MINERAL DEPOSITS LIMITED
(INCORPORATED IN NEW SOUTH WALES)
81 ASHMORE ROAD, BUNDALL, QUEENSLAND, AUSTRALIA 4217

APPLICATIONS OF SPIRAL CONCENTRATORS IN FINE COAL PROCESSING

LESLIE E. APODACA

MANAGER COAL PREPARATION
MINERAL DEPOSITS (AMERICAS) INC.

INTRODUCTION

The use of spiral concentrators for processing fine coal particles is an old idea that has recently gained acceptance in the U.S. coal industry.

It was not until the Australian Minerals Industry developed a spiral concentrator specifically for separating coal from ash in the latter 1970's and early 1980's that spiral concentrators were seriously considered as viable equipment for processing fine coal.

The Wright Coal Spiral was introduced in 1980, the Mineral Deposits Limited Mark 10 Coal Spiral was introduced in 1982, and the Vickers Wyong Coal Spiral was introduced in the latter part of 1984. Each spiral design was different and utilized constant profile troughs, constant pitch troughs, compound profile troughs, and various splitter arrangements.

Mineral Deposits Limited has combined the best features of the compound profile trough and constant pitch trough with critically-placed splitters to develop the MDL LD4 spiral concentrator which is a truly efficient coal washing spiral. This spiral concentrator was introduced into the U.S. Coal Industry in 1987.

Recently, Mineral Engineering Technology of the United Kingdom and Multotec of South Africa have introduced their own coal spiral designs.

Spiral concentrators were first installed in fine coal processing circuits in the Australian, South African, and Canadian Coal Industries in the early 1980's and in the U.S. Coal Industry in 1985.

SPIRAL CONCENTRATOR SEPARATION PROCESS

The separation process that occurs within the spiral concentrator trough is very complex, as it is a combination of three gravity separtion processes. When the coal slurry first enters the spiral trough, each coal and ash particle and the water is subjected to centrifugal forces. These forces cause the water, light coal particles, fine heavy ash particles, and medium middlings particles to the outer vertical portion of the spiral trough. The coarse ash particles and the coarse middling particles remain on the inside of the spiral trough. The center or transitional area of the trough contains a mixture of middlings particles and near-gravity material that is present in the slurry, as shown in Figure 1.

At the same time the coal and ash particles are subjected to centrifugal forces, the trough design (both profile and pitch) causes the particles to be subjected to flowing film and stratified bed separations. The combination of these three separations, whose efficiency is dictated by the spiral trough design, will effect the separation of the lighter coal particles from the heavier ash and middlings particles.

As the slurry flows down the spiral, the profile and pitch design of the trough will counteract the centrifugal forces on the fine, heavy ash particles and fine middlings particles and cause them to migrate from the vertical portion of the trough to the center or inner portion of the trough. At the same time, any heavy particles trapped in the transitional area of the trough will be forced to migrate to the inner edge of the trough and any coal particles will be forced to migrate to the outer edge of the trough.

SPIRAL SPLITTER ARRANGEMENT

The critical placement of splitters along the inner edge of the trough for removal of the heavy ash particles as the slurry flows down the trough further enhances the separation of the coal particles. At the bottom of the spiral trough are product splitters arranged to make a final separation of the slurry stream into clean coal, middlings, and refuse products.

CROSS SECTION OF A SPIRAL STREAM

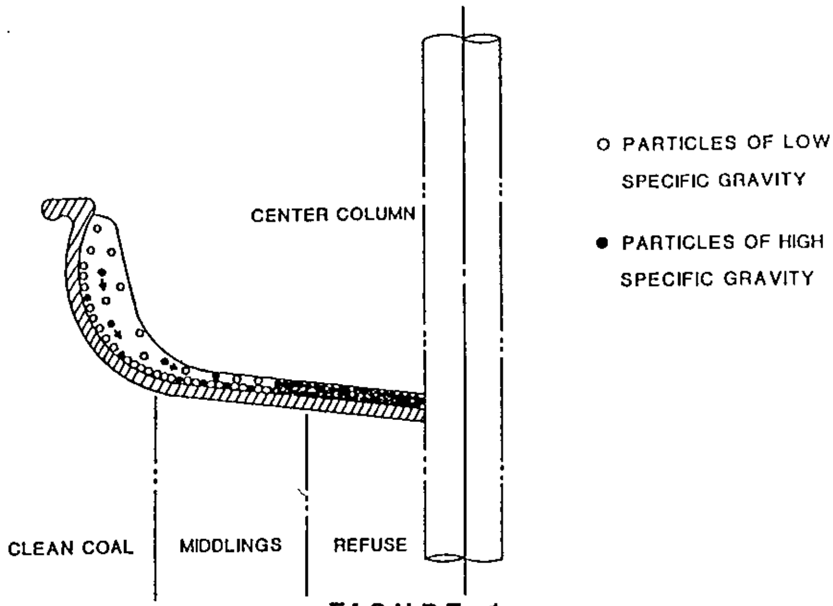


FIGURE 1

This three-product split at the bottom of the spiral is very important when a difficult-to-wash coal is being processed. The clean coal splitter can be adjusted to obtain a low ash clean coal product and the refuse splitter can be adjusted to obtain a very high ash refuse.

The middlings stream can then be further processed by a second-stage spiral circuit to obtain a clean coal product which can be blended back into the clean coal product from the primary spiral circuit. The middlings and refuse streams from the secondary stage spiral circuit would report to refuse.

SPIRAL FEED CONSIDERATIONS

In general, the feed slurry to the spiral concentrators will consist of -8 X 150 mesh particles at a pulp density of 30-35% solids by weight. The pulp density in the feed is affected by the amount of ash in the feed, the amount of slimes in the feed, and the presence of clay particles.

It is important that the feed slurry to the spiral concentrators be de-slimed, even though a certain amount of oversize and undersize material can be tolerated. It should be noted that any slimes that are in the feed to the spiral concentrators will always report to the clean coal product.

Classifying cyclones or sieve bends can be utilized to deslime the feed to the spiral concentrators. Sieve bends or other desliming screens should be used to de-slime the clean coal product stream for removal of any high ash slimes that reported to the clean coal.

Spiral concentrators are arranged in single-trough, twin-trough, or triple-trough configurations mounted on a central column. Each trough is capable of processing 1.5 to 4.0 DTPH of feed material, depending upon the Manufacturer's particular spiral design. At the present time, Mineral Deposits Limited's LD4 spiral concentrator is the highest capacity spiral design on the market; the MDL LD4 comes in a triple-trough configuration that can process 4 DTPH per trough for a total of 12 DTPH per spiral concentrator.

SPIRAL CONCENTRATOR EFFICIENCY

Spiral concentrators, in general, achieve a specific gravity of separation at a relative density of 1.8 to 1.9. In some cases, depending upon the feed coal and the amount of near gravity material, the specific gravity of separation has been as low as 1.5 and as high as 2.0. The partition coefficient (Ep) corresponding to the 1.8 -1.9 S.G. of separation is, in general, 0.12 to 0.15. In some cases, again depending on the feed coal, the partition coefficient has been as low as 0.07 and as high as 0.18.

SPIRAL CONCENTRATOR APPLICABILITY

To determine the applicability of spiral concentrators in a particular fine coal processing circuit one must first obtain a true analysis of what is happening in the circuit. A determination must be made of the true feed conditions to the circuit and the true process capabilities of the particular coal preparation equipment in the circuit.

Most of the time fine coal processing equipment is simply overloaded with fine material because the tonnage throughput has increased to the coal preparation plant over and above the plant's true design capabilities. In general, there has also been a change in the underground mining equipment or its usage so that more fine material is reporting to the plant.

Spiral concentrators are capable of processing -8 X 150 mesh particles at an S.G. of separation of 1.8 to 1.9. A screen analysis of the feed to the fine coal circuit should be obtained along with the ash and sulfur analyses in each size fraction. A washability of the feed should also be obtained with particular emphasis placed on the 1.5 to 2.0 S.G. of separation. An analysis of the screen fractions and the washability will give a good indication of how a spiral concentrator will perform on a particular coal and in a particular plant.

The best procedure is to install a test spiral in the fine coal processing circuit to obtain the actual process capabilities of the spiral concentrator.

Once this information is obtained a determination can be made of how removal of the -8 X 150 mesh material or a portion of this size fraction will improve the overall efficiency and clean coal quality of the fine coal processing circuit.

SPIRAL CONCENTRATOR APPLICATIONS

Spiral concentrators are being utilized as direct replacements for such conventional coal preparation equipment as water-only cyclones (both primary and secondary circuits), fine coal jigs, and coarse froth flotation (See Figures 2, 3, and 4). Spiral concentrators are selected rather than conventional coal preparation equipment because of:

1. Higher overall clean coal yields;

2. Lower ash and pyritic sulfur in the clean coal product;

3. Ease of operation and maintenance;

4. Corrosion and erosion resistance; and

5. Reduced operating and maintenance costs.

One of the primary uses of spiral concentrators is to complement existing fine coal preparation equipment, thus allowing this equipment to operate in its optimum processing range. Spiral concentrators, in many cases, are simply more efficient than froth flotation, shaking tables and heavy media cyclones in the approximate size range of -16 X 100 mesh when this equipment is being used to process much broader particle size ranges.

Flotation cells are generally used to process -28 X 0 mesh fine particles at a pulp density of 8-10% solids by weight. In general, 10 to 20% of the feed reporting to the flotation cells are +28 mesh particles; these particles will always report to the flotation tailings because a higher pulp density of 12-14% solids by weight is required in the slurry in order for these larger coal particles to float. Unfortunately, this high of a pulp density will also cause some of the smaller (-100 mesh) ash and pyritic sulfur particles to float and thus contaminate the clean coal product.

A compromise is reached when processing -28 X 0 mesh particles in a flotation circuit. The pulp density of the slurry is too low for efficient flotation of the -28 X 100 mesh particles and too high for efficient flotation of the -100 X 0 mesh particles. In addition, the reagent dosage utilized for -28 X 0 mesh flotation is also a compromise, resulting in inefficient use of the reagents.

The incorporation of spiral concentrators into the -28 X 0 mesh froth flotation circuit (See Figure 4) will recover all of the +28 mesh and -28 X 100 mesh coal particles that previously had been reporting to the flotation tailings because of a too low pulp density and incorrect reagent dosage. The use of spiral concentrators will now allow the flotation cells to operate at the optimum pulp density and reagent dosage for recovery of the -100 X 0 coal particles.

Shaking tables also become inefficient when they are used to process -3/8 in. (or -1/4 in.) X 100 mesh material. A compromise must be reached on the slope and pitch of the table, amplitude of the stroke, and the amount of wash water required, thus resulting in the loss of fine coal to the middlings and tailings streams.

Most table circuits are also overloaded with fine material generated by continuous miners. The shaking tables are simply trying to process more material than they are designed to handle and the loss of fine coal is the result.

The addition of spiral concentrators to a shaking table circuit (See Figure 5) to process the -10 X 100 mesh particles will allow the shaking tables to be adjusted for optimum recovery of the -3/8 in (or -1/4 in.) X 10 mesh coal particles. Overall recovery in the circuit will go up since the fine coal particles are no longer being washed away.

Coal operators are presently using single heavy media cyclone circuits to process fine coal down to 100 mesh or even 0 when realistically the separation process should stop at about 16 mesh. Below this particle size range, the single heavy media cyclone circuit begins to lose its separation efficiency, magnetite losses increase, and the heavy media recovery system becomes inefficient and burdensome.

This inefficiency can be overcome by using separate coarse coal/fine coal heavy media cyclone circuits, but the capitol costs, operating costs and maintenance costs are prohibitive.

In the approximate size range of -16 X 100 mesh the spiral concentrators are as efficient as heavy media cyclones, they are much simpler to operate, and no media (other than water) is required.

The addition of spiral concentrators to a heavy media cyclone circuit (See Figures 6 & 7) washing down to 28 mesh (or 100 mesh) will accomplish the following:

1. Increase the efficiency and tonnage throughput of the heavy media cyclone circuit since the -16 X 28 mesh (or 100 mesh) fine material has now been removed from the cyclone feed;

2. Increase the efficiency of the heavy media recovery circuit and decrease the heavy media losses since the fine material has now been removed from the heavy media cyclone circuit; and

3. Reduce the operating costs of the heavy media cyclone circuit since there will now be less magnetite consumption.

Spiral concentrators are also being utilized as the primary process equipment for recovering fine (-8 X 150 mesh) coal from slurry ponds, gob piles, and coal preparation plant waste streams (See Figures 8 & 9). Spiral concentrators are selected over other conventional fine coal processing equipment because of:

1. Excellent yields in spite of oxidized coal surfaces and the presence of pyrite and clays; and

2. Simplicity of the process circuitry and equipment required for recovering this fine coal.

ECONOMIC ANALYSIS COMPARISON

A capital and operating cost comparison between a two-stage water-only cyclone circuit and a spiral concentrator circuit processing fine coal (nominal -28 X 100 mesh) is shown in Table 1.

An analysis of the operating costs between the two circuits indicates that the operating horsepower for the two-stage, water-only cyclone circuit will be greater than the spiral concentrator circuit; 242 KW versus 149 KW.

The water-only cyclone circuit will require two more sumps and pumps along with the accompanying piping. The water-only cyclone circuit will also require more floor space and building volume.

SUMMARY

Spiral concentrators will complement and enhance most fine coal processing equipment already installed in existing coal preparation plants. Spiral concentrators will also improve new preparation plant fine coal circuitry by increasing the plant capacity and increasing the overall quality and yield of the clean coal product.

REFERENCES

R.G. Richards, "Spiral Concentrators for Fine Coal Treatment." Mineral Deposits Limited, Queensland Coal Preparation Society, May 1983.

Armstrong. L.W. and Bensley, C.N. "Spiral Concentrators and Water Washing Cyclones for Fine Coal Preparation." Shortland N.S.W. Australia, BHP-CTD/R/9/85.

Apodaca, L.E. And West, T.W., "Flotation Circuit Optimization Focused on High Yield, SO2 Reduction and Minimum Moisture in the Clean Coal." Coal Prep `86, Lexington, Kentucky.

Robinson, C.N. and West, T.W., "Coal Washing Spirals - Are They Right for Your Preparation Plant?", Technical Brochure, Mineral Deposits (Americas) Inc., Golden, Colorado, 1987.

Apodaca, L.E. and West, T.W., "Cost Effective BTU Recovery By Fine Coal Washing Spirals", 1988 AMC Convention, Phoenix, Arizona.

Apodaca, L.E. and West, T.W., "The Role of Spiral Concentrators in Improving Heavy Media Cyclone Circuits", 1988 AMC MINEXPO, Chicago, Illinois.

EQUIPMENT COST COMPARISON

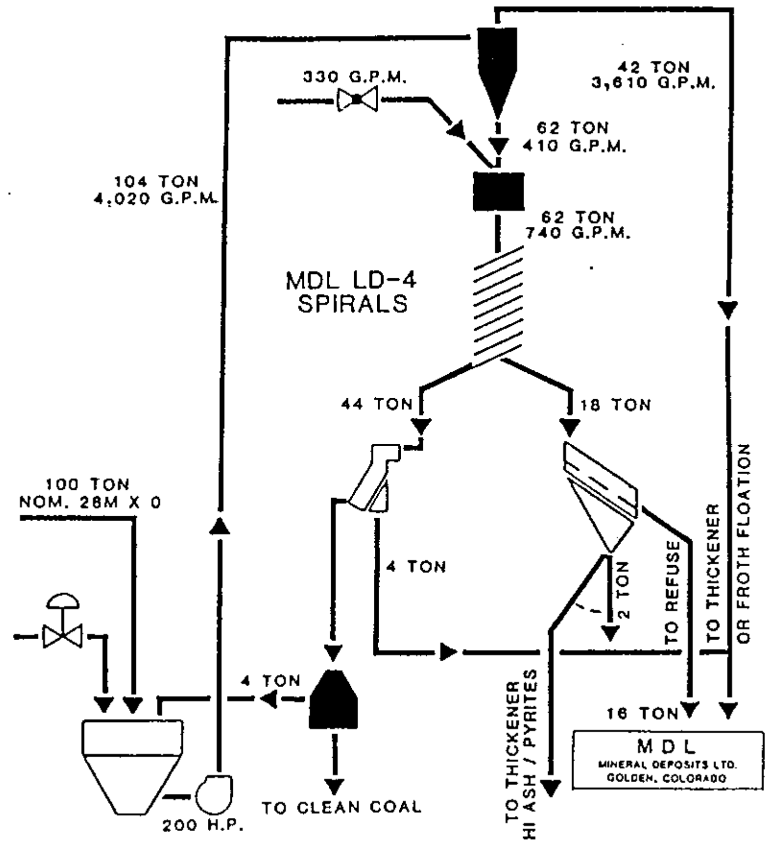
(U.S. DOLLARS)

	2-STAGE WATER-ONLY CYCLONE CIRCUIT	SPIRAL CIRCUIT
(14) WATER-ONLY CYCLONES 14 IN. DIAMETER	63,000	------
(18) LD4 COAL WASHING SPIRALS	------	75,000
(6) CLASSIFYING CYCLONES	30,000	30,000
(1) VIBRATING REFUSE DEWATERING SCREEN	20,000	20,000
(1) CLEAN COAL SIEVE BEND 100 MESH SEPARATION	10,000	10,000
(1) CLEAN COAL CENTRIFUGE 75 HP DRIVE	48,000	48,000
PROCESS SUMPS	18,000 (3)	6,000 (1)
PROCESS PUMPS	39,000 (3)	17,000 (1)
PUMP MOTORS, STARTERS, ETC. 325 CONNECTED HP 200 CONNECTED HP	24,000	12,000
	252,000	218,000

TABLE 1

TYPICAL SPIRAL OPERATION
(ALTERNATE TO TWO STAGE W.O. CYCLONES)

FIGURE 2



SUPPLEMENT TO COAL WASHING JIGS

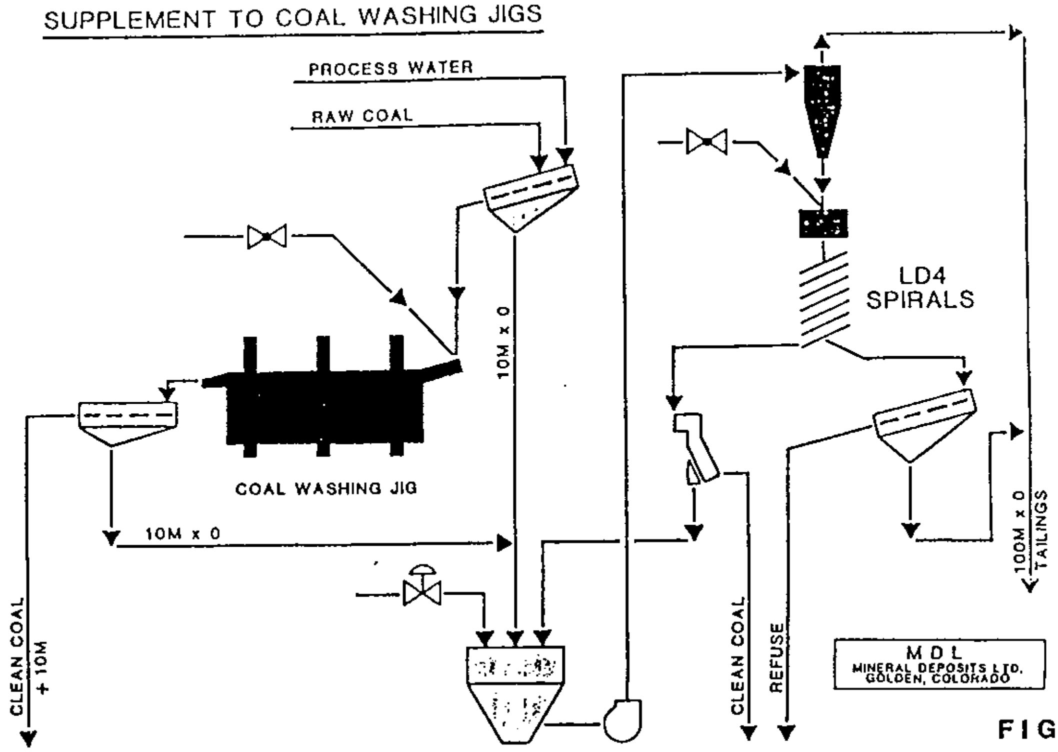


FIGURE 3

APPLICATIONS OF SPIRAL CONCENTRATORS

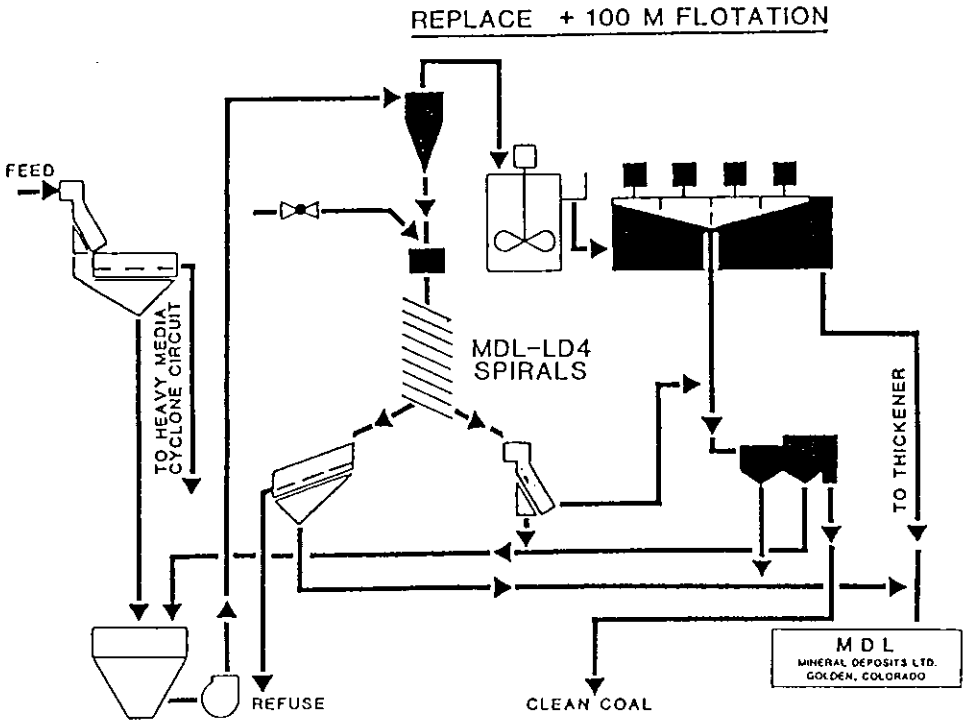


FIGURE 4

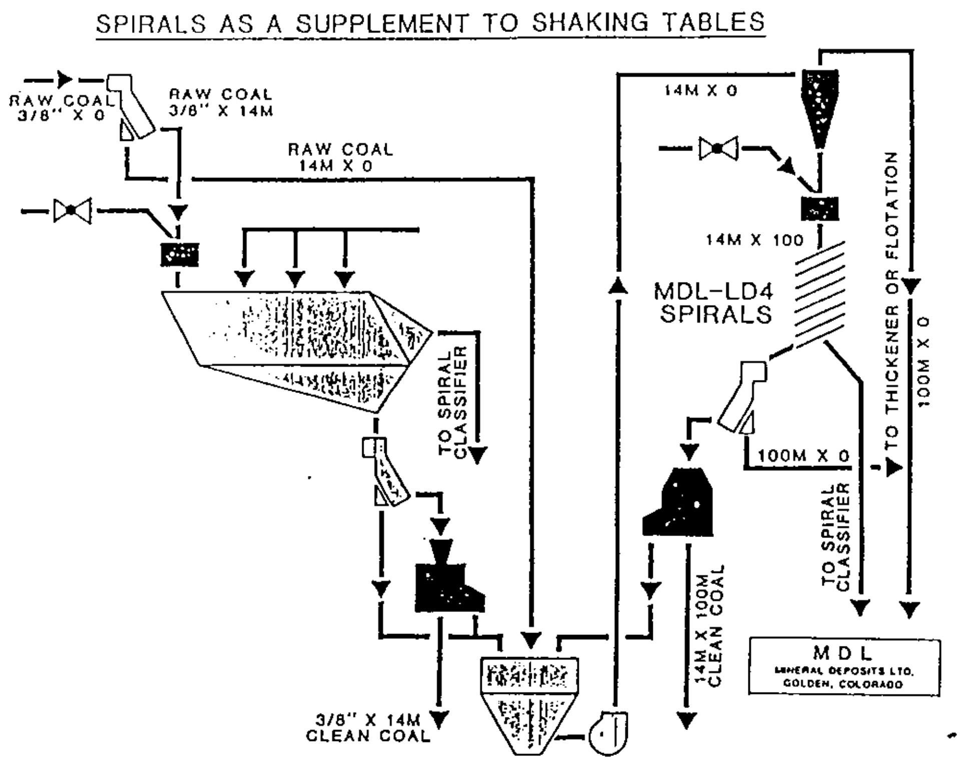


FIGURE 5

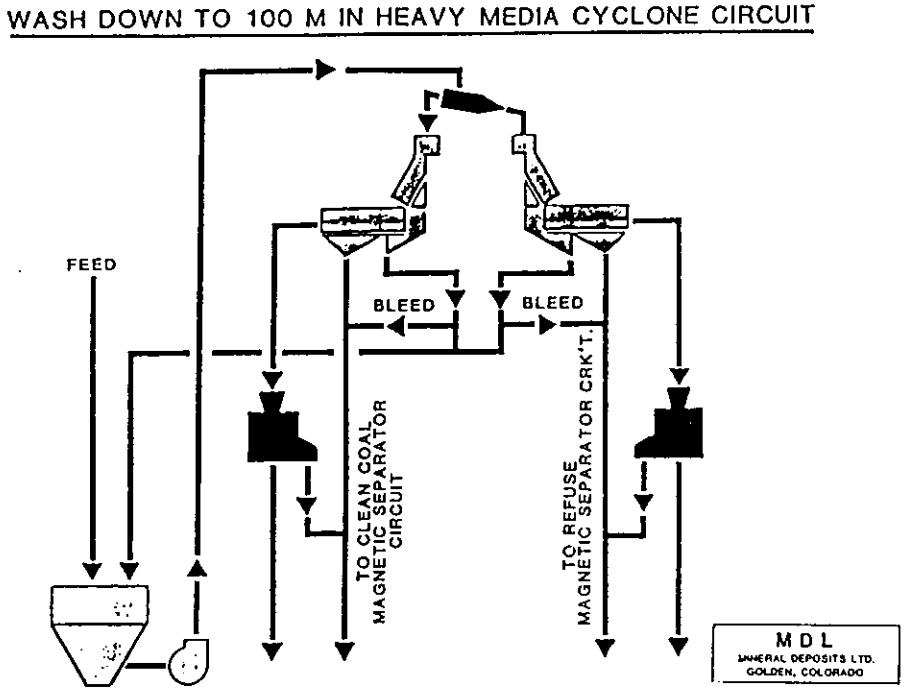


FIGURE 6

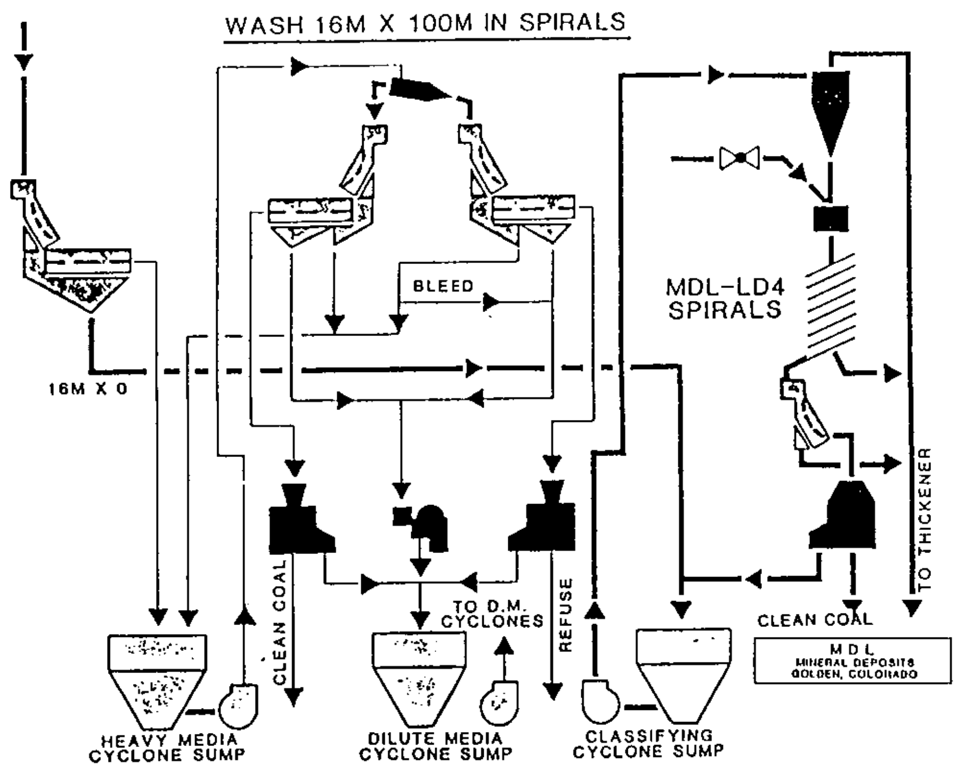


FIGURE 7

APPLICATIONS OF SPIRAL CONCENTRATORS

FINE COAL (NOMINAL 28 M x 0)
SLURRY POND RECLAMATION

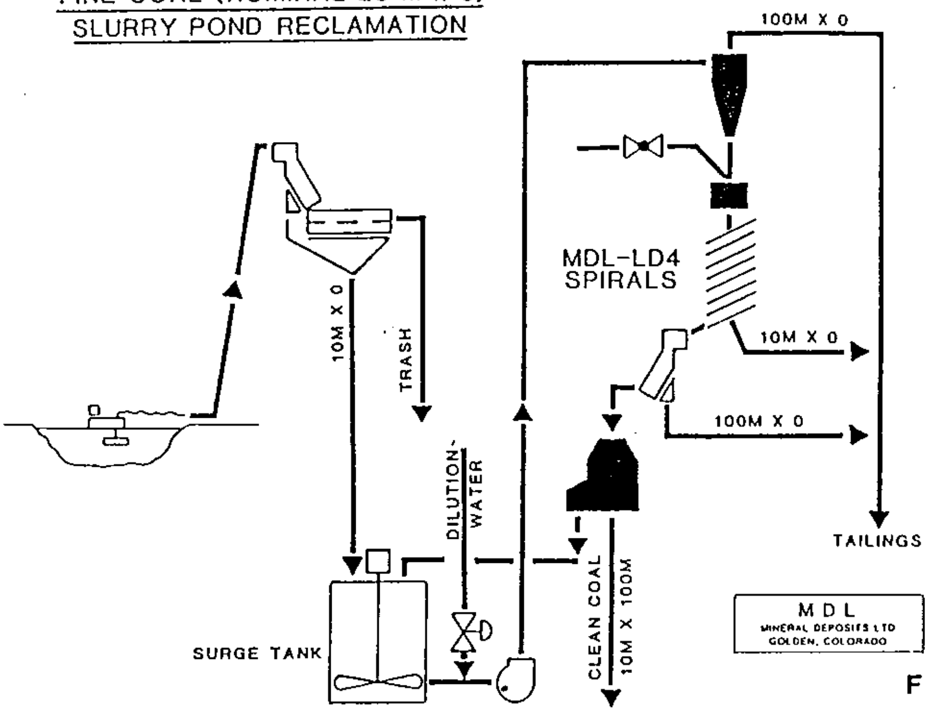


FIGURE 8

SCAVENGING STREAM REWASH
(WITH SECOND STAGE REWASH OPTION)

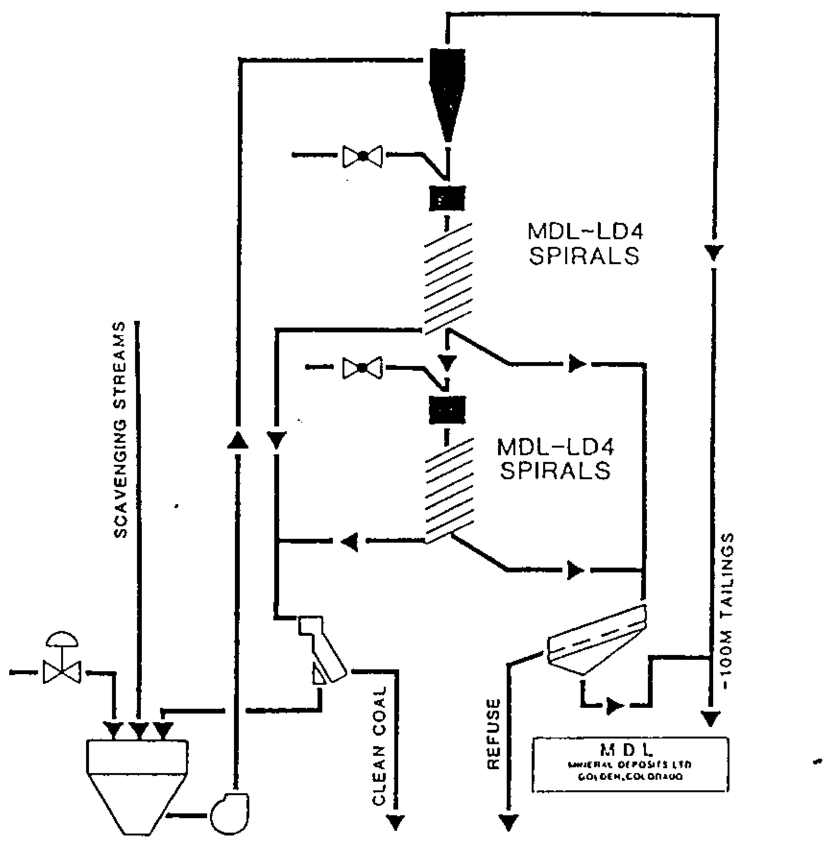


FIGURE 9

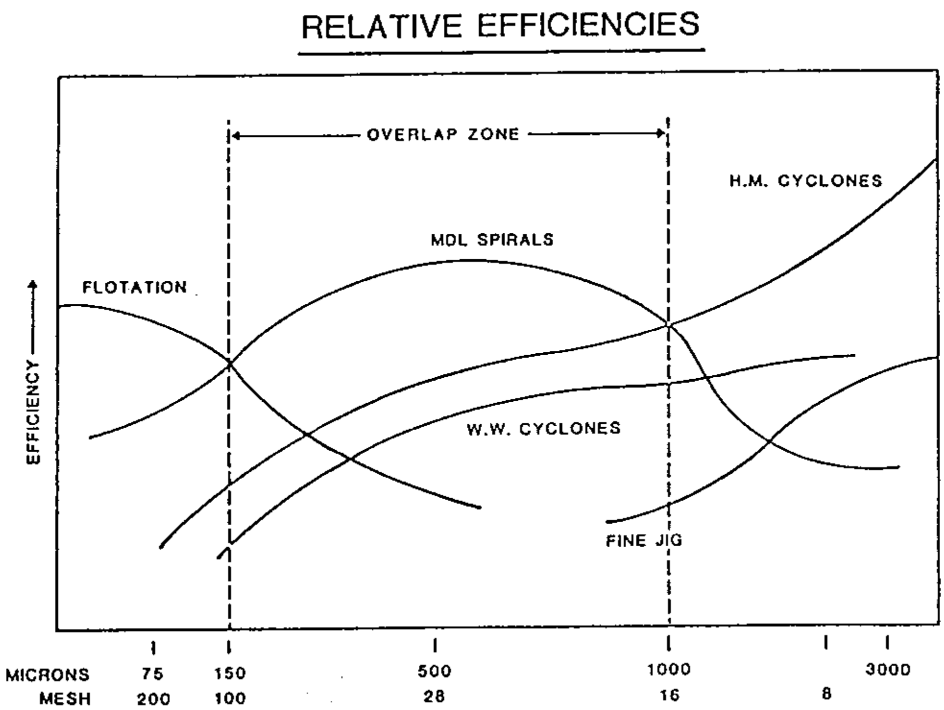


FIGURE 10

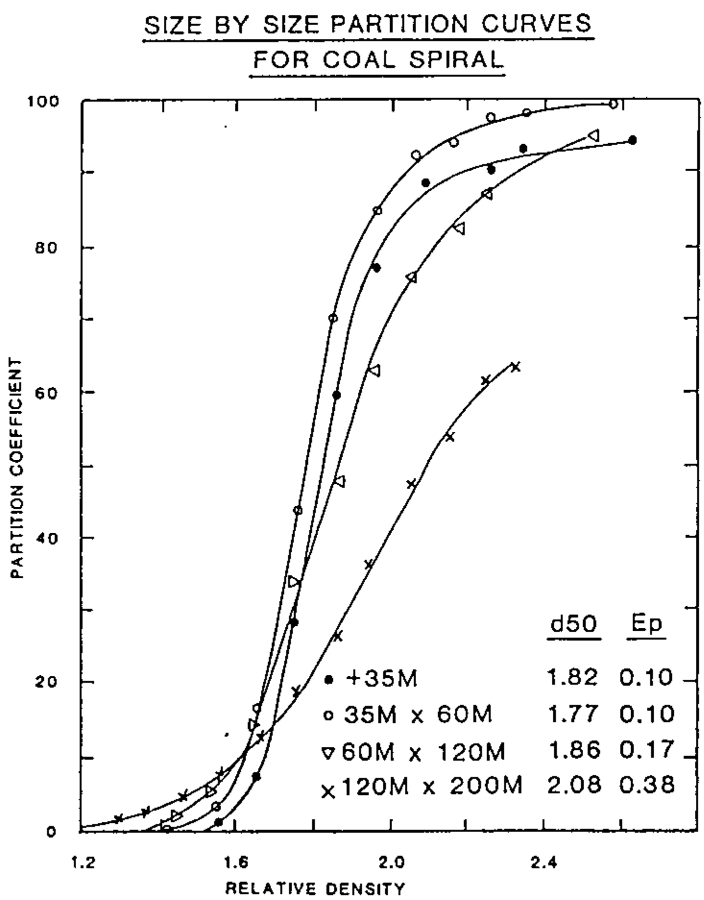


FIGURE 11