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FUEL RESEARCH INSTITUTE

OF SOUTH AFRICA.

ONDERWERP:
SUBJECT: THE BREAKAGE OF SOUTH AFRICAN COAL DURING PREPARATION, HAULAGE AND SHIPPING.

AFDELING:
DIVISION: CHEMISTRY.

NAAM VAN AMPTENAAR:
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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

REPORT NO. 9/1945.

THE BREAKAGE OF SOUTH AFRICAN COAL DURING PREPARATION, HAULAGE AND SHIPPING.

INTRODUCTION.

Many experiments designed to determine the friability of South African coals have been carried out at the Institute and the results of some of these have been published. The experiments comprise a comprehensive series of shatter tests in a standard coke shatter test apparatus,(1) a series of trommel tests in a standard cochrane coke drum (2) and a series of grindability tests using the standard A.S.T.M. Ball mill method, (3) on all South African coals. Work published by the Fuel Research Institute (4) shows that the relative friability or the relative ease of disintegration of a coal, can be measured by its +1" shatter index. Those coals giving high +1" shatter indices are hard coals while those with low indices are friable coals. Table 1 gives the +1" shatter indices for a number of South African coals.

TABLE 1

+1" SHATTER INDICES.

Colliery	Coalfield	+1" Shatter index
(1) Witbank South	Witbank	93.9
(2) Tweefontein	Witbank	93.7
(3) T. & D.B.	Witbank	93.3
(4) Black Diamond	Ermelo - Breyten	93.1
(5) Coronation	Witbank	93.1
(6) Schoongezicht	Witbank	92.9
(7) Middelburg Steam	Witbank	92.8
(8) Douglas	Witbank	92.7
(9) Union	Ermelo - Breyten	92.6
(10) Landau	Witbank	91.9
(11) Consolidated	Ermelo - Breyten	91.7
(12) Durban Navigation	Natal	89.3
(13) Hlobane	Natal	86.1
(14) Natal Navigation (Northfield)	Natal	84.6
(15) Natal Cambrian	Natal	83.6
(16) Enyati	Natal	82.9
(17) Burnside	Natal	80.4
(18) Vryheid Coronation	Natal	70.2

(1) British Standard Specification No. 1016 of 1942 p.p. 81-83
(2) British Standard Specification No. 1016 of 1942 p.p. 83-84
(3) Am. Soc. Testing Materials Designation D408-37T. 1942 ed. Part III p. 865
(4) J. Chem. Mett. and Min. Soc. of S.A. Vol. 37 (1937) p.469

Table 1 shows that without exception, the Natal coals are all softer than the Transvaal coals.

The soft nature of the Natal coals has, of course, been realised by the collieries and efforts have been and are being made to reduce breakage owing to the complaints by consumers that the shipment coal supplied contains an excessive amount of fines. These complaints have extended over a considerable period of years and an investigation into the matter was carried out by the Natal Coal Grading Committee as far back as 1930.

Some of the breakage has been attributed to bumping and shaking of the trucks of coal during shunting and hauling after leaving the colliery, but in the case of bunker and export coal the major cause has been attributed to the appliances used for loading the ships at the Bluff, Durban.

SUMMARY OF INVESTIGATIONS ON THE BREAKAGE OF SHIPMENT COAL.

(a) Experiments by Natal Coal Grading Committee.

During 1930 a series of experiments was carried out by officials of the Natal Coal Grading Committee to demonstrate that the coaling appliances at the Bluff caused an excessive amount of breakage and that one of the methods employed was preferable to the other. Although a great deal of work was carried out and some valuable information was obtained, the results are, on the whole, unsatisfactory, mainly owing to the small size of the samples taken.

(b) Experiments by the Fuel Research Institute.

During 1931 to 1941 no large scale experiments were carried out although a great deal of academic work in the laboratory was done. In 1941 however, practical investigations were started on the initiative of the Institute. The number of cases of spontaneous combustion on board ship had increased considerably. It was felt that the breakage of the coal might have been partly responsible.

An example of the state of affairs was provided by the investigation of a case of spontaneous combustion which had occurred in a cargo of coal on board the S.S. Nurtureton. Grab samples of coal taken from the holds showed very large percentages of fines. The breakage caused by the various systems of loading employed at the Bluff was therefore determined, and by the use of large samples, excellent results were obtained. At the same time the percentage of fines in trucks of coal arriving at the Bluff was determined in order to find the percentage produced during loading at the collieries. A series of experiments was also carried out to determine the breakage that occurs in transit during a normal journey from the collieries to the Bluff. Subsequently further tests were conducted to determine the breakage occurring at all intermediate stages during loading by the Bluff belt plant. Other tests carried out were designed to determine the relative breakage caused when nut coal, round coal and mixtures of nut and round coal were dropped under similar conditions. The effect of the height of the drop and the number of drops on the breakage of coal was also determined.

DESCRIPTION OF THE BLUFF COAL LOADING AND STORING APPLIANCES.

In view of the importance of the Bluff coal loading appliances in these investigations, it is necessary to give a brief description of them at this stage. The different methods of loading and storage used are shown diagramatically in Figures 1-6 (see back of report)

(a) Belt system of loading

Figure 1 depicts the path of coal loaded by means of the conveyor belt system. Each truck of coal is lifted by the Dumper (Dumper No. 2) and tilted over so that all the coal falls into an apron from which it slides down onto the feeder belt. From the feeder belt, the coal makes a right angled turn onto the inclined belt from which it passes to the main horizontal belt. It then makes another right angled turn on to the telescopic belt from which it drops into the ship. A funnel shaped chute is sometimes used at the end of the telescopic belt to direct the coal into the ship.

Each transfer from one belt to another entails a drop, as indicated, through a steel chute, at which points considerable impacting of coal against the sides occurs. The wide limits given for the height of the drop from the telescopic belt to the ship are due to three causes: (1) variation in shape and size of ships, (2) Difference between empty and partially filled bunkers or holds (3) Variations of tide (about 8 feet). Apart from the original tipping from the truck, and 30 ft. apron slide, the overall collective maximum fall suffered by the coal during belt loading is estimated at 86 feet and the minimum at 27 feet.

(b) Bucket system of loading

Figure 2 shows the slower bucket system of loading. Two separate dumpers (Dumper No. 1 being of old design and Dumper No. 3 which is of modern design and recently erected) are used for truck tipping from both of which the coal slides through six chutes to fall into an equal number of buckets below. The buckets, each holding approximately 6 tons of coal, are then swung singly over the ship's bunker or hold by means of a transporter and the contents released through the underneath sides. The final fall into the ship varies in practice as does that from the belt and for similar reasons, but actually it is possible here to reduce the drop to a minimum by careful operation of the transporter. Figure 2 shows the total fall limits for the bucket system to be 8 feet and 70 feet.

(c) Systems of storage and subsequent loading.

Although the greater part of Natal export coal is shipped directly from trucks, varying amounts which arrive in excess of requirements are from time to time stored either in steel bins or on the floor of concrete stacks. When needed, the coal is again transferred to trucks which are tipped at the appropriate dumper and shipped as previously described. The path of the coal through the four possible combinations of storage and subsequent loading are shown in figures 3 to 6 which are self-explanatory.

Coal intended for the bins proceeds normally from the belt dumper to the main belt, but is there tripped at right angles onto two successive subsidiary ones, off which it falls into the bin (Figs. 3 and 4). The drop from the bin feeder belt varies from 5 to 30 feet depending on the volume of coal already inside the bin. When required for shipment, the coal is released through the bottom doors of the bin into a truck, the distance from the doors to the truck floor being 12 feet. The coal is then shipped by either belt or bucket method.

Coal intended for stacking is tipped into buckets at No. 1 or No. 3 dumper and dropped by the transporter into the stacks. The drop may vary between 0 feet to 25 feet depending on the operator. 25 feet can be taken as usual practice. Subsequent transference to trucks is more complicated than in the case of the bins and two alternative methods are used: (a) A grab picks up the coal and its jaws on closing can exert a crushing effect on any lumps of coal caught between them. The grab empties its charge into a funnel suspended above a truck. The fall from the grab to the truck floor is 22 feet. (b) The coal is picked up from the stack with a mechanical shovel and dropped directly into a truck. The coal is then loaded from the trucks into a ship via the belt or bucket systems (Figs. 5 and 6).

EXPERIMENTS BY THE FUEL RESEARCH INSTITUTE.

Sampling and screening.

In view of the difficulties experienced in previous experiments due to inaccurate samples, it was decided that in these tests, the minimum weight for all samples would be 5 tons and they were in many cases considerably larger than this.

Samples from trucks were taken by opening the side doors and gradually taking out a cross section of uniform width. The samples were screened through square mesh screens of 4" and $1\frac{1}{2}$" aperture by hand placing, and through square mesh screens of $\frac{3}{4}$" $\frac{1}{2}$" and 3/8" aperture by shaking. The agreement between preliminary duplicate determinations was very close.

(1) Breakage occurring during transit from the collieries to the Bluff.

At each of the four collieries a large (40-50 tons) and a small truck (10-20 tons) were filled normally with round coal, in the presence of an officer of the Institute who satisfied himself that the trucks were loaded as evenly as possible. A sample, having a minimum weight of 5 tons, was then taken from one end of each truck and screened. After screening, the coal was returned to the truck which was then covered by tarpaulins and sent off on a normal journey to the Bluff. On arrival there, another sample was taken from the other end of the truck and screened.

Table 2 gives the screen analyses obtained. The percentage decrease in the on $\frac{3}{4}$" and on $\frac{1}{2}$" sizes are given in the last two lines of the table.

The screen analyses are not entirely satisfactory and in many cases there is actually an apparent increase in the percentage on $\frac{3}{4}$" and on $\frac{1}{2}$" material after transit to the Bluff. In all but one case (40 ton truck of Vryheid Coronation coal) the discrepancies are not large and may well be within the experimental error. Segregation of the coal during loading at the collieries may also tend to cause anomalies.

The results indicate however, that there is very little -$\frac{3}{4}$"

TABLE 2.

SCREEN ANALYSES OF COALS AT COLLIERY AND AFTER TRANSIT TO BLUFF.

Colliery		Durban Navigation				Natal Navigation (Northfield)				Burnside				Vryheid Coronation			
Weight of truck tons		46		17		45		18		48		11		40		11	
Place screened		Coll	Bluff	Coll	Bluff	Coll	Bluff	Coll	Bluff	Coll	Bluff	Coll	Bluff	Coll	Bluff	Coll	Bluff
Screen analysis	On 4"%	22	12	34	24	51	22	43	25	31	23	33	17	25	10	15	19
	on $1\frac{1}{2}$"%	75	60	81	83	75	78	83	87	72	65	69	67	59	51	61	55
	on $\frac{3}{4}$"%	92	93	92	93	92	91	93	94	90	83	87	87	80	81	85	79
	on $\frac{1}{2}$"%	96	96	94	96	95	94	95	97	94	89	91	92	85	89	90	88
	on $\frac{3}{8}$"%	97	97	96	97	96	96	96	97	95	92	93	94	89	92	92	91
	through $\frac{3}{8}$"%	3	3	4	3	4	4	4	3	5	8	7	6	11	8	8	9
% decrease in $+\frac{3}{4}$" size		-	-1.1	-	-1.1	-	1.1	-	-1.1	-	7.8	-	0	-	-1.2	-	7.1
% decrease in $+\frac{1}{2}$" size		-	0	-	-2.1	-	1.1	-	-2.1	-	5.3	-	-1.1	-	-4.7	-	2.2

or $-\frac{1}{2}$" material produced during transit even with the two soft coals. There is, however, a substantial decrease in the percentage of +4" lumps, but most of this is reduced to $+1\frac{1}{2}$" size. These results agree with those reported in the literature (5). The effect of the size of the truck appears to be negligible.

(2) Percentage of fines in trucks arriving at the Bluff.

Table 3 gives the percentage $-\frac{3}{4}$" material found in trucks of round coal at the Bluff. These values were determined in order to obtain some idea of the variation from truck to truck. In determining these values, about one third of the contents of the trucks were screened.

TABLE 3.

PERCENTAGE $-\frac{3}{4}$" SIZE OF COALS AT THE BLUFF.

Colliery	% $-\frac{3}{4}$"
A	10.3, 6.0, 6.1, 4.8, 5.1
B	7.3,10.8,12.5, 8.9, 5.6, 7.8, 6.7
C	13.6,12.2,14.1,18.1,10.2,14.0,13.0
D	13.1,14.0,11.8,17.4,11.0
E	12.9, 8.7,12.3
F	9.8,15.5,15.3
G	9.4
H	46.8,23.3

In some cases screen analyses were carried out using $\frac{3}{4}$", $\frac{1}{2}$" and $\frac{3}{8}$" screens, in order to determine the distribution of the smaller sizes. The values obtained are given in Table 4.

TABLE 4.

SCREEN ANALYSES OF COALS AT THE BLUFF.

Screen Size	Colliery A		Colliery B		Colliery C	Colliery E	Colliery F
	(a)	(b)	(a)	(b)			
on $\frac{3}{4}$"%	94.0	93.4	94.4	91.1	86.4	87.1	90.2
on $\frac{1}{2}$"%	96.3	96.2	96.6	94.4	90.9	92.6	94.4
on $\frac{3}{8}$"%	97.2	97.2	97.3	95.7	-	-	-
through $\frac{3}{8}$"%	2.8	2.8	2.7	4.3	-	-	-

(5) "Coal Preparation" A.I.M.E. 1943 chapter 5.

(3) <u>Comparison of the breakage caused by the belt and bucket systems of loading and storage.</u>

The experiments carried out in this connection are similar to those performed by the Natal Coal Grading Committee, although their scope was considerably widened and greater efforts were made to avoid sampling difficulties.

(a) <u>Breakage caused by belt and bucket systems of loading.</u>

For testing the breakage produced by belt loading, four trucks of round coal, each representing the average quality of coal produced by the four collieries were selected and a 5 ton sample was taken from each. The screen analyses of these samples represented the size of the coal as received. The remainder of the coal was then put through the belt plant and dropped 37 feet from the telescopic belt into an empty truck. A 5 ton sample was taken from this truck to represent the coal after belt loading. The 37 feet drop represents a fair average one for the drop from the final belt into the ship's hold.

Two sets of samples were examined to test the effects of bucket loading: one after a drop from a bucket into an empty truck from 6 feet (a minimum working height) and the other after a drop of 35 feet, this figure representing the average working height in practice. 5 ton samples were taken before and after loading as with the belt system.

The results obtained are given in Table 5. The percentage decrease in the $+\frac{3}{4}$" and $+\frac{1}{2}$" sizes are given in the last two lines of the table. (Table 5 page 8).

A comparison of the methods of loading shows the bucket with a six feet drop to be clearly the most satisfactory. The decrease in the percentage $+\frac{3}{4}$" coal is approximately 10% and it does not appear to be governed by the friability of the coal. With the belt plant, the degradation in the $+\frac{3}{4}$" fraction is from 2 to 3 times greater than that produced by the bucket used with a 6 feet drop, and, except in the case of Durban Navigation Colliery, results in a coal definitely overloaded with $-\frac{3}{4}$" fines (32 to 41%). The decrease in the perdentage $+\frac{3}{4}$" size varies from 15 to 31%.

These analyses bear out the contention that the bucket when carefully handled, is less severe on coal than the belt.

When, however, the bucket with a 35 feet drop is considered, the extra fall is found to alter this conclusion. Breakage again assumes serious proportions and is equal to or greater than that for the belt. When the buckets are not operated with the maximum care, therefore, there is little to choose between the two systems of loading.

(b) <u>Breakage caused by systems of storage.</u>

Efforts were also made to measure the breakage produced by both methods of storage as distinct from the loading breakage. Accordingly 5 ton samples were transferred from the belt plant to a bin. As it was necessary that no other coal should be inside, each sample fell the maximum distance of 30 feet into the bin. The bottom doors were then opened and the sample allowed to fall into an empty truck, after which it was screened.

Other samples were stacked on a stack by means of the buckets, a drop of 25 feet being employed. The coal was then transferred via the grab and the funnel to an empty truck and screened.

The screen analyses of the four coals before and after storage in the bin or on the stack are given in Table 6. The percentage decrease in the $+\frac{3}{4}$" and $+\frac{1}{2}$" sizes are given in the last two lines of the table. (Table 6 see page 8.)

If the bin and stack methods of storing coal are compared, it will be seen that two coals suffered less relative breakage in the bin than on the stack, while the other two coals suffered more. The figures however, are not greatly divergent, and one system cannot be preferred to the other, both causing much breakage. In the most extreme case (Burnside), a coal containing anything up to 50% of fines ($-\frac{1}{2}$") results, while even the hardest coal is left with 26% of fines.

The above figures refer only to coal which has been stored and then put into trucks. It must be remembered that if it is to be shipped it still has to go through either of the two normal loading operations, and further breakage will therefore take place.

(4) <u>Comparison of the breakage caused by the three dumpers used at the Bluff.</u>

The following is a short description of the three dumpers used at the Bluff.

<u>No. 1 Dumper</u> has an apron which receives the coal tipped from a truck set at an angle of 60° to the horizontal. The length of the apron from top to bottom is approximately 15 feet. This dumper is used for filling buckets for the bucket plant and is therefore fitted with doors (six) at the bottom of the apron for discharging the coal. The fall from the apron into the buckets is approximately 8 feet.

<u>No. 2 Dumper</u> is part of the belt plant. The apron is in two sections each 15 feet in length from top to bottom, the upper one being at an angle of 60° and the lower 45° to the horizontal. The bottom of the apron tapers to a single opening through which the dumped coal feeds onto the feeder belt.

<u>No. 3 Dumper</u> which was completed during 1944, differs considerably in construction from the other two. The coal, on being tipped from the truck, falls a distance of approximately 8 feet onto the apex, a squat inverted V-shaped plate, from which it slides 6 feet and then drops 5 to 10 feet into a hopper. The coal is removed from the hopper by a further semi-circular container which "pours" the coal over its edge by a revolving action and drops it from a height of 8-10 feet into the buckets for loading by the bucket system.

In comparing the breakage caused by the three dumpers, three 10 ton trucks of a hard (Durban Navigation) and a soft (Burnside) coal were prepared by very carefully loading the trucks with coal forked from another truck. The prongs of the forks were $1\frac{1}{2}$" apart so that the small test trucks contained no fines. After cleaning the dumpers of all coal, one small truck from each colliery was then dumped at each dumper. In the case of No. 1 and No. 3 Dumpers, the coal was dropped into empty trucks, but the coal was loaded out of the apron into bags in the case of No. 2 dumper. All the coal dumped was recovered and screened, and the percentage of the coal passing through a $\frac{1}{2}$" screen determined. In the case of Durban Navigation coal, the percentage of $-1\frac{1}{2}$" was also determined.

The results obtained are given in Table 7.

TABLE 7

COMPARISON OF BREAKAGE AT DUMPERS.

Colliery	Durban Navigation			Burnside		
Dumper Number	No.1 dumper	No.2 dumper	No.3 dumper	No.1 dumper	No.2 dumper	No.3 dumper
% -1½" produced	31.8	24.5	32.1	-	-	-
% -½" produced	9.1	7.8	10.3	9.9	10.1	12.6

With Durban Navigation coal, the No.1 Dumper gives a greater amount of breakage than the No. 2 Dumper. In the case of the former, however, the coal dropped approximately 8 feet from the apron into a truck and this did not take place with the No. 2 dumper. There are no facilities for dropping the coal from No.2 dumper directly into a truck. With Burnside coal, there does not appear to be any appreciable difference in the breakage caused by the No.1 and No.2 dumpers.

The No.3 dumper caused slightly more breakage with both coals than was the case with the other two dumpers.

(5) Breakage occurring at intermediate points during loading by the belt system.

The tests carried out to determine the breakage occurring at various intermediate points on the belt loading system were done at the request of the South African Railways and Harbours Administration. Durban Navigation and Burnside coals were used and the method, described in the previous section, of preparing the coal so as to contain no fines was again employed.

The tests were carried out in the following manner:-

All parts of the plant including the dumper apron were thoroughly cleaned. The travelling tower and the main belt tripper were placed at a point 250 feet from the top of the inclined belt and the end of the telescopic belt was set at a height of 44 feet 8 inches above a barge at the quay-side. A 40 ton truck of previously prepared coal was then dumped at normal speed and the plant run normally until approximately 15 tons had been dropped onto the barge and some 7 tons were left in the dumper apron. At this stage, the plant was stopped and all the coal was carefully loaded into bags to give the following samples.

(a) The coal remaining in the dumper apron and on the feeder belt.

(b) the coal remaining on the inclined belt

(c) the coal remaining on the first 150 feet of the main belt

(d) the coal remaining on the remaining 100 feet of the main belt

(e) the coal remaining on the telescopic belt

(f) the coal remaining on the barge.

Each of these samples was screened to determine the percentage of $-\frac{1}{2}$" material.

The results of the tests are given in Table 8.

Due to practical difficulties in obtaining samples from the dumper apron, the values obtained at this point on the plant were unsatisfactory. The values obtained from the dumper tests described in the previous section have therefore been inserted in this table. For each coal, the increases in the percentage $-\frac{1}{2}$" at the various sampling points are also given.

TABLE 8

% $-\frac{1}{2}$" SIZE AT VARIOUS POINTS ON BELT PLANT.

Origin of sample	Durban Navigation				Burnside			
	% $-\frac{1}{2}$"		Increase in % $-\frac{1}{2}$"		% $-\frac{1}{2}$"		Increase in % $-\frac{1}{2}$"	
In truck	0		-		0		-	
on dumper & feeder belt	7.8		7.8		10.1		10.1	
on inclined belt	10.2		2.4		14.5		4.4	
on first 150 ft. of main belt	10.6	Av. 10.2		0.0	15.0	Av. 15.8		1.3
on remaining 100 ft. of main belt	9.8				16.6			
on telescopic belt	11.0		0.8		18.3		2.5	
on barge	16.5		5.5		27.8		9.5	

The figures show slight discrepancies as for example with Durban Navigation, the coal on the first 150 feet of main belt has a greater percentage of $-\frac{1}{2}$" size than the remaining 100 feet and with Burnside coal, the reverse is apparently the case. It is likely that no breakage takes place between these two points and that the anomalies are due to experimental error. It is also probable that some segregation has taken place during the discharge of the coal from the dumper apron in these tests. The result would be that the percentages of $-\frac{1}{2}$" coal found on the inclined belt and at subsequent stages would be less than would have been the case if no segregation had taken place.

It is clear that a large amount of breakage takes place at the dumper amounting to 7.8% in the case of Durban Navigation and 10.1% for Burnside coal. The transfer of the coal from the feeder to the inclined belt entailing a right angled turn and a drop of about 8 feet also causes an appreciable increase in the $-\frac{1}{2}$" content of the coal. The breakage caused by the drop from the inclined belt to the main belt is small (0 to 1.3%). The right angled turn at the tripper onto the telescopic belt causes an increase in the % $-\frac{1}{2}$" size varying from 0.8 to 2.5%. The final drop onto the barge causes, as would be expected, a considerable degradation in size.

The figures given in Table 8 show a larger production of $-\frac{1}{2}$" material than was found in previous experiments (see pages 7 - 9) in which the total breakage caused by the belt plant after a final drop of 37 feet was determined. Here the $-\frac{1}{2}$" material was not screened from the coal before the tests and the increase in percentage of this size after loading was 9.6 units for Durban Navigation coal and 18.2 units for Burnside coal. By calculating these figures back to 100% $+\frac{1}{2}$" coal, the increase in $-\frac{1}{2}$" size would be 9.9 units and 20.0 units respectively for Durban Navigation and Burnside coals. Apart from experimental errors, higher values given in Table 8 are probably due to two causes (a) the extra drop onto the barge of 7 feet 8 inches and (b) the cushioning effect of the fines present in the coal used for the previous experiments.

(6) <u>Percentage $-\frac{1}{2}$" material present in cargo coal aboard the S.S. Nurtureton.</u>

The S.S. Nurtureton loaded cargo coal at the Bluff, Durban during 3-6 March 1943. On the 28th April, while the ship was at Cape Town, it was observed that fires had broken out in some of the holds. The following coals were loaded into holds 1, 2 and 6.

Hold	Durban Nav. C.	Natal Nav. C.	Hlobane	Northern Natal Nav. Coll.	Total
	Tons	Tons	Tons	Tons	Tons
1	796	320	465	233	1,814
2	1,042	187	530	416	2,176
6	776	Nil	47	236	1,059

An investigation of this case of spontaneous combustion was made and the following is an extract of Report No. 6 of 1943.

"As it appeared that the coal contained rather a large percentage of fine material for a coal which was loaded under the description of round coal, grab samples were taken and screened through a screen with square apertures of $\frac{1}{2}$ side.

<u>Coal from No. 1 Hold</u>

Weight of grab sample	Percentage $-\frac{1}{2}$"
1277 lbs	48
1098 lbs	28
1164 lbs	31
1280 lbs	38.5

<u>Coal from No. 2 Hold</u>

Weight of grab sample	Percentage $-\frac{1}{2}$"
1331 lbs	25
1516 lbs	51
1408 lbs	38
1528 lbs	57

Weight of grab sample	Percentage $-\frac{1}{2}$"
Coal from No. 6 Hold	
1130 lbs	40
1401 lbs	35.7
1440 lbs	27
1587 lbs	35
1385 lbs	39

Each grab sample was taken by a single grab of a mechanical grab.

It appears from these screen analyses that the coal contains an excessive percentage of fine material."

(7) Relative breakage caused by dropping nut coal, round coal and mixtures of nut and round coal.

Although the round coal sent for shipment should strictly speaking be screened over a $1\frac{1}{4}$" screen at the collieries, nut coal, if there is an excess at the mine, is sometimes mixed with the round coal. It was considered possible that the amount of breakage produced when a truck of mixed coal is shipped would be greater than if the rounds and nuts were shipped separately, and experiments were carried out to test this contention.

The coal used for the experiments was carefully prepared by hand screening, the bulk sample being taken from a truck of Natal Navigation coal. The nut coal was $+\frac{1}{2}$ $-1\frac{1}{2}$" and the round coal $+1\frac{1}{2}$" in size. Samples weighing 380 lbs each were made of (1) 100% rounds, (2) 100% nuts, (3) 75% rounds +25% nuts, (4) 50% rounds + 50% nuts, (5) 25% rounds + 75% nuts, and these were dropped separately from a height of 30 feet onto a steel plate. After dropping a screen analysis of the coal was carried out. The results obtained are given in Table 9. (See page 14)

The $\frac{1}{2}$" screen analyses show that there is a small but definite decrease in the $-\frac{1}{2}$" material produced when rounds and nuts are dropped separately than is the case when mixtures of the two are dropped.

(8) Effect of number of drops and height of drop on breakage.

It has been stated (The Friability of South African Coal: Vogel and Quass, F.R.I. Bulletin No. 9 page 2.) that the amount of breakage produced by three drops of 6 feet is equivalent to the breakage produced by one drop of 54 feet. Experiments carried out by dropping the same coal three times from 10 feet and once from 30 feet do not appear to bear out this statement. The coals used were round ($+1\frac{1}{2}$") and nut ($+\frac{1}{2}$ $-1\frac{1}{2}$") coals carefully prepared by hand screening from trucks of Natal Navigation coal. In each case the coal (380 lbs) was dropped onto a steel plate from the appropriate height after which a screen analysis was carried out. The results obtained are given in Table 10. (See page 16) Two sets of results are given, the first were carried out on coal eight weeks old and the second on coal three weeks old.

It is clear that three drops of 10 feet do not produce more breakage than one drop of 30 feet. In general the breakage increases with the time after the coal has been mined.

TABLE 9.

BREAKAGE OF ROUND, NUT AND MIXED ROUND AND NUT COAL.

Screen Size	Round Coal	Nut Coal	75% Rounds +25% Nuts	50 Rounds +50 Nuts	25% Rounds +75% Nuts
through 1½"	37.6	-	56.4	59.9	82.9
through ½"	16.6	18.9	21.1	19.1	20.2
through ⅛"	6.9	4.8	7.7	6.7	6.7

TABLE 10.

EFFECT OF HEIGHT AND NUMBER OF DROPS ON BREAKAGE.

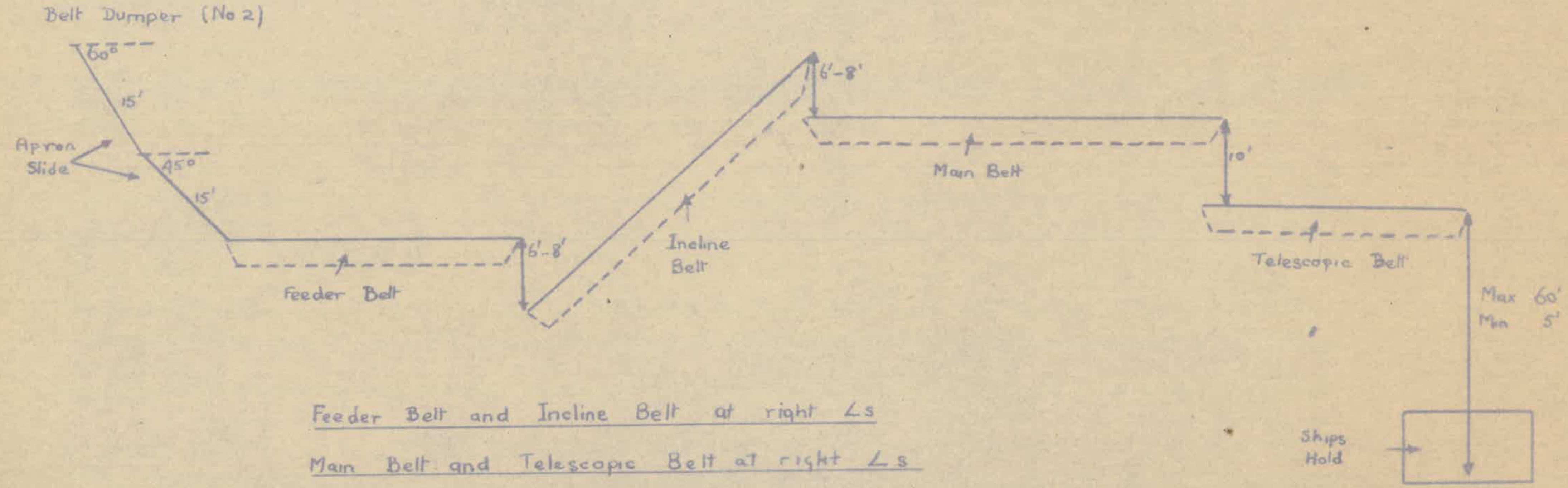
Screen Size	Coal 8 weeks old.				Coal 3 weeks old.			
	Rounds		Nuts		Rounds		Nuts	
	1 drop 30 ft	3 drops 10 ft	1 drop 30 ft	3 drops 10 ft	1 drop 30 ft	3 drops 10 ft	1 drop 30 ft	3 drops 10 ft
through $1\frac{1}{2}$"	37.6	30.4	-	-	43.6	30.7	-	-
through $\frac{1}{2}$"	16.6	15.8	18.9	15.2	14.1	11.1	11.9	10.5
through $\frac{1}{8}$"	6.9	7.5	4.8	4.0	5.3	4.0	4.2	3.6

Our sincerest thanks are due to the South African Railways and Harbours Administration and to the Natal Collieries for their co-operation and assistance in the carrying out of these tests. The experimental work was mainly carried out by Mr. le R. H. le Riche, Mr. S.D. Coetzee and Dr. G. Armstrong-Smith. We express our appreciation to these gentlemen for the care they have taken in carrying out these tests.

31st August, 1945.

BELT LOADING

Fig I



Feeder Belt and Incline Belt at right ∠s

Main Belt and Telescopic Belt at right ∠s

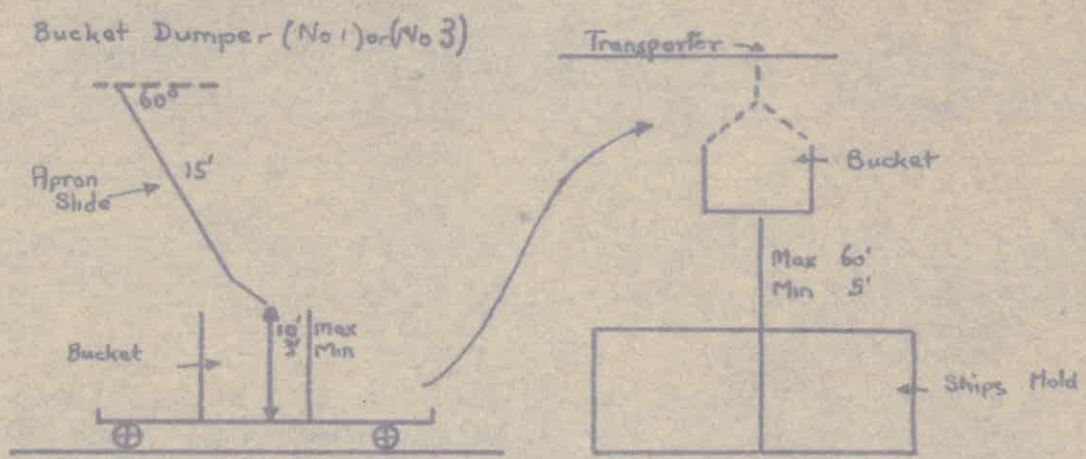
Each drop from one belt to another is throuh a steel-sided chute

(a). 30' slide and minimum of 27' drop

(b). 30' slide and maximum of 86' drop

BUCKET LOADING

FIG 2



Loading Buckets

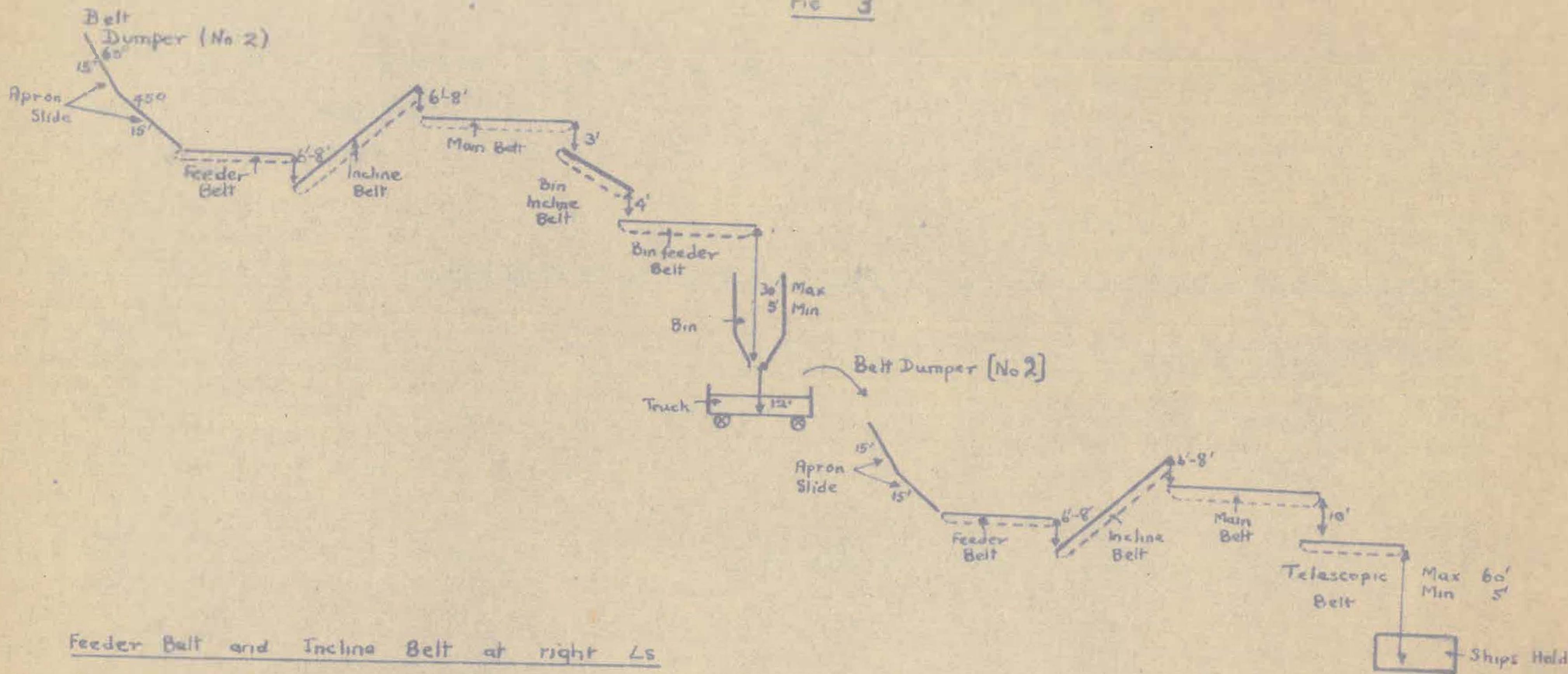
Bucket → Ship

(a) 15 ft Slide and minimum of 8 ft Drop

(b) 15 ft slide and maximum of 70 ft Drop

STORAGE IN BIN AND SUBSEQUENT LOADING BY BELT

FIG 3



Feeder Belt and Incline Belt at right ∠s

Main Belt and Telescopic Belt at right ∠s

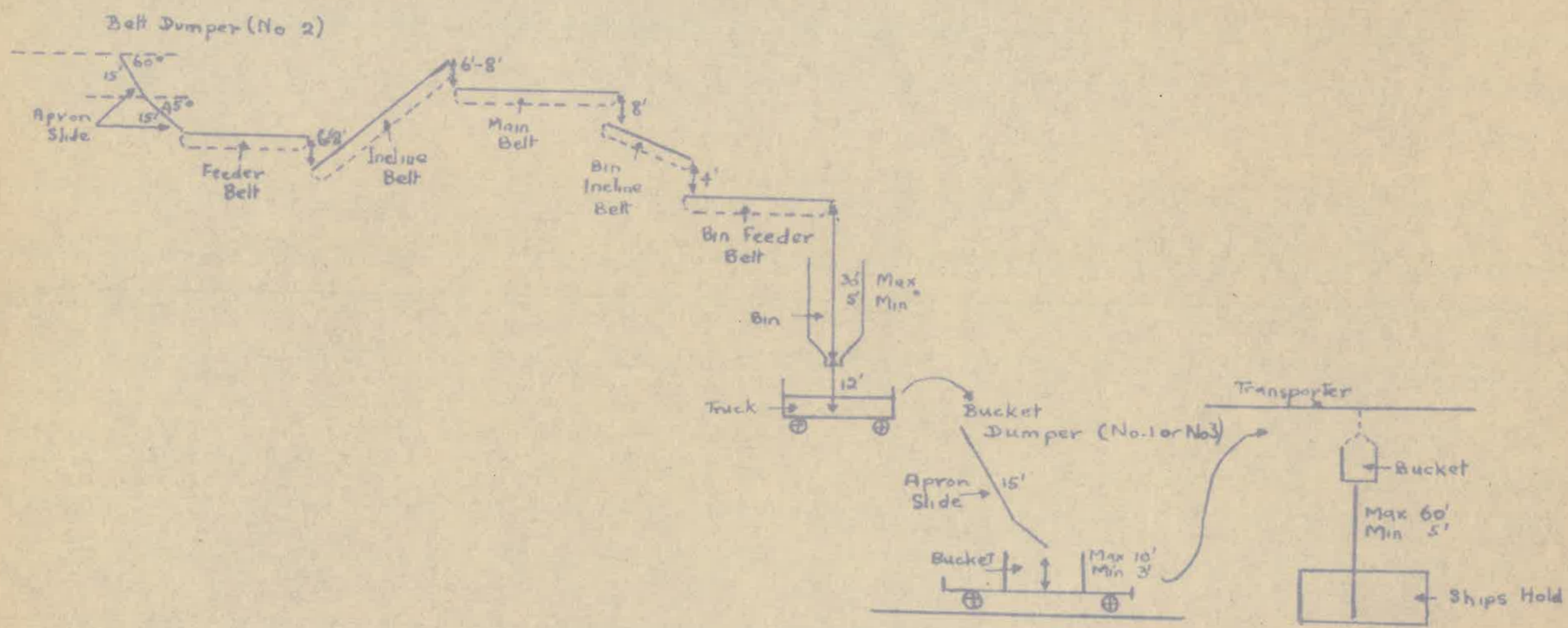
Each drop from one belt to another is through a steel-sided chute

(a) 60 ft slide and minimum of 68' drop

(b) 60 ft slide and maximum of 136' drop

STORAGE IN BIN AND SUBSEQUENT LOADING BY BUCKET

Fig 4



Feeder Belt and Inclined Belt at right ∠s

Main Belt and Telescopic belt at right ∠s

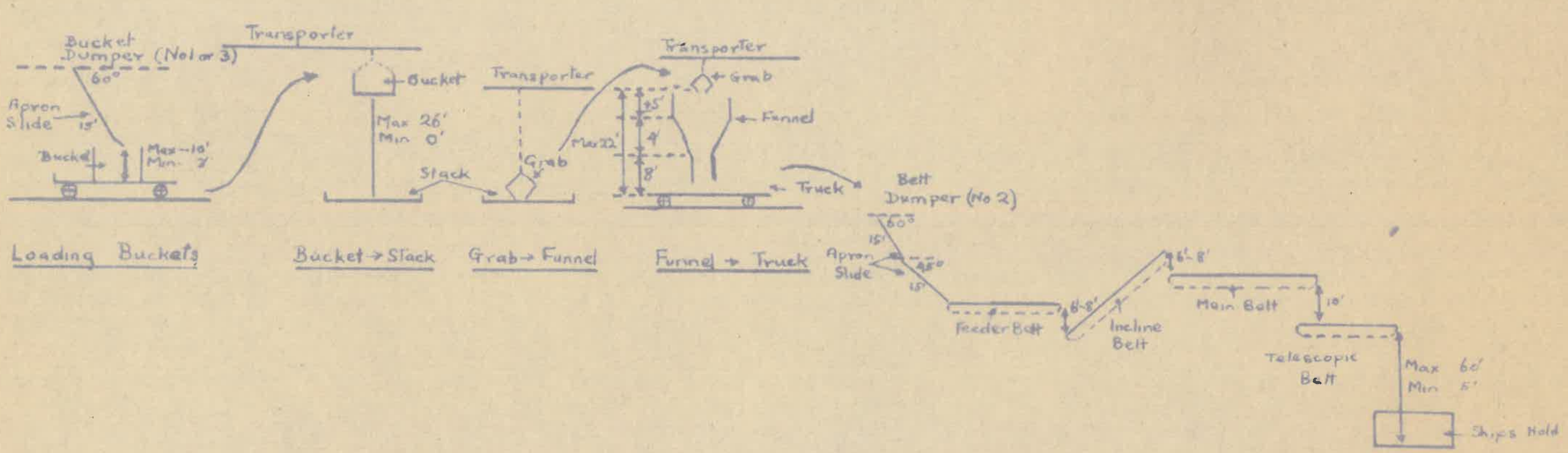
Each drop from one belt to another is through steel-sided chute

(a) 45 ft slide and minimum of 49' drop

(b) 45 ft slide and maximum of 140' drop

Stack Storage and Subsequent loading by Belt

Fig 5

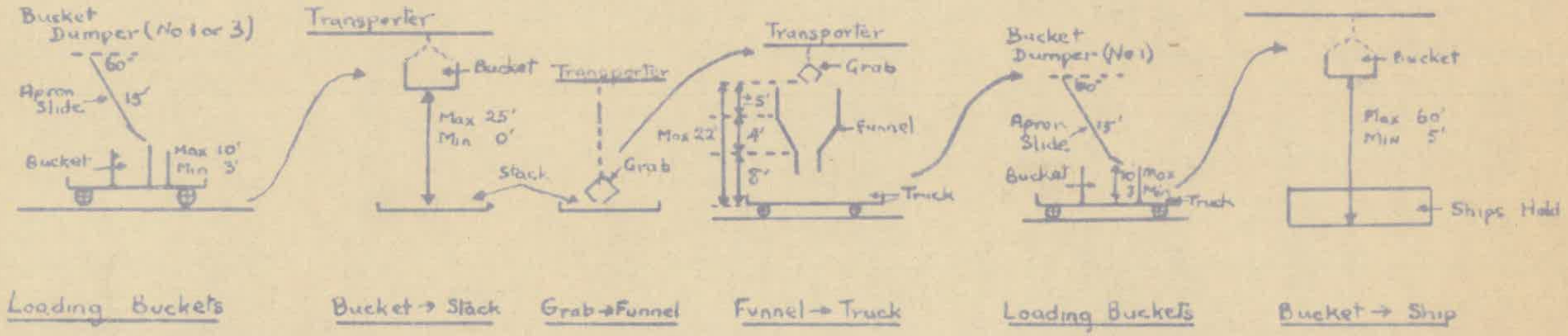


(a). 45' slide and minimum of 47' drop

(b). 45' slide and maximum of 133' drop

Stack Storage and subsequent loading by Buckets

Fig 6



(a) 30' slide and minimum of 28' drop

(b) 30' slide and maximum of 127' drop

SCREEN ANALYSES OF

Colliery		Durban Navigation					Natal Navig	
Loading system		Belt		Bucket			Belt	
		Before	After	Before	After 6' drop	After 35' drop	Before	Afte
Screen Analysis	on 4" %	39.5	23.5	28.0	18.0	11.4	44.9	13.6
	on $1\frac{1}{2}$" %	88.7	66.4	78.0	60.7	52.2	81.8	48.5
	on $\frac{3}{4}$" %	95.2	81.1	94.9	87.4	77.7	92.7	67.6
	on $\frac{1}{2}$" %	97.2	87.6	96.9	91.4	85.5	95.1	76.5
	Through $\frac{1}{2}$" %	2.8	12.4	3.2	8.6	14.5	5.0	23.6
Decrease in +$\frac{3}{4}$" size %		-	15	-	8	18	-	27
Decrease in +$\frac{1}{2}$" size %		-	10	-	6	12	-	20

SCREEN ANALYSES OF COA

Colliery		Durban Navigation				Natal Nav	
Storage System		bin		stack		bin	
		Before Storage	After Storage	Before Storage	After Storage	Before Storage	Af Sto
Screen Analysis	on 4" %	39.5	12.9	28.0	13.2	44.9	1
	on $1\frac{1}{2}$" %	88.7	54.6	78.0	51.2	81.8	5
	on $\frac{3}{4}$" %	95.2	73.8	94.9	76.9	92.7	7
	on $\frac{1}{2}$" %	97.2	82.5	96.9	84.8	95.1	8
	through $\frac{1}{2}$" %	2.8	17.5	3.2	15.1	5.0	1
Decrease in + $\frac{3}{4}$" size %		-	22	-	19	-	2
Decrease in + $\frac{1}{2}$" size %		-	15	-	13	-	1

TABLE 5.

OALS BEFORE AND AFTER LOADING AT BLUFF.

ation (Northfield).			Burnside.					Vryheid Coronation.				
Bucket			Belt		Bucket			Belt		Bucket		
Before	After 6' drop	After 35' drop	Before	After	Before	After 6' drop	After 35' drop	Before	After	Before	After 6' drop	After 35' drop
31.1	18.9	15.3	26.6	9.4.	30.3	11.7	9.4	17.3	15.0	10.4	6.7	3.8
76.1	64.3	45.4	67.2	34.5	68.9	53.5	41.7	55.0	43.5	60.5	47.5	31.7
93.3	81.6	64.1	86.0	58.9	87.0	77.1	62.9	82.6	62.7	89.0	79.6	61.1
96.7	86.9	72.6	91.1	73.0	92.3	83.4	74.6	88.2	72.7	92.7	86.1	72.0
3.3	13.1	27.4	8.9	27.1	7.8	16.6	25.4	11.6	27.2	7.2	13.9	28.0
-	13	31	-	31	-	11	28	-	24	-	11	31
-	10	25	-	20	-	10	19	-	18	-	7	22

TABLE 6.

S BEFORE AND AFTER STORAGE AT BLUFF.

gation (Northfield)			Burnside				Vryheid Coronation			
	stack		bin		stack		bin		stack	
er age	Before Storage	After Storage	Before Storage	After Storage	Before Storage	After Storage	Before Storage	After Storage	Before Storage	After Storage
.8	31.1	8.7	26.6	7.3	30.3	8.8	17.3	7.7	10.4	3.0
.4	76.1	43.9	67.2	29.8	68.9	37.9	55.0	33.3	60.5	29.3
.8	93.3	64.6	86.0	50.6	87.0	60.1	82.6	58.2	89.0	58.6
.4	96.7	73.9	91.1	63.5	92.3	72.5	88.2	71.6	92.7	70.1
.5	3.3	26.1	8.9	36.5	7.8	27.4	11.6	28.5	7.2	29.9
	-	31	-	41	-	31	-	30	-	34
	-	24	-	30	-	22	-	19	-	24