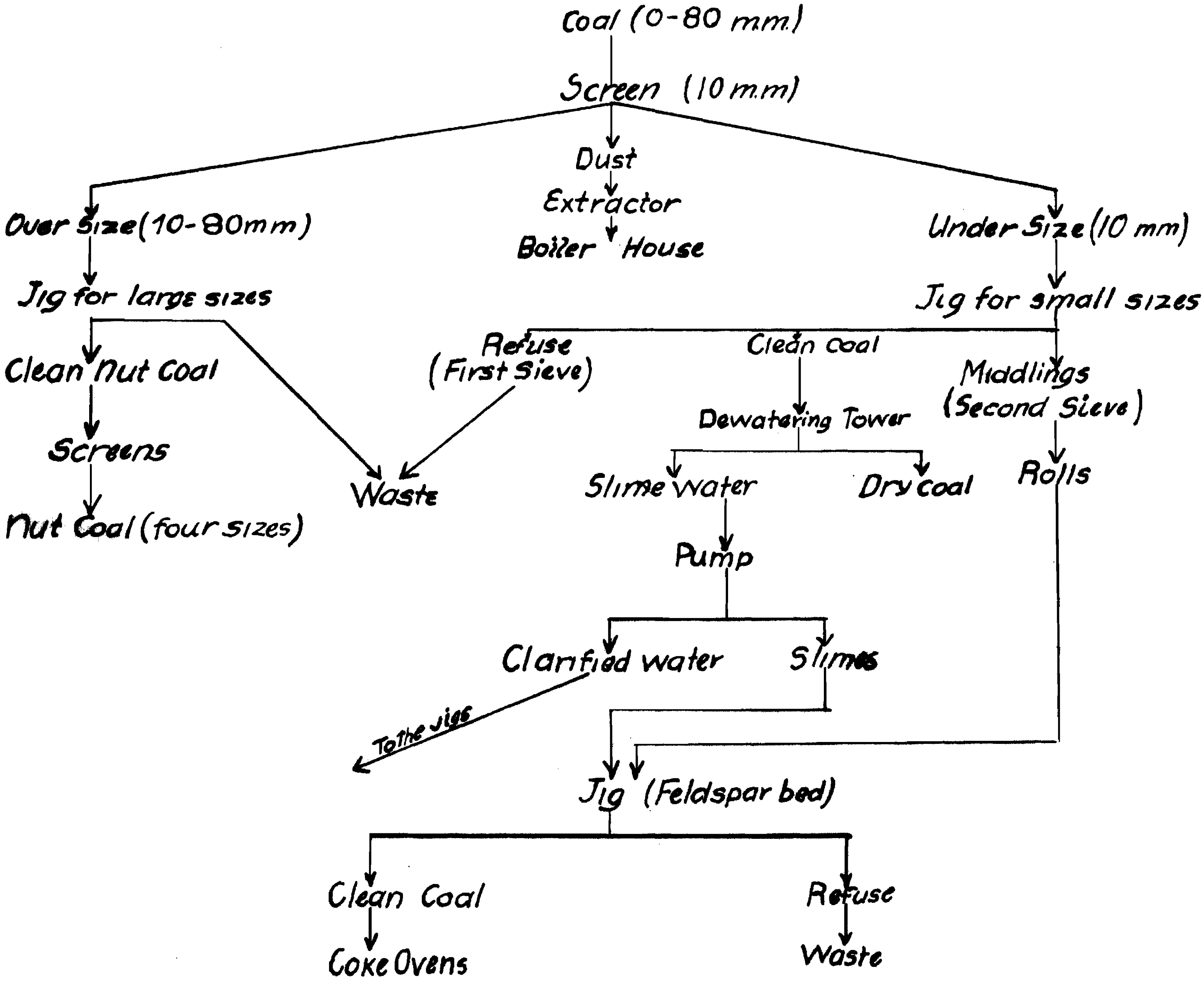
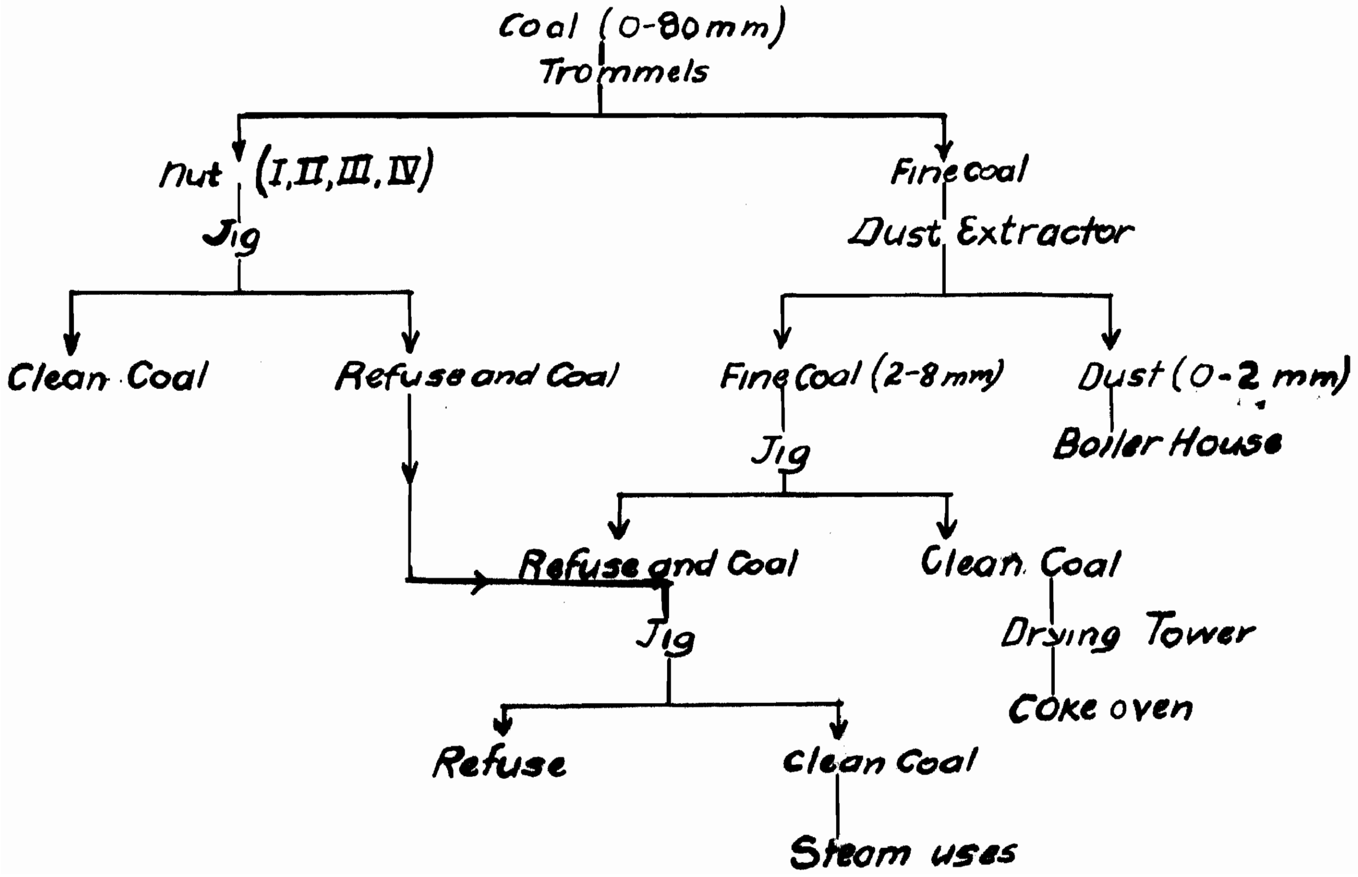


PLATE No 8

Flow Sheet
of
The Dahbush Washery
(Humboldt System)



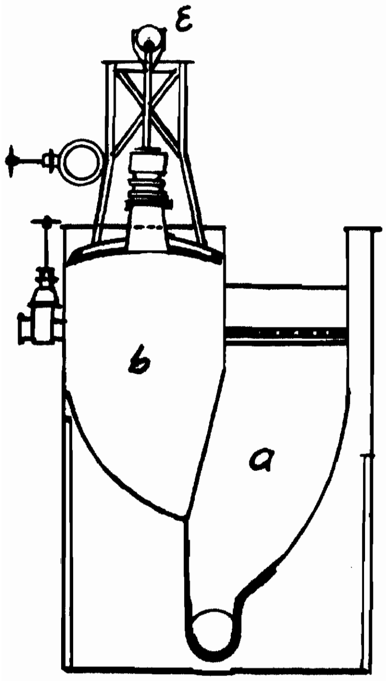


Fig 1

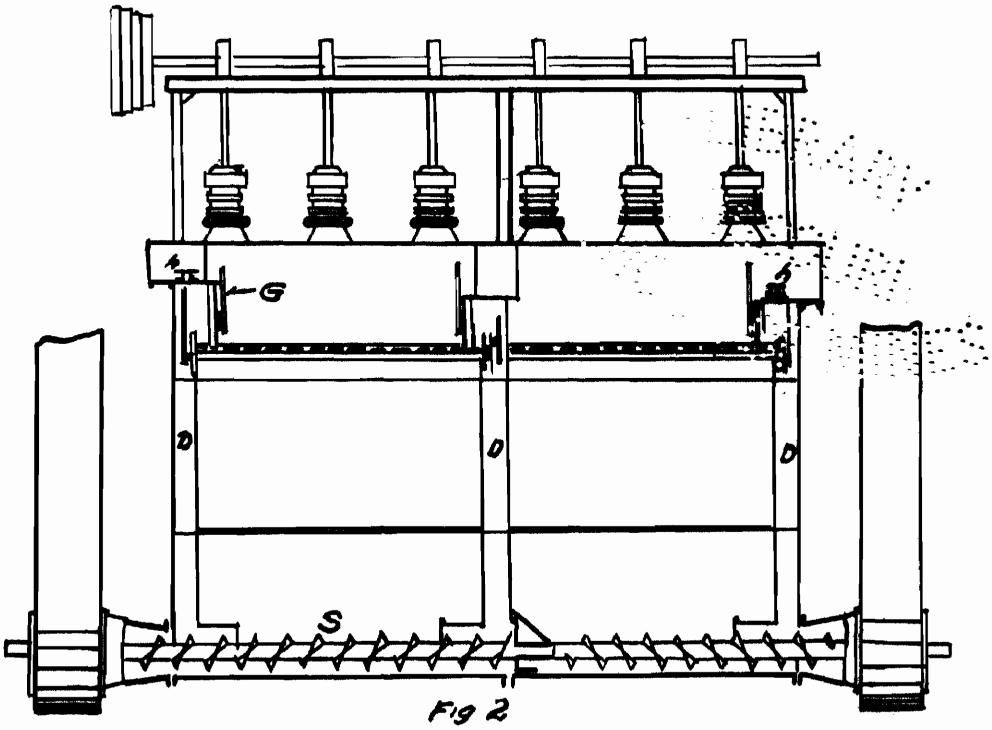


Fig 2

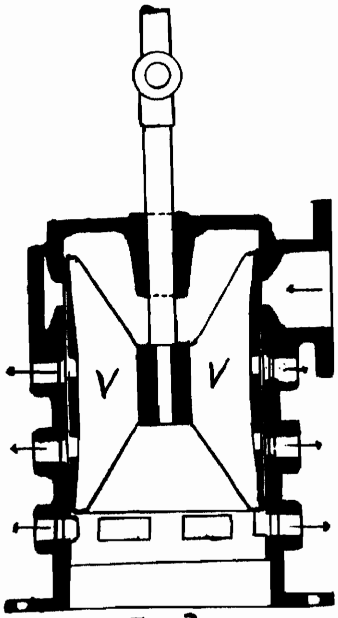
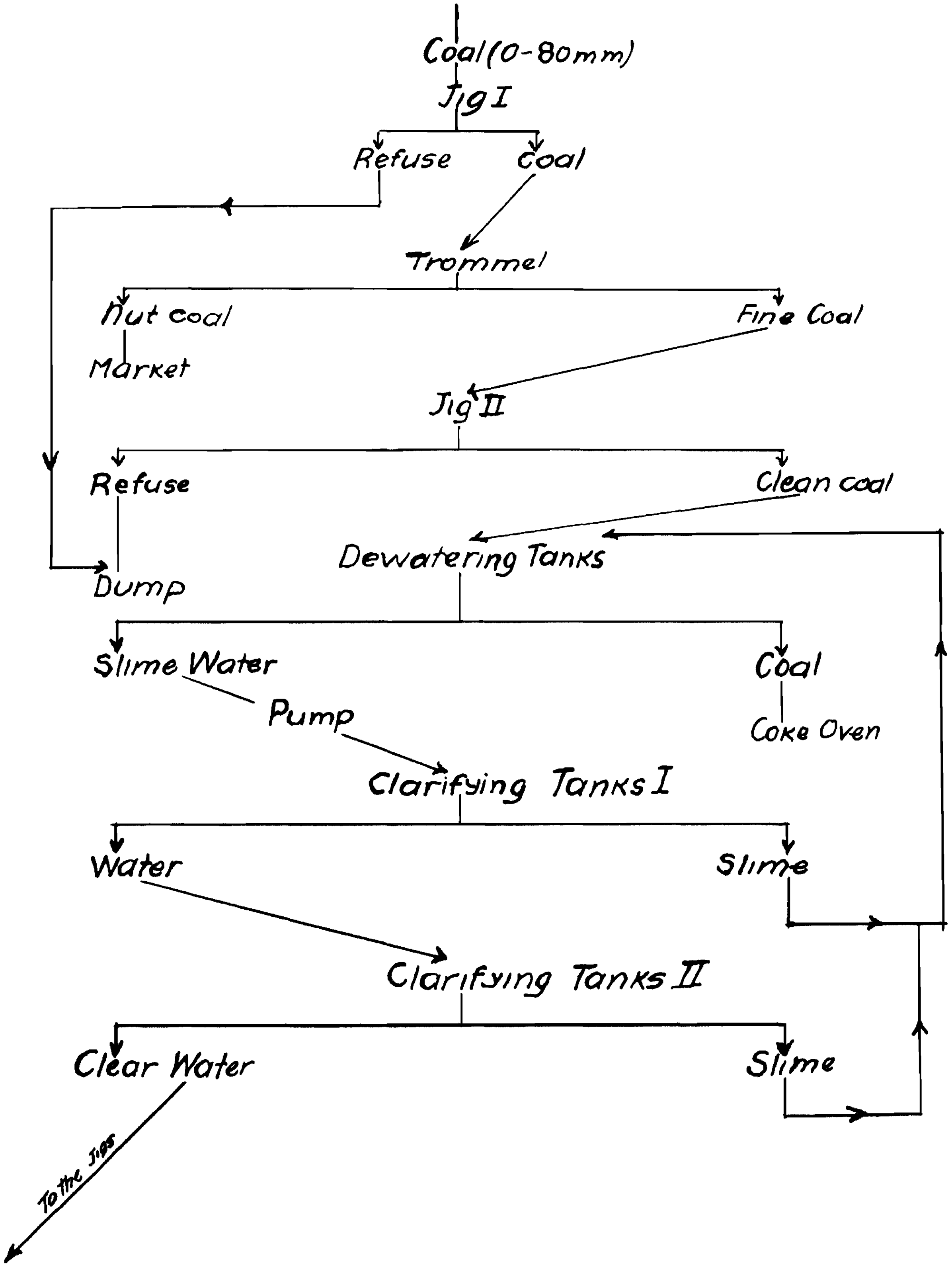


Fig 3

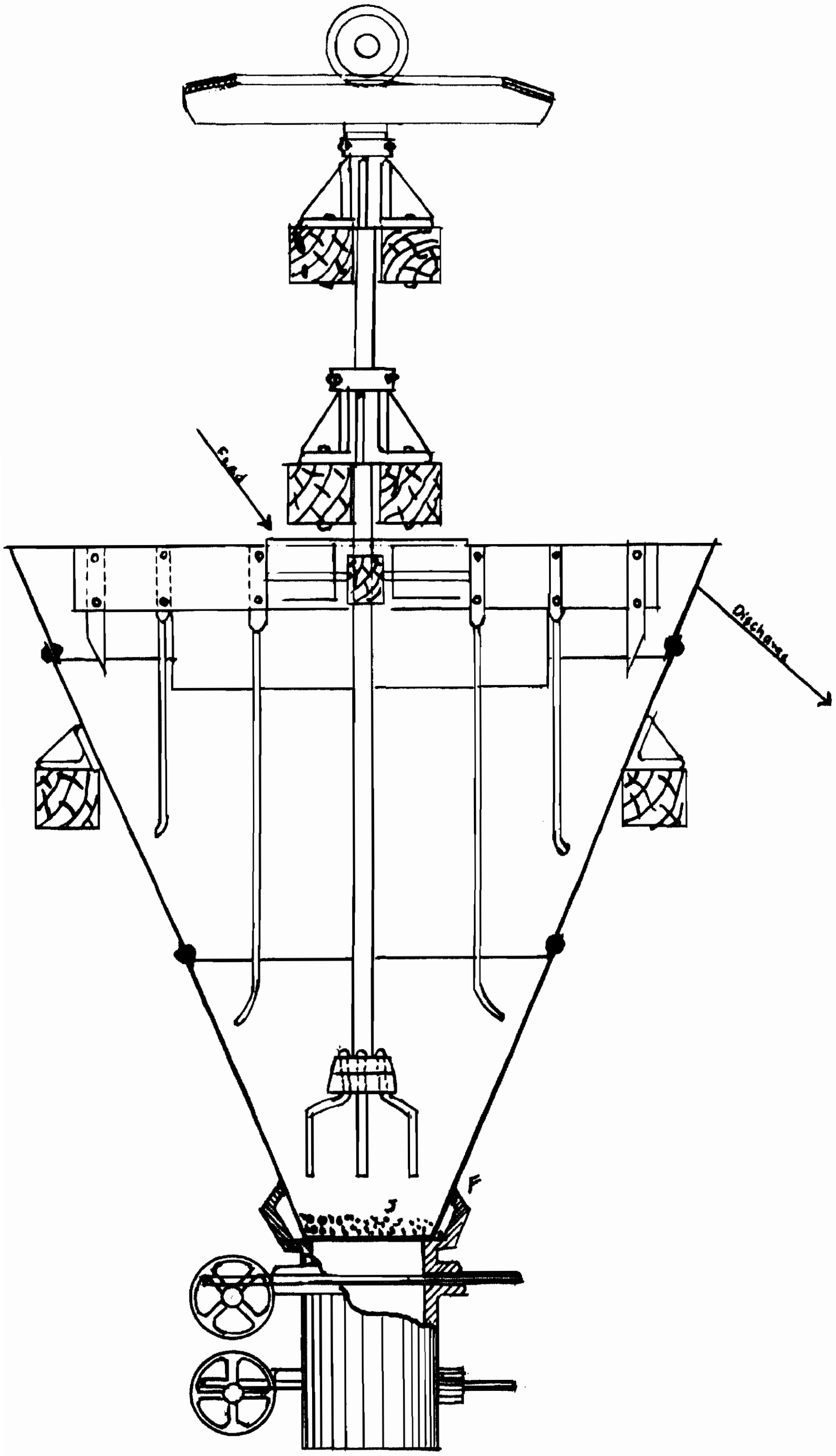
"Baum" Pneumatic Coal Jig

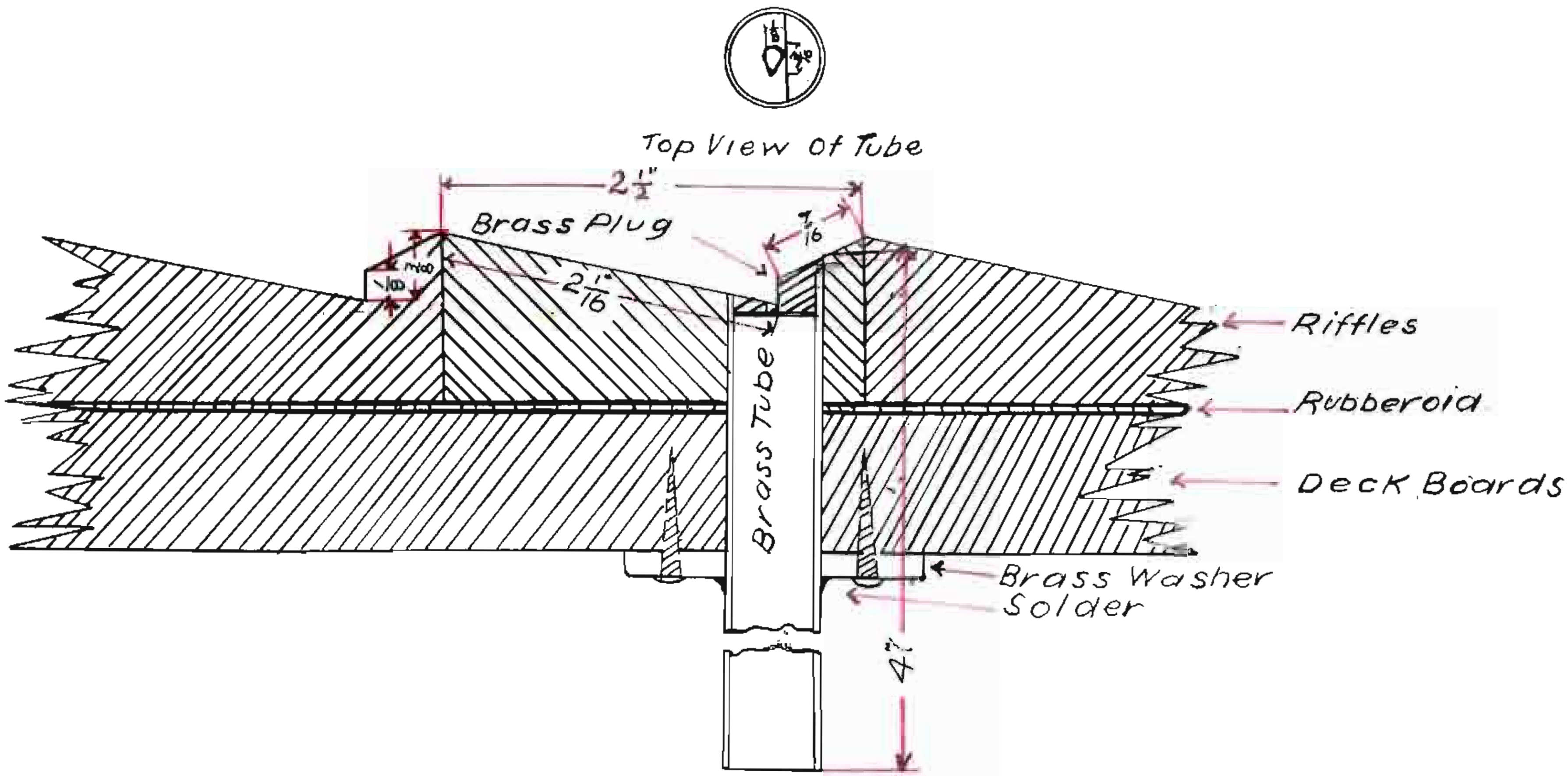
PLATE No 10

Flow Sheet of The Grimberg-Monopol Washery (Baum System)



The Jeffrey-Robinson Washer





Cross-section Of Riffles
of the New Century
Rougher Concentrating Table
full size

PLATE 12