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SUPERINTENDENCIA DE INDUSTRIA Y COMERCIO



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Señor

Jefe de la División de Nuevas Creaciones

Superintendencia de Industria y Comercio

Ministerio de Comercio, Desarrollo Industria y Turismo

E. S. D.

Re.: Expediente No. **06.119.666**

Solicitud del examen de patentabilidad correspondiente a la Patente PCT Entrada en Fase Nacional, para:

“PROCESO PARA LA EXTRACCION DE NIQUEL, COBALTO Y OTROS METALES BASE DE MENAS DE LATERITA MEDIANTE USAR LIXIVIADO POR ACUMULACION Y EL PRODUCTO QUE CONTIENE NIQUEL, COBALTO Y OTROS METALES DE MENAS DE LATERITA”

Solicitante: **COMPANHIA VALE DO RIO DOCE**

INFORME DE ALERTA SOBRE PATENTABILIDAD

Yo, **Margarita Castellanos Abondano**, mayor de edad, identificada y domiciliada como aparece al pie de mi firma, respetuosamente acudo ante su Despacho con el fin de poner a su disposición y consideración la siguiente información sobre la solicitud de patente de la referencia, con el fin de mostrar que ésta no cumple con el requisito de patentabilidad de nivel inventivo establecido en el Título II, Capítulo I de la Decisión 486 de 2000 de la comisión de la Comunidad Andina:

En solicitud No. 06.119.666 a nombre de COMPANHIA VALE DO RIO DOCE el proceso comprendido por la reivindicación 1 y sus dependientes 2-16 corresponde a varios pasos de trituración y un proceso de lixiviación en pila a contra corriente. La forma en que estas etapas se encuentran definidas en dichas reivindicaciones corresponde a técnicas ampliamente conocidas en el estado de la técnica.

Los pasos de trituración de la reivindicación 1 de la solicitud en cuestión incluyen 3 pasos primario, secundario y terciario, los cuales son bien conocidos dentro de la técnica. Por ejemplo, en el documento **“Mineral Processing hereto plant design, Jerome C. Motz,**

1978, Denver Colorado” (D3: ANEXO 1) se menciona un proceso de trituración primario para obtener un tamaño de partícula de 162-100 mm, seguido de un proceso secundario en que se alcanzan entre 100-19 mm (página 215). La trituración secundaria de la solicitud 06.119.666, es fácilmente comparable con la descrita en D3, por cuanto la invención define un tamaño máximo de partícula entre 50-25 mm. Y para el caso de la trituración terciaria, tal como se muestra en la tabla 1, el tamaño de partícula alcanzado en la solicitud a nombre de COMPANHIA VALE DO RIO DOCE, se encuentra dentro del rango descrito en D3.

Tabla 1: comparación de procesos de trituración por tamaño de partícula obtenido

Proceso de trituración	Solicitud 06.119.666, tamaño de partícula obtenido	D3: Motz, 1978, Tamaño de partícula obtenido
Primario		162-100 mmm
Secundario	50-25 mm	100-19 mm
Terciario	12,5-3 mm	25-3 mm

En cuanto al proceso de lixiviación en pila a contracorriente, este también es ampliamente conocido en el estado de la técnica, por ejemplo, en el documento “**Mass Transfer operartions, Robert E. Treybal, secod edition, 1988**” (D2) y en el libro “**Principles of unit operations, Alan S. Foust et.al., New York, 1960**” (D4).

Asimismo, el documento **ES 2241816 (D1)** describe todos y cada uno de los elementos esenciales de la solicitud 06.119.666. En este documento se describen todas las características del proceso a contracorriente reivindicado en la invención de COMPANHIA VALE DO RIO DOCE, en el cual se define un sistema continuo a contracorriente, donde la solución de lixiviación preñada (SLP) va secuencialmente del paso n al primer paso de la pila. Por su parte en la figura 6 de D1, se encuentra el mismo proceso a contracorriente, siendo sustancialmente el mismo proceso del diagrama 3 de la solicitud 06.119.666. Como se muestra en la tabla 2, el paso 2 de esta solicitud corresponde a la pila 1 de D1.

Tabla 2: Comparación entre el proceso de lixiviación a contracorriente en la solicitud No. 06.119.666 y D1.

Solicitud 06.119.666, proceso de lixiviación a contracorriente	ES 2241816 (D1) , proceso de lixiviación a contracorriente
Paso 2	Pila 1
Diagrama 3	Figura 6

Es importante notar que la solución inicial de ácido sulfúrico se agrega en la pila 1 en la figura 6 de D1, y la “solución de lixiviación” que lixivió dicha pila, se utiliza para lixiviar la pila

2. Esto es equivalente al modo en que el proceso de lixiviación se describe en la reivindicación 1 de la solicitud 06.119.666, en la cual se establece que luego de la cesación del lixiviado de la etapa n (equivalente a la pila 1), éste es removido y una nueva mena se introduce a la primera etapa. El conjunto de estas características es muy similar a “repetir el proceso” tal como se indica en la figura 6 de D1. Aunque el reemplazo de la pila no se menciona específicamente en D1, es claro que esto es parte del proceso de contracorriente como se muestra en D2, y en la patente Estadounidense US 7,597,738 (D5), que se describe a continuación. Estas técnicas estándar llevadas a cabo a contracorriente que aparecen en los documentos mencionados, constituyen la materia reivindicada en la solicitud 06.119.666, lo cual carece de nivel inventivo.

En cuanto a las etapas de trituración de la solicitud a nombre de COMPANHIA VALE DO RIO DOCE, D1 también describe todos sus pasos. De hecho, en la columna 5 de D1, se muestran datos de los tamaños de partícula obtenidos por trituración, donde se observa que el proceso incluye la una pulgada (25,4mm) (líneas 30-32, columna 5, D1), lo cual comprende los rangos establecidos en la reivindicación 1 de la solicitud 06.119.666. Esto puede verse también en la columna 6, líneas 25-27 de D1.

En la columna 7, líneas 18 a 23 de D1, se establece que la muestra de mena se tritura inicialmente a un tamaño de menos de 1 plg, preferiblemente entre 3,35mm (1/8 plg) y 19,05mm (3/4 plg), rango que es equivalente al de la trituración terciaria de la solicitud de COMPANHIA VALE DO RIO DOCE, y es comparable con las técnicas divulgadas en D3.

La solicitud en Estados Unidos **5,571,308 (D5)**, equivalente a la patente en Colombia de certificado No. 26979 (solicitud No. 96.037.399) está claramente relacionada con la extracción de Níquel, Cobalto y/o otros metales de menas de laterita por medio de lixiviación en pila. Por ejemplo, en la columna 13, líneas 44-50, D5 divulga un proceso de lixiviación en pila donde la mena es aglomerada con un tamaño de partícula de menor de una pulgada (25,4mm), y en la tabla 16 se muestra una típica distribución tamaños de partículas de la mena triturada, en la cual se observa que gran parte de la mena posee un tamaño inferior al de la apertura de una malla 10, es decir, 1,7mm en una pantalla estándar.

En la columna 14, líneas 3 a 6, tabla 15 y tabla 16 de D5, se muestra la distribución de los tamaños de partícula de la mena triturada en la cual se observa un porcentaje alto de partículas con tamaños de ¼ plg. (6,35mm) o mayores. De modo que el proceso de trituración y la distribución del tamaño de partícula son los mismos que aquellos de los pasos de trituración primario a terciario reivindicados en la solicitud 06.119.666.

Adicionalmente, pongo de presente que en D5, columna 8, líneas 35 en adelante, bajo el título de "lixiviación de columna consecutiva", se describe un proceso de lixiviación en pila a contracorriente, en el cual la solución de lixiviación preñada (SLP) de las columnas 2 y 3 es introducida a las columnas 4 y 5 respectivamente, de modo que el arreglo a contracorriente se beneficia de la alta acidez residual en la SLP, lo cual es el propósito del proceso a contracorriente reivindicado en la solicitud a nombre de COMPANHIA VALE DO RIO DOCE.

Por otro lado, en la figura 8 y la columna 13, líneas 18-42 de D3, se muestra un proceso a contracorriente en el cual la mena de la segunda etapa se lixivia utilizando un líquido proveniente de la primera etapa para disminuir así la acidez residual, y luego, el Níquel y el Cobalto se recuperan de la PLS. Como puede verse D5 constituye otra referencia en que la técnica a contracorriente es utilizada en el proceso de lixiviación en pila de menas de laterita de Níquel.

Otro documento que debería ser considerado en el estudio de patentabilidad de la solicitud 06.119.666 es la patente Estadounidense 7,597,738 (D6) (equivalente a la solicitud en Colombia No. 07.036.126), la cual se relaciona con la lixiviación en pila e incluye un proceso a contracorriente tal como puede verse en la figura 1, en que se ilustra un proceso a contracorriente de la misma forma que el reclamado en la solicitud a nombre de COMPANHIA VALE DO RIO DOCE.

Adicionalmente, en la columna 4, líneas 53-60 de D6 se describe un proceso de lixiviación en pila, en el cual *"la solución licor (producto intermedio) se agrega al lixiviado de la primera pila en un proceso a contracorriente, produciendo una solución licor rica en Níquel y Cobalto (SLP) de baja acidez, la cual contiene también hierro y otras impurezas. Cuando todo el Níquel es retirado de la pila secundaria, ésta es descargada, y entonces la pila primaria se vuelve una pila secundaria, y una nueva mena constituirá la pila primaria"*. Este paso de remplazar la pila primaria o la pila número n es descrito en la solicitud 06.119.666, que a su vez corresponde al proceso estándar a contracorriente encontrado en D2 (Mass Transfer operations, Robert E. Treybal).

En la columna 4, líneas 42-60 (D6) se muestra que es preferible trabajar la mena aglomerada en al menos dos pilas, toda vez que en el sistema de lixiviación en pila a contracorriente, se tiene la ventaja de disminuir el consumo de ácido, y se obtiene una solución más limpia que con el uso de una sola pila.

Finalmente, en la columna 4, línea 39 de D6, se menciona que la mena es triturada a un tamaño de partícula menor a 25mm, y en el ejemplo 1 de D6 se muestran tamaños de

partícula de 3,35-25,4mm, los cuales coinciden con la distribución de tamaño de partícula lograda por los pasos de trituración primario a terciario de la solicitud 06.119.666. De manera similar, el ejemplo 3 de D6 divulga un proceso en contracorriente con tamaños de partícula del material entre 3,35-25,4 mm, que se sobrelapa con los de la solicitud a nombre de COMPANHIA VALE DO RIO DOCE y con la misma distribución alcanzada en técnicas conocidas como las encontradas en D3 (*Mineral Processing hereto plant design, Jerome C. Motz*).

En resumen, la solicitud en Colombia No. 06.119.666 a nombre de COMPANHIA VALE DO RIO DOCE no proporciona ningún aporte nuevo en la técnica, toda vez que los pasos descritos en dicha invención corresponden a procesos ampliamente conocidos en el arte previo mencionado. La combinación de los pasos de trituración y el uso de un sistema de lixiviación a contracorriente son características divulgadas en el arte previo, cuyo comportamiento, ventajas y modo de operación son ampliamente conocidos, y podría esperarse que una persona versada en la materia técnica de manera obvia pudiera derivar tal invención.

Amablemente solicito al señor examinador que tenga en cuenta los anteriores argumentos dentro del examen de patentabilidad que se lleve a cabo sobre la solicitud No. 06.119.666.

Del Señor Jefe,


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Bogotá, D.C. **24 AGO. 2011**

TABLA COMPARATIVA DEL PROCESO:

Solicitud 06.119.666	D1 (US 6,312,500)	D5 (US 5,571,308)	D6 (US 7,597,738)
Procesos para la extracción de Níquel y cobalto y/o otros metales de menas de laterita por lixiviación en pila	Columna 1, líneas 1-11 y a lo largo de la descripción	Columna 3, líneas 50-62 y a lo largo de la descripción	Columna 4, líneas 36-42
Triturar la mena de laterita	Columna 7, líneas 18-22	Columna 14, líneas 3-6 muestra que se tritura la mena a tamaños de partícula de 1plg a ¾ pld (25,4-19mm)	Columna 4, líneas 36-42
Aglomerar la mena triturada	Columna 7, línea 22		
Apilar o formar el aglomerado de la mena en pilas	Columna 7, líneas 49-52		
Lixiviación en pila de las pilas aglomeradas,	Columna 1, líneas 4-9		Ejemplos 1 y 3 (tamaño de partícula de 3,35-25,4 mm)
Donde el paso de trituración comprende un paso primario y uno secundario, donde se obtiene un tamaño máximo de grano entre 25,0 – 50,0mm;	Columna 7, líneas 17-23 (menos de 1plg, 25,4mm)		
Un paso de trituración terciario, donde se obtiene un tamaño máximo de grano entre 12,5 – 6,30mm;	Columna 7, líneas 17-23 3,35mm (1/8 plg) a 19mm (3/4 plg)	Tabla 16 muestra una distribución de tamaños de partícula, en la cual se observa un alto porcentaje de partículas de 3/8 plg (9,5mm) o menores	Ejemplos 1 y 3 (tamaño de partícula de 3,35-25,4 mm)
Donde el paso de lixiviación en pila es un proceso continuo a contracorriente, con al menos dos pilas con la mena secuencialmente, colocadas cada una de la primera pila a la pila número n.	Columna 7, línea 66 a columna 8, línea 3 a columna 9, líneas 15-40, figura 6.	Columna 16, líneas 18-42, figura 3.	Figura 1, columna 4, líneas 53-60
En cada etapa la pila se lixivia con una solución que fluye desde la pila n hasta la primera etapa	Columna 9, líneas 15-40, figura 6 (la primera pila de D1 es equivalente a la pila 2 de la solicitud 06.119.666)	Columna 13, líneas 18-42, figura 3.	Figura 1, columna 4, líneas 53-60
La mena en cada uno de las etapas 1-n es lixiviada por una solución de lixiviación que lixivió la mena en una etapa inmediatamente siguiente.	Columna 9, líneas 15-40, figura 6 (la segunda pila de D1 es equivalente a la pila n de la solicitud 06.119.666)	Columna 13, líneas 18-42, figura 3.	Figura 1, columna 4, líneas 42-60

La mena en la etapa n es lixiviada por una nueva solución de lixiviación	Columna 9, líneas 15-18, figura 6.	Columna 13, líneas 18-42, figura 3.	Figura 1, columna 4, líneas 42-60
Luego de completar la lixiviación de la etapa n, la mena se retira y una nueva mena se introduce a la etapa inicial.	Columna 9, líneas 15-40, figura 6, columna 7, línea 66 a columna 8, línea 3, columna 9, líneas 15-40, figura 6.	Columna 13, líneas 18-42, figura 3	Figura 1, columna 57-69
Luego de pasar por la mena de la primera etapa, la solución de lixiviación es una solución preñada (SLP)	Columna 9, líneas 15-40, figura 6.	Columna 13, líneas 18-42, figura 3.	Figura 1, columna 4, líneas 42-60
Se separa la SLP para obtener el Níquel, el Cobalto y otros metales	Columna 9, líneas 15-40, figura 6.	Columna 13, líneas 35-39	Figura 1 en la columna 4, líneas 60-64

Chapter 11

CRUSHING

by Jerome C. Motz

Product Manager, Crusher Department
Process Machinery Division, Rexnord Inc.
Milwaukee, Wisconsin

Primary Crushers

The types, sizes and number of crushers employed in a complete reduction system will vary with such factors as the volume of ore to be processed, the size of the mine-run lump material, the hardness of the ore bearing rock and the size and dimension required for the final product.

Basically, for primary crushing there are only three distinct types of crushing equipment. These are the Jaw crushers, Gyratory crushers and Impact crushers, and they each have their own distinctive operating characteristics.

Jaw crushers operate by squeezing the rock between the fixed and the movable sides of a tapered cavity. Variations of pitch and swing have been tried, but most Blake-type machines have a crushing angle of about 27° between swing and stationary jaws.

The principle of which Gyratory crushers work is very simple. If a Cone is mounted on the upper end of a vertical shaft and the top of the shaft is held stationary while the lower end is rotated eccentrically, the Cone will also swing eccentrically. If the Cone is enclosed in a suitable housing, it will swing toward and away from the housing walls as it rotates. If the Cone and the housing walls are sufficiently strong and heavy, anything caught between them will be crushed.

Besides the increased efficiency developed by the continuous crushing action and curved crushing faces, Gyratory-type crushers have other advantages:

1. The largest unrestricted feed opening available in comparison to other crusher types.
2. A high range of sizes and capacities where rates of between 600 and 6,000 tons per hour are required
3. Generally, no feed control is necessary. Direct dump trucks of 150 to 200 tons capacity are now being used in the larger installations.

Impact crushers accomplish material breaking and reduction primarily through impact action of the material with fixed or free-swinging hammers revolving about a central rotor.

Product gradation is a function of rotor speed and friability of the material. An increase in rotor speed or material friability leads to an increase in the proportion of fines in the product; conversely, a decrease in rotor speed or material friability will decrease the proportion of fines in the product.

The principle of impact crushing is the total use of rotor energy in the reduction of the material. Kinetic energy is imparted to a particle of the material, and this energy is used chiefly to break down the bonding of the particle structure. The particle breaks along its planes of weakness producing a cubical natural grain-shaped product as the result. The end product is free from weak zones. The impact factor is equal to the particle kinetic energy and varies as:

$$E = \frac{MV^2}{2} \text{ when } E = \text{Energy, } V^2 = \text{Speed Squared, and } M = \text{Mass Weight}$$

The velocity is fixed by the peripheral speed of the rotor; therefore, particles of a material with a common impact value will break according to their initial mass. A large piece will receive a severe impact and will break more readily than a small one. The latter receives only a light impact and will tend to pass through with minimal further breakage. If two materials of different impact value are fed to a machine, even though they may be particles of the same mass, one will be reduced more than the other.

Benefits in using primary Impact-type crushers, as compared to compression crushers, are lower installed capital costs per ton of capacity, much greater capacity weight for weight of comparable Jaw and Gyratory crushers thus reducing installation cost and raising the feasibility for mobile units, production of more cubical product and generally, a finer product gradation. This may reduce the need for secondary crushing units.

Due to the relatively high maintenance costs generated through welding of hammers and the internals of the Impact unit when crushing moderately abrasive rock types, thorough testing and evaluation of the feed material is recommended by the manufacturer. Refer to Tables 1 through 5 for capacities and product analyses for primary-type crushers.

Table 1

JAW CRUSHERS		JAW CRUSHER CAPACITY								CAPACITY
		TPH								
DISCHARGE SETTING (INCHES)		1236	1836	2136	2436	2540	3040	3240	3648	4248
	1½	40								
	2	55	55	55						
	3	85	90	90	90	145				
	4		125	125	125	185	185	185	275	
	5			155	155	240	240	240	350	
	6			195	195	290	290	290	425	425
	7					340	340	340	475	475
	8					390	390	390	525	525
	9								575	575
	10								650	650
	12									800

Capacities listed are average based on dry, free crushing rock at 100 lbs. per cubic foot. Tonnage will vary depending on size of feed, rate of feed, operating conditions, breaking characteristics of the rock, type and condition of crushing members (jaws), speed of crusher, and horsepower available. Listed capacities may vary $\pm 25\%$.

Crusher cannot be operated economically where ratings are not specified.

Table 2

JAW CRUSHERS

GRADATION

PRODUCT ANALYSIS

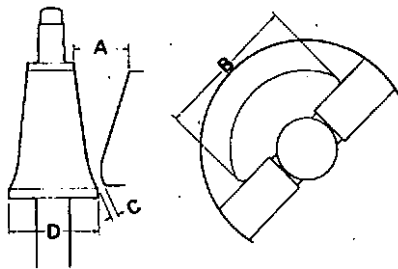
This chart gives an average analysis of stone crushed by an overhead eccentric jaw crusher. It does not imply any guarantee of product sizing, since all stone varies from area to area and local conditions are never constant.

OPEN CIRCUIT												
Percent of Each Size in the Product of a Crusher												
Size Range	Crusher Setting to Give 15% Recirculation											
	1/4"	1/2"	3/4"	1"	1 1/4"	1 1/2"	1 3/4"	2"	2 1/4"	2 1/2"	3"	4"
+10"												15
-10" +9"												15 32
-9" +8"												15 29 9
-8" +7"												15 20 6 4
-7" +6"												15 16 9 5 4
-6" +5"												15 13 9 6 4 3
-5" +4"												15 10 8 7 6 5 4
-4" +3 1/2"												15 9 8 8 6 5 4 3
-3 1/2" +3"												15 8 8 8 6 6 5 5 4
-3" +2 1/2"												15 7 6 6 5 4 3 3 3 2
-2 1/2" +2 1/4"												15 7 7 7 6 5 4 3 3 2 2
-2 1/4" +2 1/2"												15 6 6 6 5 4 3 3 2 2 2
-2 1/2" +2"												15 7 7 7 6 5 5 4 4 3 2 2
-2" +1 1/2"												15 8 8 8 7 6 6 6 5 3 2 1
-1 1/2" +1 1/4"												15 8 7 7 7 7 6 5 6 5 4 3 2 1 1
-1 1/4" +1 1/2"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-1 1/2" +1 1/4"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-1 1/4" +1 1/2"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-1 1/2" +7/8"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-7/8" +3/4"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-3/4" +5/8"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-5/8" +1/2"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-1/2" +3/8"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-3/8" +5/16"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-5/16" +1/4"												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-1/4" +4M												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-4M +8M												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1
-8M												15 12 11 11 10 9 9 8 7 5 4 3 3 2 2 1 1

EXAMPLE: Jaw crusher for 1 1/2" with 15% recirculation - find 1 1/2" at top and follow down vertical column.

+1 1/2"	-15%	7/8" to 3/4"	-7%	3/8" to 5/16"	-4%
1 1/2 to 1 1/4"	-9%	3/4" to 5/8"	-7%	5/16" to 1/4"	-5%
1 1/4" to 1"	-11%	5/8" to 1/2"	-8%	1/4" to 4M	-4%
1" to 7/8"	-6%	1/2" to 3/8"	-8%	4M to 8M	-6%
				8M	-10%
TOTAL					100%

Table 3A



SELECTION DATA: The condensed information on these pages is only a guide in determining the size and operating data of a Nordberg Primary Gyratory Crusher for a particular application. Crusher capacities in these tables are given in short tons (2000 lbs.) per hour and are based on average operating conditions when handling a dry friable material weighing 100 lbs./cu. ft. (crushed). Factors which may affect capacity include hardness, toughness, fracture pattern, moisture content, size gradation of the feed material and method of feeding.

The horsepower column represents the maximum rated horsepower required for the crusher. These ratings do not refer to the horsepower required for throws and capacities listed. In general, the recommended duty and capacity of the crusher can be determined by knowing the feed, throw, speed and product desired. Horsepower for specific applications can be determined on following pages.

CAPACITIES IN TONS PER HOUR (2000 Lbs.)

Size	A x B Feed Opening (Inch)	D Head Dia. meter (Inch)	Gyr. per Min.	Cmtr. Shaft RPM	Eccen- tric Throw Inch	Max. HP	Open Side Discharge Settings - C													
							3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	10	
42-70 HD	42 x 114	70	137	514	3/4 1 1 1/8 1 1/4	200 250 270 300					525 700 785 1040	625 830 936 1220	730 975 1100 1390	835 1110 1250 1540	925 1230 1385 1700	1020 1360 1530 1700				
42-70 XHD	42 x 114	70	137	514	3/4 1 1 1/8 1 1/4	240 320 380 400			430	525 700 785 1040	625 830 936 1220	730 975 1100 1390	835 1110 1250 1540	925 1230 1385 1700	1020 1360 1530 1700					
48-75 HD	48 x 133	75	140	514	1 1 1/4 1 3/8 1 1/2	300 375 410 450				1175 1250 1567 1720	1330 1600 1880 1980	1440 1800 2150 2340	1585 1950 2350 2550	1700 2125 2530 2760	1840 2300 2630 2760					
54-75 HD	54 x 144	75	140	514	1 1 1/4 1 3/8 1 1/2	300 375 410 450				1300 1400 1750 1925	1400 1510 1885 2075	1510 1630 2040 2240	1630 1775 2220 2440	1775 1915 2410 2655	1915 2130 2550 2855					
54-80 HD	54 x 145	80	140	514	1 1/4 1 3/8 1 1/2 1 5/8	400 425 460 500				1825 2010 2145 2340	1950 2170 2385 2605	2170 2420 2680 2905	2420 2680 2915 3180	2680 2915 3180 3480	2900 3145 3445 3770	2900 3145 3445 3770				
60-90 XHD	60 x 185	90	115	514	1 3/8 1 1/2 1 5/8 1 3/4	550 600 650 700					1955 2130 2330 2775	2130 2330 2540 3080	2420 2660 2900 3386	2660 2900 3140 3635	2900 3145 3425 4000	3145 3425 3715 4000				
60-102 HD	60 x 174	102	115	514	1 1/2 1 5/8 1 3/4 2	600 650 700 750							3140 3400 3750 4085	3500 3750 4085 4655	3800 4085 4655 5200	4270 4625 5025 5695	4640 5025 5415 6185	5400 5850 6300 7200		
80-102 XHD	80 x 174	102	115	514	1 1/2 1 5/8 1 3/4 2	750 800 875 1000							3140 3400 3750 4085	3500 3750 4085 4655	3800 4085 4655 5200	4270 4625 5025 5695	4640 5025 5415 6185	5400 5850 6300 7200		

Table 3B - pg. 1
HORSEPOWER REQUIREMENTS *

This method employs a common factor known as the work index which is the total work input in kw-hr per short ton required to reduce a given material from theoretically infinite particle size to 80% passing 100 microns or 67% passing 200 mesh.

Material: (Notes 1 & 4) _____ Wt./Cu. Ft.: (Note 1) _____
 Sp. Grav: (Note 2) _____ Av. Impact: (Note 2) _____
 Work Index = $2.59 \frac{\text{Av. Impact}}{\text{Sp. Grav.}}$ _____; ROM (Run of Mine) or Scalped
 Feed Size = 80% Passes (Note 3) _____ in. F = _____ microns
 Prod. Size = 80% Passes (Note 4) _____ in. P = _____ microns
 (In calculating F & P, 1" = 25,400 microns)
 HP/Short Ton = $\frac{Wt \times 134 (\sqrt{F} - \sqrt{P})}{\sqrt{F} \times \sqrt{P}}$ _____ HP/Short Ton
 (Note 1)

Total HP = Capacity in Short Tons/Hr. x HP/Short Ton = _____ HP

NOTE 1 - Refer to Nordberg Bulletin 318C for crusher capacities. Interpolate for specific bulk density since the values are based on 100 lbs./cu. ft.

NOTE 2 - The average impact, specific gravity and the resulting work index can be determined at the Nordberg Process Machinery Test Center if the samples are provided.

NOTE 3 - If the feed analysis is not available, experience indicates that 80% of the feed size will pass a square opening equal to from half to two-thirds of the crusher receiving opening.

Feed Size = 80% Passes _____ in. F = _____ microns

NOTE 4 - Product size can be determined with reasonable accuracy from Product Gradation Curve Tables A & B.

Prod. Size = 80% Passes _____ in. P = _____ microns

MATERIAL FRACTURE CHARACTERISTICS

Example:

Assuming the feed to be run of quarry soft limestone (W-6.5) including fines to a 54-80 Nordberg Gyromatic Crusher set at 6" O.S.S.

Table "A" shows 80% of product should pass a 6" square opening in first testing screen. Follow the 80% horizontal line within the 6" screen size opening on table "B". This line will yield the approximate screen analysis shown on the right.

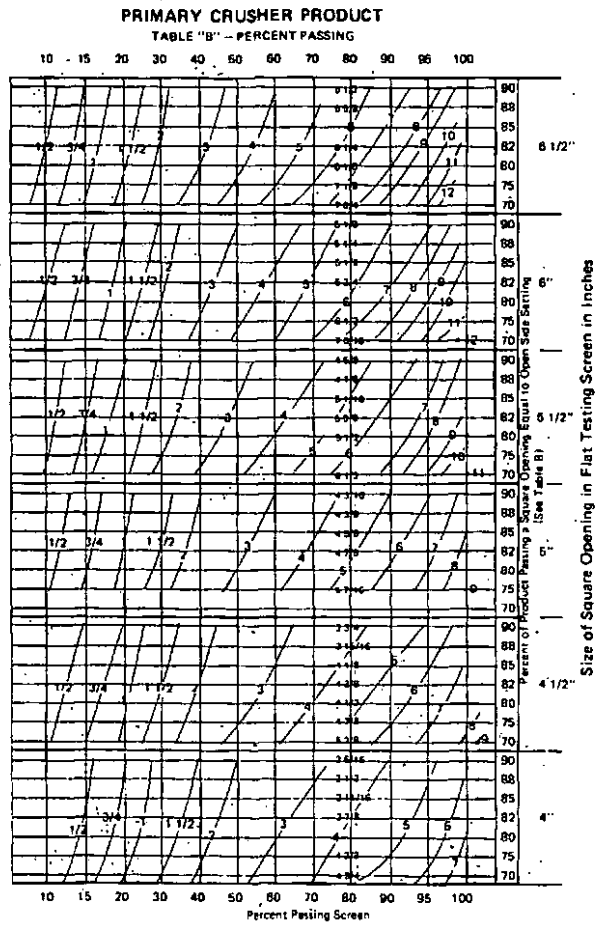
Square Screen Opening in inches	Approx. % Passing
8	98
4	66
3	50
2	34
1-1/2	29
3/4	16
1/2	12

TABLE A
Percent of Product Passing a Square - Opening Equal to Open Side Setting of Crusher

Work Index - Grade -	Material Characteristics	Run of Mine or Quarry	Scalped Feed	
			Crusher Product Only	Crusher Product And Grizzly Thus Recombined
6.0 to 10.0	Soft	90	85	88
	Soft (Spongy)	85	82	85
10.0 - 13.0	Average	90	85	85
	Average (Stabby)	85	82	85
13.0 & Up	Hard (Brittle)	90	85	85
	Hard (Tough)	82	75	80
	Hard (Stabby)	75	70	75

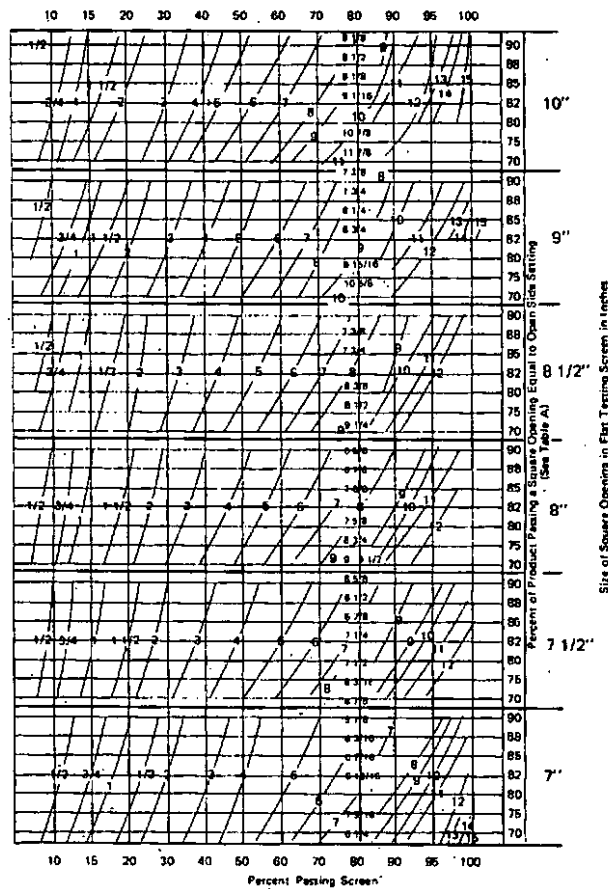
*From Fred C. Bond, "Third Theory of Comminution"

Table 3B - pg. 2



The above product gradations which represent square screen openings in inches yield the approximate screen analyses and should be used in conjunction with table "A".

Table 3B - PR. 3
PRIMARY CRUSHER PRODUCT
Table "B" - Percent Passing

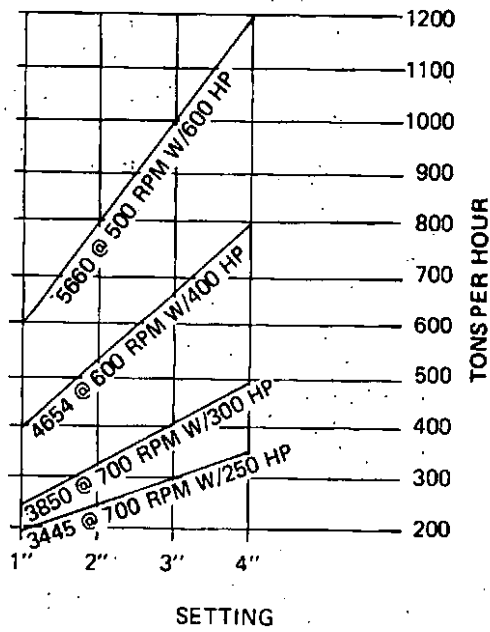


The above product gradations which represent square screen openings in inches yield the approximate screen analyses and should be used in conjunction with table "A".

Table 4

DYNAPACTORS Impact Crusher CAPACITY
DYNAPACTOR CAPACITY

Capacities listed are average based on dry, free crushing limestone at 100 lbs./cu. ft. Actual tonnage will vary with size of feed, rate of feed and general operating conditions.



SECONDARY, TERTIARY AND FOURTH STAGE CRUSHING

Cone Crushers

The Cone crusher is used as a secondary, tertiary and fourth stage crusher in hard rock applications. The Cone crusher was invented by Mr. Edgar B. Symons in the mid-1920's after spending considerable time in the development of secondary crushing machinery. The Cone crusher proved to be remarkable due to its radical departures from the normal principles of a Gyratory crusher operation.

In previous Gyratory machines the crushing process comprises reduction by pressure between two confining faces and a subsequent freeing movement during which the material settles by gravity until it is caught and subjected to further pressure and again released. In the normal Gyratory the crushing stroke or travel of the head has usually an important bearing on the size of the finished product, although this factor is subject to modification when a parallel sizing zone is adopted.

The movement of the head in the Cone crusher is similar to that in the ordinary Gyratory with the exception that, towards the bottom of the Cone, it travels through a much greater distance and gyrates much faster. This large stroke, combined with the flat angle of the Cone, causes the stone to follow a zigzag path through the crusher. The rock entering at the top drops upon the head and is then elevated and crushed against the bowl liner. As the head recedes in its gyration, faster than the effect of gravity on the crushed particles, the crushed rock drops vertically down towards the head to be met on the next gyration by the upcoming face, and again is crushed against the bowl liner.

The long movement changes the crushing stroke from pressure to impact, and the increased clearance on the freeing stroke allows the stone to fall away vertically after each impact. The wide gap at the end of the opening movement also permits the stone to move freely for the greater part of the time occupied in passing through the crushing zone. The periods of confinement are therefore limited.

The angle between the faces of the bowl liner and the mantle decreases gradually, and these faces are parallel near the outlet for a sufficient distance to ensure that the head must make one or two gyrations before the material can pass through the sizing zone, which again means that it is the opening on the closed side of the crushing head which regulates one dimension of the product size. As in the slow-speed Gyratory crusher, the volume transported through each vertical position in the Cone crusher cavity is directly related to the length of the crushing stroke, sometimes called eccentric throw, but more accurately defined as head displacement.

The machine departs from the usual design in that there is no upper bearing for the Gyratory shaft and no spider to bridge over the feed opening. The head is supported in a part-spherical seating and the tapering main shaft is actuated by an eccentric. The absence of the spider ensures a more even distribution of the feed to all parts of the crushing chamber.

The crushing bowl, inverted over the Cone and screw-threaded to permit vertical adjustment inside an adjustment ring, is held down to the main frame by a series of powerful springs which allows the bowl to rise when tramp iron or other uncrushable material enters the crushing cavity.

It is very desirable with this machine that the feed be controlled and the material be evenly distributed around the circumference if optimum efficiency is to be obtained. A feed-distributing and regulating plate is therefore mounted on the top of the main shaft with a vertically adjustable spout above it.

CONE CRUSHER APPLICATION

Crushing Stages

To reduce run-of-mine to mill feed requires reduction in a series of stages. The physical size and power requirements of a crusher capable of reducing hard rock vary depending on the application.

Even when a crusher has the capability of achieving a high reduction ratio it is normally more efficient to run the crusher at a mid-setting, as shown in the manufacturers' tables, rather than choosing the closest setting which offers the greatest reduction ratio. The main consideration at each stage for maximum production is efficient power draw.

There is an optimum setting for each crusher and an optimum number of stages required for maximum plant production based on the individual characteristics of the material being crushed. Overloading the crusher does not increase production, but instead is counterproductive and will decrease the lives of the crusher components. Ideally, the top-size feed should receive four to five impact blows during its progress through the crushing chamber. This is a combination of reduction at the upper zone of the liners as well as the parallel zone. The crusher should be fed so as to be operating at or near continuous full load horsepower capability. Operating the

crusher at too narrow a setting decreases capacity and creates high wear. Too wide an opening, in proportion to top size feed, will prevent crushing in the upper zone and will develop excessive power draw. Power drawn per ton of crusher feed is not in itself a measure of productivity. Efficient use of power through proper application of the cavity, with respect to feed and product requirements, will determine the optimum production per horsepower drawn. From the following crusher application descriptions, it can readily be seen that each crusher has its own designed level of reduction. The range of feed sizes and product sizes, for each crushing stage, somewhat overlaps into the succeeding and preceding stages. This allows for flexibility in adjustment at each stage for optimum production of the entire system. This also presents the option of eliminating a stage when it is advantageous.

Primary Crusher

The Primary crusher's main purpose is to reduce large fragments of blasted or natural rock down to a size suitable for handling by transfer equipment and the secondary stage crusher. Feed opening and product size ranges for the various models of Gyratory crushers are as follows:

Maximum Feed Opening -- 1500 MM to 750 MM (5 ft. to 2-1/2 ft.)

Recommended Minimum Product -- 162 MM to 100 MM (6-1/2 In. to 4 In)

Preferred Reduction Ratio -- 8:1

Standard (Secondary) Cone Crusher (Refer to Fig. 1)

The Standard Cone crusher is normally applied as a secondary crusher in a multi-stage crushing circuit. The small diameter feed distributor and the wide throat opening at the top of the liners enable the Standard Cone crusher to accommodate the larger feed produced by the Primary crusher.

Feed opening and product size ranges for the various models of the Standard Cone crusher are as follows:

Maximum Feed Opening -- 625 MM (25 In.)

Recommended Product Range -- 100 MM to 19 MM (4 In. to 3/4 In.)

Preferred Reduction Ratio -- 6 or 8:1

The feed to the Standard Cone is normally scalped if over 10 to 15 percent of the desired crusher product is present in the new feed. Since the range of feed size will often vary from approximately 300 MM to 5 MM (12 In. to 2 In.) in a given installation, the crushing cavity must be selected to reduce these sizes efficiently. Where the majority of the top size of the feed is only 200 MM (8 In.) the crushing cavity would be modified to reflect this smaller feed size. To meet these variations in size of feed and desired product size, Standard Cones can be equipped with various designs of fine, medium, coarse, or extra coarse crushing cavities.

In selecting the crushing cavity, care is taken to obtain a design that will permit the top size of the feed to enter the crusher in sufficient volume throughout the entire wear life of the liners. Since the most efficient crushing action takes place when the feed is reduced in a series of four or five blows as it passes through the cavity, it becomes important to select a design that will effect some reduction in the upper portion of the cavity as well as the lower or parallel sizing zone. In other words, too large an opening for the feed will prevent crushing in the upper zones and can develop excessive power draw. Since the crusher feed rate is best governed by the power draw, an incorrect cavity can reduce the crusher capacity and, on occasion, create unnecessary maintenance. On the other hand, if the cavity will only accept the feed when the liners are new, but as the liners wear the feed opening closes off reducing the feed rate, a more efficient cavity is required. Since no two ores or crushing applications are exactly the same, a large number of cavity designs have become available through the years. Therefore, the optimum in cavity design is one which permits close-to-the-rated power draw throughout the entire wear life and results in a scrap loss of between 25 and 40 percent, depending on crusher type and size.

With the proper cavity design, maximum efficiency will be obtained if the feed is evenly distributed around the entire crushing cavity. Normally, the wide feed size range required in the Standard or secondary crushing stage is such that the crushing cavity is required to have a receiving opening considerably larger than the average portion of the feed. For best results, the feed should be regulated based on the crusher motor kilowatt draw. When handling the harder materials, it is likely that the crushing cavity in the Standard Cone crusher will not be entirely filled up or "choked". Depending on the size and type of secondary crusher, normal kilowatt fluctuations during crushing may approach 50 to 70 kilowatt, depending on the feed analysis and method of feed control. However, maximum capacity will be obtained under these conditions when cavity design and proper feed distribution methods are observed.

Short Head (Tertiary) Cone Crusher (Refer to Fig. 2)

The Short Head Cone crusher is normally applied as a third stage crusher in plants designed for three or four stages of crushers. However, the wide range of crushing cavities available in the Short Head crusher permits its installation as a secondary crusher in some cases.

Feed opening and product size ranges for the various models of Short Head Cone crushers are as follows:

Maximum Feed Opening -- 250 MM (10 In.)

Finished Product Range -- 25 MM to 3 MM (1 In. to 1/8 In.)

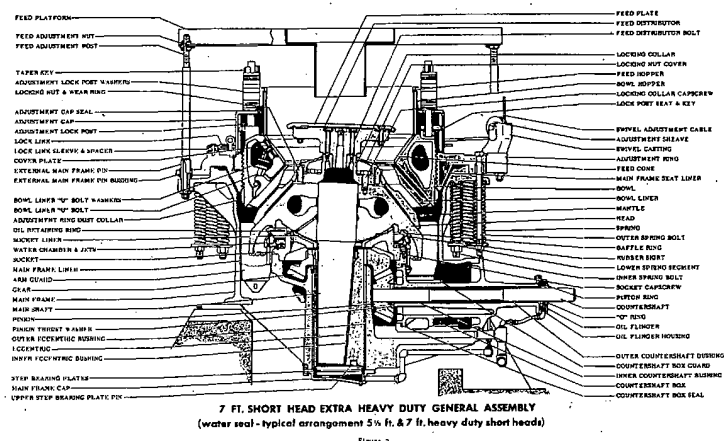
Reduction Ratio -- 4 or 6:1

The feed to the Short Head Cone crusher is normally screened prior to the crusher to remove the finished product sizes and to provide void space for the crushed particles produced in the cavity. Maximum production will be obtained when the crusher operates at or near full horsepower load continuously. To achieve this condition, plant design, feed distribution and the type of crushing cavity are factors which warrant considerations. The schematic arrangement shown in Figure 3 permits the crusher to operate with a controllable feed rate. The circuit shown in Figure 3 offers the optimum in crusher feed control and automation. The new feed is withdrawn from the bin directly to the crusher assuring a steady, controllable feed rate. In a properly fed crushing cavity the material is distributed in a manner which utilizes the entire circumferential area of the receiving opening. It is equally important to have the finer gradations in the feed interspersed with the coarse feed.

To meet variations in feed size and product requirements, the Short Head Cone can be equipped with various designs of fine, medium, coarse or extra coarse crushing cavities. Essentially, the same considerations for selecting the crushing cavity should be used in this stage as was described for the Standard Cone crusher.

When the feed material is relatively nonabrasive, the crushing cavity selection is usually made to permit a condition where the entire cavity is filled up or "choked". A certain degree of self-regulation takes place under these conditions.

When crushing a material which is both hard and abrasive, it is possible that the full motor power can be drawn without having the



CRUSHING

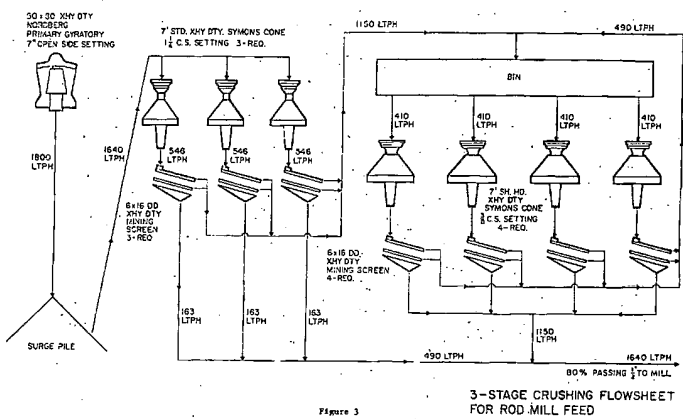


Figure 3

crushing cavity entirely filled up or "choked". As the crusher liners wear, the condition will develop where a "choked" cavity can be observed.

The normal 10 to 30 kilowatt fluctuations in the tertiary position are much less than those observed in the secondary due to better control of feed consist and control.

Refer to Tables 6 through 8 for capacities and product analyses for secondary and tertiary Cone crushers.

GRADATION

CONE CRUSHERS

Table 6

SCREEN ANALYSES
SYMONS CONE CRUSHER
"OPEN CIRCUIT"

PRODUCT SIZE	CLOSED SIDE SETTING OF CRUSHER										
	2½"	2"	1½"	1¼"	1"	7/8"	3/4"	5/8"	1/2"	3/8"	1/4"
+ 4½"	2%										
-4½" + 4"	4%										
-4" + 3½"	6%	3%									
-3½" + 3"	12%	5%									
-3" + 2½"	16%	13%	4%								
-2½" + 2¼"	9%	10%	5%	2%							
-2¼" + 2"	7%	10%	7%	4%							
-2" + 1½"	8%	10%	11%	6%	3%						
-1½" + 1¼"	7%	10%	13%	12%	6%	4%					
-1¼" + 1¼"	7%	9%	14%	16%	12%	7%	4%				
-1¼" + 1"	5%	8%	13%	17%	19%	17%	12%	6%			
-1" + 7/8"	2%	3%	6%	7%	11%	12%	11%	6%	3%		
-7/8" + 3/4"	2%	3%	5%	7%	9%	12%	13%	12%	6%		
-3/4" + 5/8"	2%	3%	4%	7%	10%	11%	14%	16%	12%	4%	
-5/8" + 1/2"	11%	2%	4%	5%	8%	10%	12%	17%	19%	12%	
-1/2" + 3/8"		11%	3%	4%	6%	8%	12%	14%	20%	24%	8%
-3/8" + 5/16"			11%	2%	3%	4%	4%	7%	10%	14%	13%
-5/16" + 1/4"				11%	2%	3%	4%	5%	8%	12%	19%
-1/4" + 3/16"					11%	12%	2%	4%	6%	12%	20%
-3/16" + 6M							12%	3%	4%	7%	12%
-6M + 10M								10%	12%	6%	11%
-10M + 14M										9%	4%
-14M + 28M											13%
-28M											
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

CONE CRUSHERS

Table 7

GRADATION

SCREEN ANALYSES

"CLOSED CIRCUIT"

These average table values will vary with the method of feeding, selection of crusher cavity, the weight, cleanliness & moisture contents of the material and its fracture pattern. Accurate values should be established by actual testing.

PRODUCT SIZE	TOP SIZE OF PRODUCT			
	3/4"	5/8"	1/2"	3/8"
+ 5/8"	4%			
- 5/8" + 1/2"	12%	6%		
- 1/2" + 3/8"	24%	19%	8%	
- 3/8" + 5/16"	14%	15%	13%	4%
- 5/16" + 1/4"	12%	16%	19%	12%
- 1/4" + 3/16"	12%	15%	20%	24%
- 3/16" + 6M	7%	11%	16%	24%
- 6M + 10M	6%	7%	12%	21%
- 10M + 14M	2%	3%	3%	4%
- 14M + 28M	7M	8%	3%	4%
- 28M			6%	7%
	100%	100%	100%	100%

CONE CRUSHERS

Table 8A

CONE CRUSHER CAPACITY CHARTS

Cone crusher capacity charts are developed for use as an application tool to properly utilize the machine's capabilities when operated in closed circuit. Symons cone crushers have 3 separate and distinct capacities (see diagrams on following page). The difference between these is the point in the circuit at which the measure is taken in either open circuit or closed circuit operation. The crusher is one component of the circuit. As such, its performance is in part dependent on the proper selection and operation of feeders, conveyors, screens, supporting structure, electric motors, drive components and surge bins. Where used, attention to the following factors will enhance crusher capacity and performance.

1. Proper selection of crushing chamber for material to be crushed.
2. A feed grading containing proper distribution of the particle sizes.
3. Controlled feed rate.
4. Proper feed distribution 360° around the crushing chamber.
5. Discharge conveyor sized to carry maximum crusher capacity.
6. Properly sized scalping and closed circuit screens.
7. Automation controls.
8. Adequate crusher discharge area.

The following factors will detract from crusher capacity and performance.

1. Sticky material in crusher feed.
2. Fines in crusher feed (smaller than crusher setting) exceeding 10% of crusher capacity.
3. Excessive feed moisture.
4. Feed segregation in crusher cavity.
5. Improper feed distribution around circumference of crushing cavity.
6. Lack of feed control.
7. Inefficient use of recommended connected horsepower.
8. Insufficient conveyor capacity.
9. Insufficient scalper and closed circuit screen capacities.
10. Insufficient crusher discharge area.
11. Extremely hard or tough material.
12. Operation of crusher at less than recommended full load countershaft speed.

The capacities shown in the tables are based on results obtained from thousands of installations worldwide, crushing the broadest range of ores, rocks and minerals to determine effect of individual conditions. Consult Rexnord Process Machinery Division.

USING THE CHARTS ON THE FOLLOWING PAGES

To determine crusher capacity for proposed installation, determine whether crusher is to be operated in open circuit or closed circuit, as shown in schematic on following page.

For Open Circuit Operation:

- A. Capacities shown in column listed as "Capacity 3" lists the capacities of all size short head crushers in tons per hour passing through crusher. Recommended closed side setting for each crusher size and type of cavity is listed from left to right.
- B. To determine exact tonnage, using known data of proposed feed size and tonnage, select correct size machine and proper type of crushing schematic on following page.

For Closed Circuit Operation

- A. Column listed as "Capacity 1" shows capacity at various settings of each size. Crusher to produce a net finished product passing the effective square opening of the screen.
- B. Using known data on proposed feed size and tonnage required, select correct size machine and proper type of crushing cavity.

Crushing Cavity Selection:

For preliminary selection of crushing cavity, proposed feed grading top size should pass a square opening not to exceed 80% of "D" dimension at open side.

Note: Capacities shown in column listed as "Capacity 2" are provided to assist in the proper sizing of conveyors, feeders and screens. These capacities are based on an average screen efficiency of 90%.

Table 8B

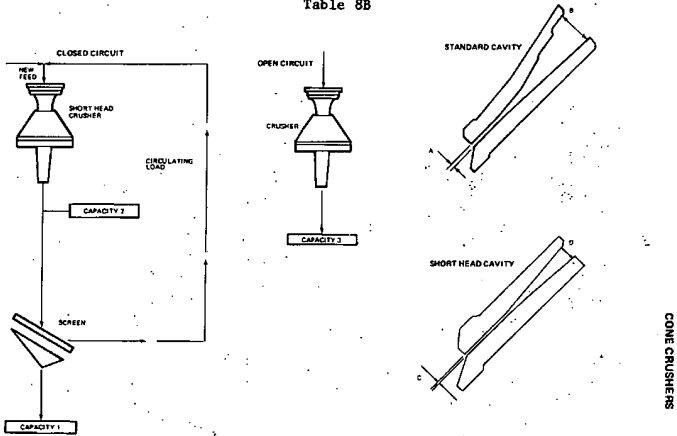


Table 8C

STANDARD SYMONS CONE CRUSHERS—OPEN CIRCUIT / Cavities Feed Openings Product Sizes Capacities*												
Size	Type of Crusher	Recommended Minimum Discharge Setting, A	Feed Opening With Minimum Return Mandrel Discharge Setting, B									
			Capacities in Tons (2000 lb.) Per Hour Passing Through the Crusher at Indicated Discharge Setting A									
			B Closed Side	B Open Side	1/4" 6 mm	3/8" 10 mm	1/2" 13 mm	5/8" 16 mm	3/4" 19 mm	7/8" 22 mm	1" 25 mm	1 1/4" 32 mm
2 ft.	Fine	1 1/4"	2 1/4"	2 3/4"	19	20	25	30	35	40	45	50
	Coarse	3/8"	3 1/4"	3 3/4"	70	75	75	75	75	75	75	75
	Extra Coarse	1/2"	5 1/2"	4"								
3 ft.	Fine	3/8"	3 3/8"	4 1/8"	40	50	60	70	75	80	80	80
	Coarse	1/2"	6 1/8"	5 1/16"								
	Extra Coarse	3/4"	8 3/8"	7 1/2"								
4800	Fine	3/8"	5"	5 5/8"	70	80	110	130	140	150	170	
	Medium	1/2"	8 1/8"	6 3/4"								
	Coarse	3/4"	10 3/8"	9 1/4"								
5100	Fine	1/2"	4 1/2"	5 3/8"								
	Medium	3/8"	7 3/8"	6 1/4"								
	Coarse	1"	10 3/8"	9 1/4"								
5 1/2 ft.	Fine	3/8"	7 1/8"	7 3/4"								
	Medium	1"	10 3/8"	9 1/4"								
	Coarse	1 1/2"	13 1/2"	12 1/2"								
7 ft.	Fine	3/4"	10"	11"								
	Medium	1"	11 1/2"	12 3/4"								
	Coarse	1 1/2"	14 3/4"	13 1/2"								
10 ft.	Fine	1"	12 1/2"	14"								
	Medium	1 1/2"	15 1/2"	17"								
	Coarse	2"	18 1/2"	20"								

CONE CRUSHERS

CONE CRUSHERS

Table 8D
SHORT HEAD CAPACITIES

Size	Capacity	Minimum Discharge Setting C	Feed Opening D At Max. Discharge Setting C	D 1 Closed Side	D 2 Open Side	EFFECTIVE SQUARE OPENING OF SCREEN CLOTH ON CLOSED CIRCUIT SCREEN														
						3/16"			1/4"			3/8"			1/2"			5/8"		
						CLOSED SIDE SETTING in closed circuit, recommended to operate the circulating load in closed circuit operation, normally less than closed circuit screen opening.														
						CAPACITY 1: Not finished product (from underlies) CAPACITY 2: Total TPH passing through crusher, not limited product after circulating load. CAPACITY 3: Approximate TPH passing through crusher in open circuit operation. See circuit schematic.														
						1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
2 ft.	Fine	1/8"	3/4"	1 3/8"		18"	30	18	37 1/2"	13	26	23	15	28	25	3/16"	30	38"	40	28
	Coarse	3/16"	1 1/2"	2"		10	26	22	13	26	22	15	26	25	75	40	34	35	45	40
3 ft.	Fine	1/8"	1/2"	1 3/8"		18"	30	50	48	30	56	64	40	60	58	55	75	64	80	80
	Medium	1/8"	1"	2"		18"	30	50	48	30	56	64	40	60	58	55	75	64	80	80
	Coarse	3/16"	1 1/2"	2"		10	26	22	13	26	22	15	26	25	75	40	34	35	45	40
4 ft.	Fine	3/16"	1 1/8"	3"		30	80	72	40	80	72	65	90	81	85	120	102	100	120	111
	Medium	5/16"	2 1/2"	3 1/2"		30	80	72	40	80	72	65	90	81	85	120	102	100	120	111
	Coarse	1/2"	2 3/4"	4"		65	105	86	85	130	111	100	130	115	100	130	115	125	145	135
5 ft.	Fine	3/16"	1 1/8"	2 1/2"		45	100	90	55	100	90	80	110	98	105	150	128	125	160	136
	Medium	3/16"	1 5/8"	3"		45	105	92	66	130	106	80	120	108	105	160	136	125	170	145
	Coarse	5/16"	2 3/4"	4"		80	130	115	110	185	140	140	205	176	175	240	192	200	240	210
	Extra Coarse	5/8"	4 3/4"	5 1/2"		140	210	185	175	260	230	230	350	290	250	350	290	320	360	320
5 1/2 ft.	Fine	3/16"	1 3/8"	2 3/4"		85	130	124	125	200	180	175	230	196	210	240	204			
	Medium	1/4"	2 1/8"	3 1/2"		80	165	156	125	200	180	175	230	196	210	240	204	240	204	
	Coarse	3/8"	3 3/4"	4 1/2"		140	210	210	175	250	220	220	310	280	280	380	320	380	320	
	Extra Coarse	1/2"	7 1/4"			175	260	230	220	350	290	290	450	380	380	500	420	500	420	
7 ft.	Fine	3/16"	2"	3 3/4"		120	240	230	160	240	230	280	350	305	315	435	390	380	450	400
	Medium	3/8"	3 7/8"	5 3/4"		120	240	230	160	240	230	280	350	305	315	435	390	380	450	400
	Coarse	1/2"	5"	7"		315	400	408	360	500	468	360	500	468	450	560	500	530	600	560
	Extra Coarse	5/8"	8 1/4"	10"		360	620	510	450	620	510	450	620	510	450	620	510	450	620	510
10 ft.	Fine	1/4"	3"	5"		500	800	720	670	1000	850	850	1100	935	800	1200	960	1150	1450	1150
	Medium	1/2"	4"	6"		500	800	720	670	1000	850	850	1100	935	800	1200	960	1150	1450	1150
	Coarse	5/8"	7"	9"		850	1100	935	800	1200	960	1150	1450	1150	1250	1550	1250	1550	1250	1550
	Extra Coarse	3/4"	8"	10"		850	1200	1040	850	1200	1040	850	1200	1040	850	1200	1040	850	1200	1040

CONE CRUSHERS

CONE CRUSHERS

Gyradisc® (Quarternary) Stage (Refer to Fig. 4)

The Gyradisc is applied as a fourth or final stage crusher. The Gyradisc normally handles feed of less than 50 MM (1 to 1/2 In.).

Feed and product size ranges for the Gyradisc are as follows:

Feed Size -- 75 MM (3 In.) Maximum

Finished Product Range -- 12 MM (1/2 In. to #20)

Gyradisc crushers are specialized reduction machines. They are designed to economically produce large quantities of cubical product from stone, gravel, ores, and nonmetallic minerals. The feed for Gyradisc crushers usually has a top size not larger than 75 MM (3 In.) for the larger units and 30 MM (1-1/4 In.) for the smaller size crushers.

Gyradisc crushers differ from conventional cone-type crushers because the comminution of material is achieved by a reduction process called Inter-Particle Comminution. This principle of reduction utilizes a combination of impact and attrition of a multi-layered mass of particles.

For proper operation, the crusher always operates with a choke level in the cavity. A controlled feed rate permitting a constant power draw is required for an efficient circuit.

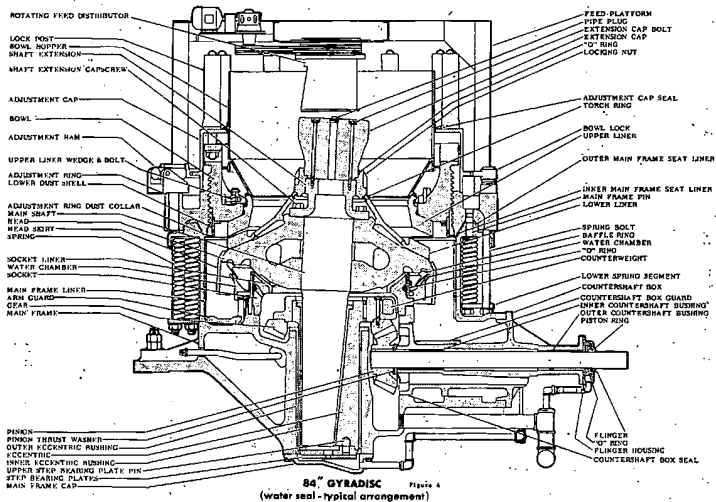
Through proper application of the Gyradisc crusher, mill feeds of 100 percent passing 3, 4, and 6 mesh are attainable. The crushing action of the Gyradisc crusher results in circulating loads of less than 50 percent of the new feed rate when closed circulating on 3 mesh, to 150 percent when closing the circuit on 6 mesh.

One 84" Gyradisc crusher is rated to produce 180 tons per hour of 3 mesh screen undersize. The flow sheet, Figure 5, shows the equipment required to produce the finer mill feed.

Using the arrangement shown in the flow sheet, mill feed rates are increased by a minimum of 20 percent over the rates possible when feeding the nominal 12 MM (1/2 In.) size. The work index and the final grind, however, directly influence the degree of feed rate improvement.

Refer to Tables 9 through 11 for capacities and product analyses for Gyradisc crushers.

® Gyradisc is a registered trademark of Rexnord, Inc.



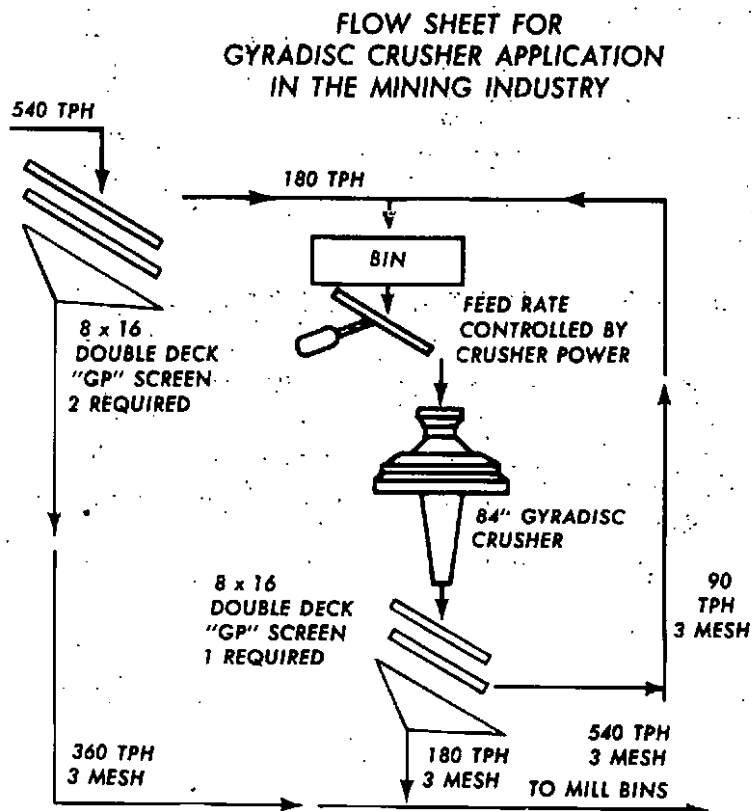
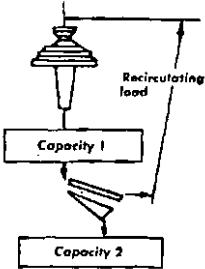


Figure 5

Table 9
Capacity table based on closed circuit operation

GYRATORY CRUSHER DESIGNATION		HEAD DIAM. INCHES (MILLI-METRES)	CAPACITY 1 TOTAL TON THRU CRUSHER	CAPACITY 2 IN TONS (1000 LBS.) PER HOUR (SCREEN UNDERSIZE)										
				RECOMMENDED SCREEN SIZE										
				375" (9mm)	250" (6mm)	185" (4mm)	131" (3mm)	99" (2mm)	65" (1.6mm)	48" (1.2mm)	36" (0.9mm)	28" (0.7mm)	22" (0.5mm)	ASTM C-33 SPEC SAND
36"	900	36"	65-75	60	50	35	30	23	18	15	10			10-15
GD	GD	(914mm)		6'x12' SD	6'x12' SD	6'x14' SD	6'x14' DD	5'x14' DD	6'x14' DD	6'x20' DD	6'x20' DD			
48"	1200	48"	115-130	105	80	55	45	40	30	25	17			34-40
GD	GD	(1219mm)		6'x12' SD	6'x14' SD	6'x14' SD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	
66"	1650	66"	190-210	160	120	85	70	60	45	40	25			55-60
GD	GD	(1676mm)		5'x12' SD	6'x20' SD	6'x20' SD	6'x16' DD	6'x16' DD	6'x20' DD	6'x16' DD	6'x20' DD	6'x20' DD	6'x20' DD	
84"	2100	84"	265-300	250	180	130	100	90	70	60	40			80-70
GD	GD	(2134mm)		6'x14' SD	6'x20' SD	6'x20' SD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	6'x20' DD	

Closed circuit



Capacities shown are neither maximum nor minimum, and are based on results secured in actual practice. The figures shown apply to short tons of material weighing 100 pounds per cubic foot, and are based on a properly graded feed with the crusher consuming a minimum of 80% of the recommended horsepower. A feed size of minus 3/4" is typical, but a minus 1 1/4" feed can be readily accepted. Optimum capacity is obtained with a closed side setting ranging between 1/4" and 3/8". The setting is not necessarily related to the closed circuit screen opening. Factors which may affect capacity include, size of feed, friability, toughness and moisture content. Figures shown under column "TPH THRU CRUSHER" are included for calculating screen areas. For finer product requirements, contact Rexnord Process Machinery Division.

SD and DD signifies single deck or double deck screen.

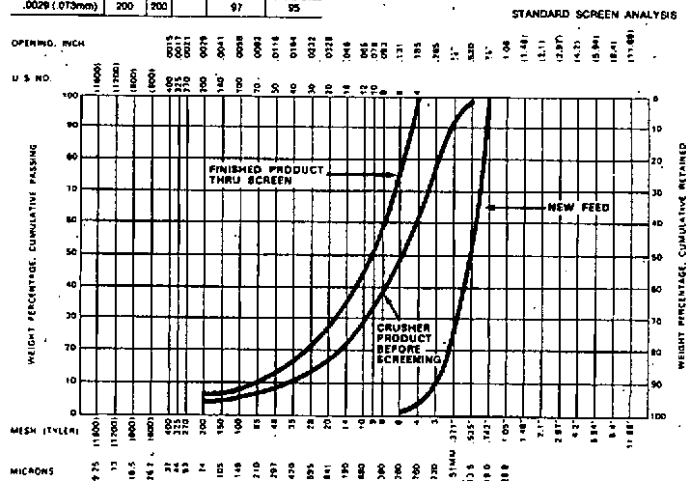
PRODUCTION CURVES

GYRADISC CRUSHERS

Table 10

SIZE SIEVE (INCHES)	MESH (TYLER)	U.S. NO.	CUMULATIVE PER CENT RETAINED		
			NEW FEED	CRUSHER PRODUCT BEFORE SCREENING	FINISHED PRODUCT THRU SCREEN
1.48 (38mm)					
1.06 (27mm)					
.742 (19mm)					
.525 (13mm)			47	1	
.371 (9mm)			81	7	
.263 (7mm)	3		91	21	
.185 (5mm)	8	4	97	36	
.131 (3mm)	8	8	99	61	19
.083 (2mm)	8	8		82	42
.063 (1.6mm)	10	12		75	55
.048 (1mm)	14	16		77	64
.0329 (.833mm)	20	20		83	73
.0232 (.589mm)	28	30		86	78
.0164 (.416mm)	35	40		89	85
.0116 (.294mm)	48	60		92	88
.0082 (.206mm)	85	70		93	89
.0058 (.147mm)	100	100		95	92
.0041 (.104mm)	150	140		98	94
.0029 (.073mm)	200	200		97	95

Feed: Copper Ore
Product: Ball Mill Feed



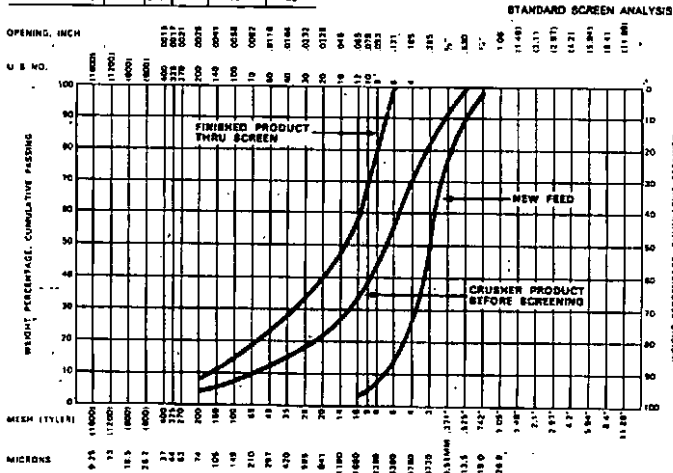
GYRADISC CRUSHERS

PRODUCTION CURVES

Table 11

SIZE U.S. SIEVE	MESH (TYLES)	U.S. NO.	CUMULATIVE PER CENT RETAINED		
			NEW FEED	CRUSHER PRODUCT BEFORE SCREENING	FINISHED PRODUCT THRU SCREEN
1.40 (35mm)					
1.00 (25mm)					
.742 (18mm)			1		
.525 (13mm)			8		
.371 (8mm)			21	8	
.260 (7mm)	3		49	16	
.180 (5mm)	4	4	72	27	
.131 (3mm)	6	6	84	42	
.092 (2mm)	8	8	92	53	19
.065 (1.6mm)	10	12	97	63	28
.046 (1mm)	14	16		72	32
.0325 (.833mm)	20	20		77	36
.0232 (.568mm)	28	30		81	38
.0184 (.416mm)	35	40		85	40
.0118 (.294mm)	48	60		87	42
.0082 (.208mm)	65	70		90	44
.0058 (.147mm)	100	100		92	45
.0041 (.104mm)	150	140		94	46
.0029 (.073mm)	200	200		96	47

Feed: Iron Ore
Product: Ball Mill Feed



FINE CRUSHING PLANT FLOW SHEETS

The trend in design of fine crushing plants is in the direction of the horizontal arrangement with all crushers on a single floor. Conveyors from the coarse ore bin or stockpile feed scalping screens are usually double decked. When the feed to the fine crushing plant contains less than 15 percent passing 19 MM (3/4 In.) and less than three percent moisture, the scalping screens ahead of the secondary crushers can be eliminated without adverse effects to the crusher.

This practice has been followed successfully in several Minnesota taconite installations. The secondary crusher product is screened and conveyed to bins ahead of the tertiary crushers. The tertiary crushers operate in either open or closed circuit with a variety of arrangements available in positioning the tertiary screens. The screens can be placed above or below the tertiary crushers or in a separate screenhouse. With the advent of automatic crusher feed control systems it becomes important to reduce the reaction time between the feed control mechanism, such as a vibrating or belt feeder, and the crusher to a minimum.

Where secondary and tertiary crushers are stacked with a scalping screen between the two, surge and feed control for the tertiary crusher becomes more difficult. This results in lower efficiency from a power utilization standpoint. The initial cost of construction for this type of plant is usually lower than the aforementioned horizontal layout.

The positioning of the secondary and tertiary crushers depends on a variety of factors including terrain, moisture level in the ore, storage capacity both before and after fine crushing, and beneficiation steps.

Usually the fine crushing plant is located some distance from the primary with an intermediate ore storage facility between. The operation of the fine crushing plant is independent, to a large degree, of the performance of the primary crusher.

A great deal of thought has been given to the problem of attaining maximum efficiency in this type of operation. Efficiency is measured by the work of reduction on the ore per unit of time and by percent running time. The work of reduction is represented by tonnage of throughput and degree of size reduction.

To attain the maximum work of reduction, each crusher must be kept at full capacity. The capacity may be limited volumetrically in the case of softer ores, or by the horsepower that can safely be applied to the crusher in the case of harder ores.

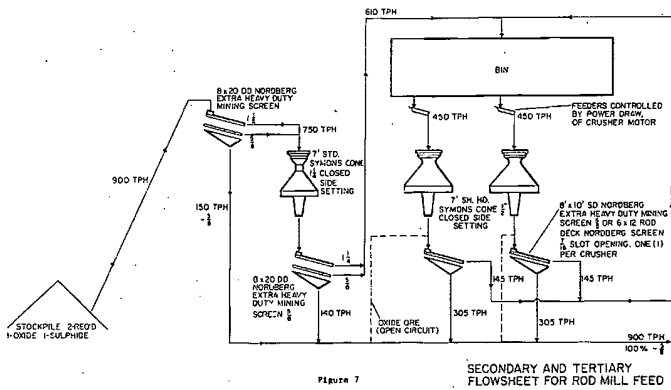
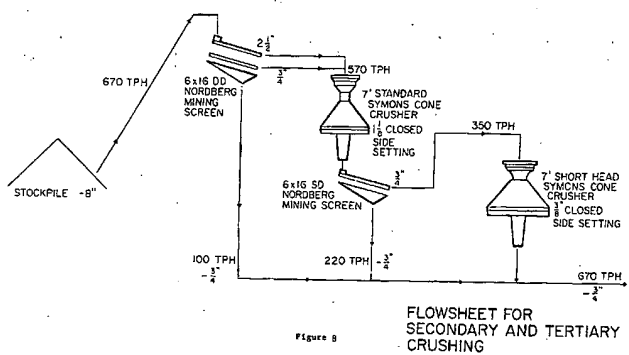


Figure 7
SECONDARY AND TERTIARY
FLOWSHEET FOR ROD MILL FEED



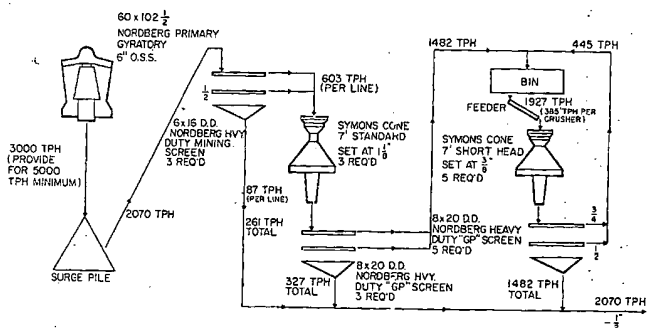


Figure 9 3 STAGE CRUSHING FLOWSHEET FOR SINGLE STAGE BALL MILLING

CRUSHING

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3. Data supplied by Remord.