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CONFERENCE ON ALASKAN PLACER MINING

FOCUS: GOLD RECOVERY SYSTEMS

APRIL 3-4, 1979

WOOD CENTER

UNIVERSITY OF ALASKA

FAIRBANKS, ALASKA

An abridged format of papers, presentations and addresses given during the conference

ORGANIZING COMMITTEE

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The Carl G. Parker Memorial Publishing fund was established in memory of Carl G. Parker, lifelong Alaskan, graduate of the University of Alaska, Fairbanks, and an innovative, successful, Alaskan placer miner.

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Most of the afternoon session was devoted to a panel discussion addressing the topic "Environmental Requirements and Permits Required to Mine in Alaska."

Moderator of the panel: Chris A. Lambert, Head, Department of Mineral Engineering, University of Alaska, Fairbanks

The participation of the following members of the panel is gratefully acknowledged.

Pete Nelson, Leasing Manager, State Department of Natural Resources, Division of Minerals and Energy Management.

Scott Grundy, Regional Supervisor, Habitat Protection Section, Alaska Department of Fish and Game

Demming Cowles, Deputy Commissioner, State Department of Environmental Conservation

Everett O. Bracken, Development Specialist (Minerals) State Department of Commerce and Economic Development

Clyde Murray, District Geologist, Division of Resources, Bureau of Land Management

William Lamareaux, Sanitary Engineer, Federal Environmental Protection Agency, Anchorage

William Murray, Mining Attorney

Michael G. Stutter, Member of Yukon Territory Water Board and Placer Miner

George Nelson, Placer Miner

John Jacobsen, Placer Miner

APPENDICES

PREFACE

On behalf of the Alaska Miners' Association and the School of Mineral Industry, University of Alaska, Fairbanks, I am pleased to welcome each of you to this Alaskan Placer Mining conference that is basically focused on Gold Recovery Systems.

The wide degree of interest shown by Alaskans and people from other states and Canada in this meeting is most gratifying, as is the large attendance.

Overall, a healthy attitude for the placer mining industry is shown by the many small scale miners participating in this meeting, a fact which shows revitalization of a true "Alaskan life-style" for many people in the past and present and, I am sure, for increasing numbers in the future.

Sometimes overlooked is the fact that the large number of small-scale placer miners in Alaska, when taken together, constitutes an important and growing segment of Alaska's mining industry. Accordingly, a placer mining conference was decided upon that would provide information of value and benefit to the present-day miners, as well as to people interested in entering the field.

In placer mining, as in all mining, several facets compose the entire operation, such as prospecting, exploration, development, recovery methods, sale of products and environmental regulations pertaining to placer mining. This conference has for its theme "Gold Recovery Systems".

Each individual miner devises his own recovery method to meet the many and different variables that exist in placer deposits. What one miner believes is nearly a perfect recovery system for his deposit may not give good recovery to a miner in a different area. Also, a general impression is prevalent that fine-size gold is often lost in some placer systems.

With this in mind, a series of presentations will be made today, April 3, 1979, that cover various units that may be incorporated in a placer recovery system. Tomorrow morning, April 4, 1979, placer mine operators will describe their particular operations. In this way, the miners can benefit from the experience of others and ideas may develop toward further improving recovery systems in their own operations, as well as for the industry in general.

Because of the great concern for land and legislation affecting placer mining, several presentations will be made apropos to these topics at luncheons and at the evening banquet.

Specific subjects to be covered in this category are as follows; Today, Tuesday noon, Professor Alan Epps, Natural Resources and Land Use Planning Specialist, Cooperative Extension Service, University of Alaska, will discuss Land Availability and Land Concerns; this evening, J.P. Tangen, President of the Alaska Miners' Association, has for his subject "Recent Decisions Affecting Placer Mining"; and Wednesday noon Cleland Conwell, Mining Engineer with the State Division of Geological and Geophysical Surveys, will review the Claim Record Systems of the Alaska State Division of Geological/Geophysical Surveys.

Wednesday afternoon, a panel discussion will take place that has for its subject "Environmental Requirements and Permits Required to Mine in Alaska". Panel members will include State and Federal agency representatives and persons from private industry.

As we look beyond this conference to similar ones in the future, we would appreciate receiving any suggestions you may have for themes for future conferences, important topics to be covered, as well as for suggestions to further increase benefits obtained from such a meeting.

At this time, I give my sincere thanks to all who have worked with diligence and dedication on putting this conference together. These include: the Faculty and Staff of the School of Mineral Industry, University of Alaska, Fairbanks; Students in the University of Alaska, Fairbanks Mining Society; Staff of the Department of Conferences and Institutes; ARA Food Service; the Speakers; the Participants; and Odom Company/West Coast Distributors.

Again, we are happy that you have come to this meeting and we hope that you will find the presentations informative and provocative for further experimenting to increase mineral recovery efficiency and that you will be better prepared to continue and/or initiate your mining operation--and that your cleanup will meet your expectations. In this way you will make significant contributions to the Mining Industry, State and Nation.

Earl H. Beistline

Fairbanks, Alaska
April, 1979

INFLUENCE OF PARTICLE SHAPE AND SIZE ON RECOVERY OF GOLD

Donald J. Cook and P. Dharma Rao

It has long been recognized that in gravity methods of concentration, particle size and shape have the greatest influence on recovery. This presentation quantitatively defines these influences. Much of the data used is from research sponsored by the U.S. Bureau of Mines (Cook and Rao, 1970). That work is broader in scope: this presentation only considers the portions relating to size and shape of gold.

Gravity separation processes take advantage of relative settling velocities of particles. Settling velocity in turn is influenced by the size and shape of particles. We would first like to review the laws of settling, namely Stoke's Law and Newton's Law. Stoke's Law states that settling velocity increases as the square of the diameter of the particle. With decreasing particle size the settling velocity drops off very rapidly. Settling velocity also varies with density, eg. for same size particles the settling velocity of gold is ten times faster than quartz. This law is applicable for particles with a Reynold's number less than one or to particles so small that the liquid flows around them in a laminar fashion (this corresponds to 120 mesh for quartz and 270 mesh for gold). The exact law is stated as follows:

$$\text{Terminal settling velocity} = \frac{g\ (\rho_s - \rho) d^2}{18\mu}$$

$g = 981$
ρs = density of solid, gm/cc
ρ = density of liquid, gm/cc
d = particle diameter, cm
μ = viscosity of liquid, .01 centipoise for water

Using Stoke's law, the terminal velocities are:
For quartz $8990d^2$ cm/sec.
For gold $92{,}650d^2$ cm/sec.

Another law (Newton's) applies to coarser particles that exhibit turbulent flow. Newton's Law states that terminal velocity varies as the square root of the diameter of the particle. Consequently increase in settling velocity is not as rapid with size as it is with Stoke's Law. This Law applies to particles with Reynold's number greater than 1,000 (this corresponds to six mesh for quartz and 14 mesh for gold).

$$\text{For Newton's law, terminal velocity} = \left[\frac{g3.33\ (\rho s - \rho) d}{\rho}\right]^{1/2}$$

$g = 981$
ρs = density of solid, gm/cc
ρ = density of liquid, gm/cc
d = particle diameter, cm

According to Newton's law, the terminal velocities are:
For quartz $(5390d)^{1/2}$ cm/sec.
For gold $(55{,}500d)^{1/2}$ cm/sec.

Between the ranges of Stoke's Law and Newton's Law, there is no single law that can be applied to calculate settling velocity accurately. Such settling velocities can be determined indirectly using Figures 1 (for spheres) and 2 (for other shapes). For determining the settling velocity for spheres $(C_D)\ (Re)^2$ is first calculated as follows: (C_D is "drag coefficient" and Reynold's number is a dimensionless number descriptive of fluid flow).

$$C_D(Re)^2 = \frac{4g\ d^3\ (\rho_s - \rho)}{3\mu^2}$$

Referring to Fig. 1, the Reynold's number is read off and the settling velocity is calculated using the following relationship:

$$Re = \frac{Wd}{\mu}$$

W = settling velocity
d = diameter of particle
ρ = density of fluid
μ = viscosity

MOTION OF FLUIDS AND PARTICLES

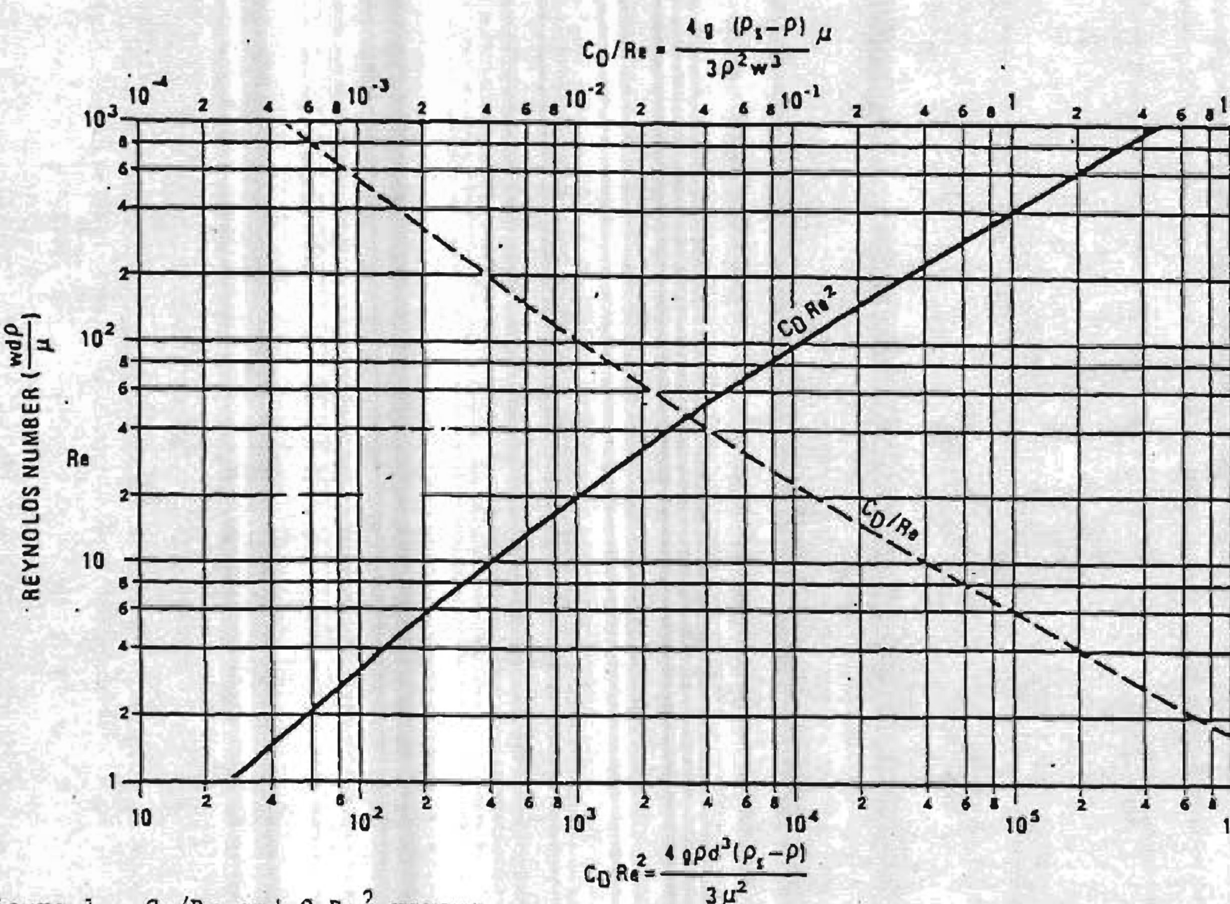


Figure 1 - C_D/Re and C_DRe^2 versus
Re for Spheres (From Wasp et al, 1977)

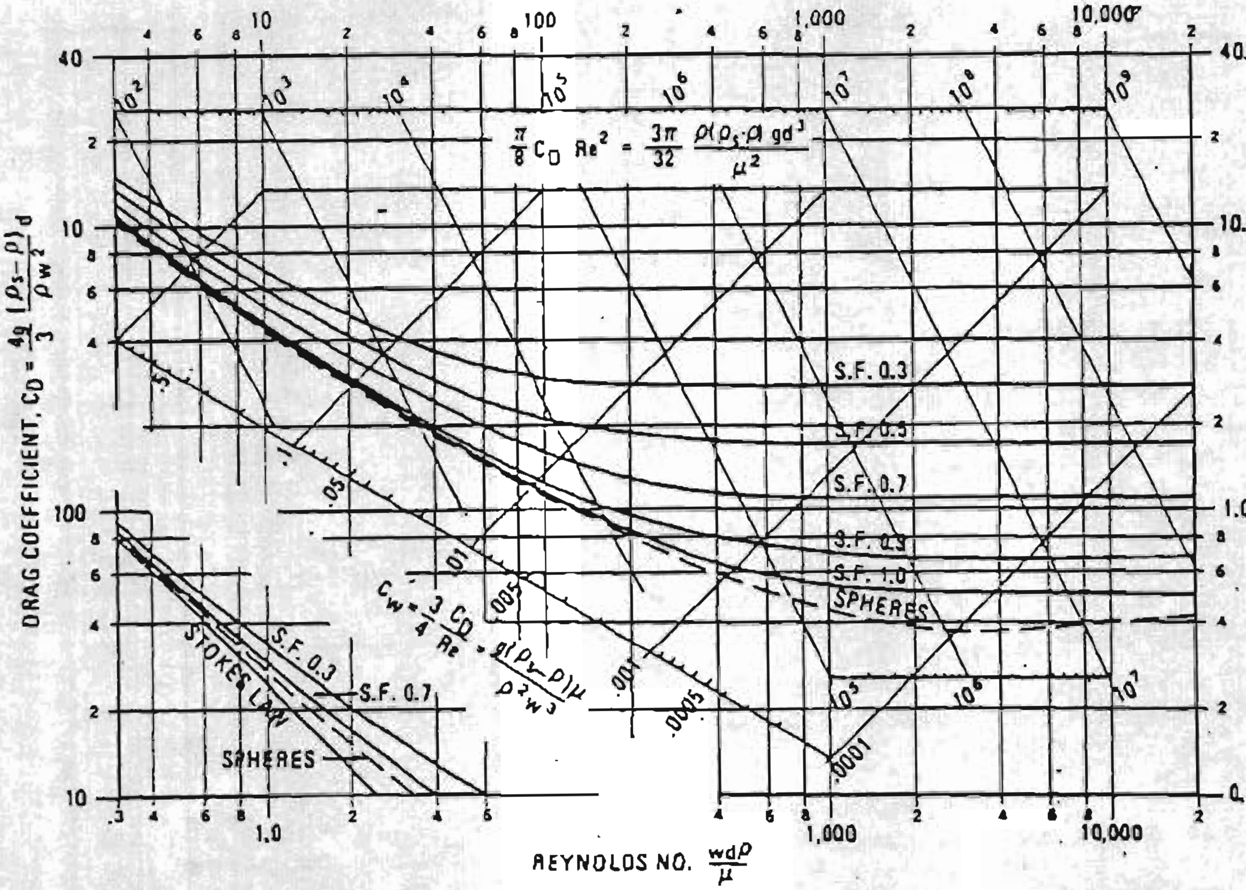


Figure 2 - C_D versus Reynold's Number Relationship for Irregular Shaped Particles (From Wasp et al, 1977)

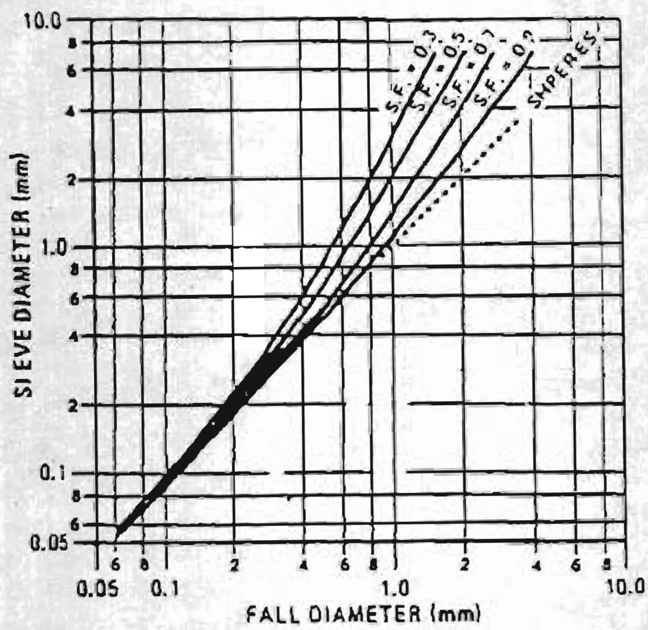


Figure 3 - Relationship Between Particle Nominal Diameter and Fall Diameter (From Wasp et al, 1977)

Another concept that is useful for the understanding of gravity concentration is the free settling ratio, i.e. the ratio of diameters of particles with same settling velocity, in this case, gold and quartz. Calculations show that the ratio is 3.2 for particles in the Stoke's Law range and 10.3 in the Newton's Law range. Thus, in the Newton's Law range a 2mm size gold particle will settle in water as fast as a 20.6 mm (3/4") fragment of quartz. It is obvious that the greater the ratio the easier it is to concentrate, and that it is easier to concentrate particles in the Newton's Law range than in the Stoke's Law range.

The above laws only relate to spherical particles and all experienced miners know that placers do not have truly spherical particles. The settling velocity of a non-spherical particle will be less than an equivalent spherical particle. How much less depends very much on how far the particle is from being spherical. There are several ways of defining non-sphericity of particles. One that has received wide acceptance is Corey's shape factors, $S.F. = c/\sqrt{ab}$, where a is the longest axis and c is the shortest of the three mutually perpendicular axes of the particle. The c axis is measured parallel to the direction of motion of the particle. In Stoke's Law any particle orientation is stable and we can have shape factors greater than unity. However, outside the Stoke's Law regime a particle's maximum area is normal to flow so the c axis is always the shortest of the three axes, and the shape factors are less than unity.

A cube has a shape factor of 1 (unity). As the shape factor gets smaller, the particles are thinner relative to other dimensions resulting in greater resistance which is expressed as the drag coefficient. Figure 2 shows the relationship of drag coefficient versus Reynold's number. It was shown before that a Reynold's number of 1000 corresponds to 14 mesh gold. Fig. 2 shows that for a Reynold's number of 1000 the drag coefficient for a sphere is 0.4 whereas the same size particle with 0.3 shape factor is 3. The greater resistance to settling of this particle as defined by the drag coefficient, is obvious.

Figure 3 compares nominal sieve diameters and actual fall diameters. It can be seen that a particle having a 1 mm sieve diameter and a 0.3 shape factor (S.F.) will settle at the same velocity as a 0.55 mm sphere. The lower shape factor erodes the advantage of having a large difference in densities of quartz and gold. Obviously, the farther the shape factor is from unity the more difficult will be the concentration of gold.

So much for the theory of settling; now to take a look at actual situations. All the data and some of the figures presented are taken from a research report titled "Distribution, Analysis, and Recovery of Fine Gold from Alluvial Deposits," by Cook and Rao in 1970. Only that portion of the report that pertains to size distribution and shape factors of gold is considered here. In order to bring actual results into perspective the laboratory procedures are briefly discussed.

The samples collected included samples of undisturbed placer material prior to sluicing, sluice tailings, and river bar and beach deposits gravels. Figure 4 shows the general procedure followed in processing the samples. The samples were screened wet over 3 mesh, 100 mesh and 400 mesh. The plus 400 mesh material was dried and dry screened. The - 400 mesh material was separated by sedimentation at 25, 15, and 5 microns equivalent quartz spheres (see Fig. 5). All size fractions were sink floated at 2.8 specific gravity to eliminate most of the gangue. The sink fractions were carefully processed using a superpanner to further concentrate the gold; then all grains were separated by hand so that the shape factors could be determined. Since this was virtually impossible for grains smaller than 100 mesh, shape factors are given only for particles larger than 100 mesh. The gold content of all fractions was determined by atomic absorption and fire assay. The weight of gold found in each size fraction was used to determine the distribution of gold by size. The gold particles separated from the sinks were used to measure shape factors so as to determine how much of the losses in the tailings can be ascribed to shape.

The following discussion considers size distributions. Gold sizes conform to a logarithmic normal distribution. Gold sizes were plotted from several regions and appear to have a good straight line relationship when plotted as cumulative percent on a probability scale versus particle size on a log scale. Fig. 6 shows the size distribution of gold separated from a cleanup at a mine near Ester. Total weight of the cleanup was 4 pounds (2,112 gms) and the total weight of gold recovered was about 13 ounces (408 gms). The cleanup was screened to various size fractions and then cleaned with a superpanner. The gold content of the - 400 mesh fraction was determined by analysis. The size distriution plot revealed a straight line relationship (Fig. 6). Some of the particles of gold recovered are as small as 10 microns in size indicating that fine gold does exist and, under favorable circumstances, is recoverable. Fig. 7 shows the size distribution of gold recovered by sluicing in the Chandlar district. It represents about 840 ounces of gold (27,992 gm). The size distribution again plotted as a straight line. The other three curves represent the distribution of gold size in the feed, in the 2.8 Sp. G. sinks, and in the 2.8 Sp. G. floats. Gold includes free gold recovered and gold found by analyses. The coarser end of the (gold in feed) curve follows the sluiced gold size distribution, whereas the finer end follows the weight distribution of 2.8 Sp. G. floats. This is because some gold was still locked in the gangue. The 2.8 sinks however, gave nearly a straight line relationship, although the line has a flatter slope than that for the sluiced gold.

Gold ore from the Mikado lode mine from which the placer was derived contains particles a few microns in size, which explains the presence of locked gold in the placer. Not all gold from Mikado mine, however, is fine.

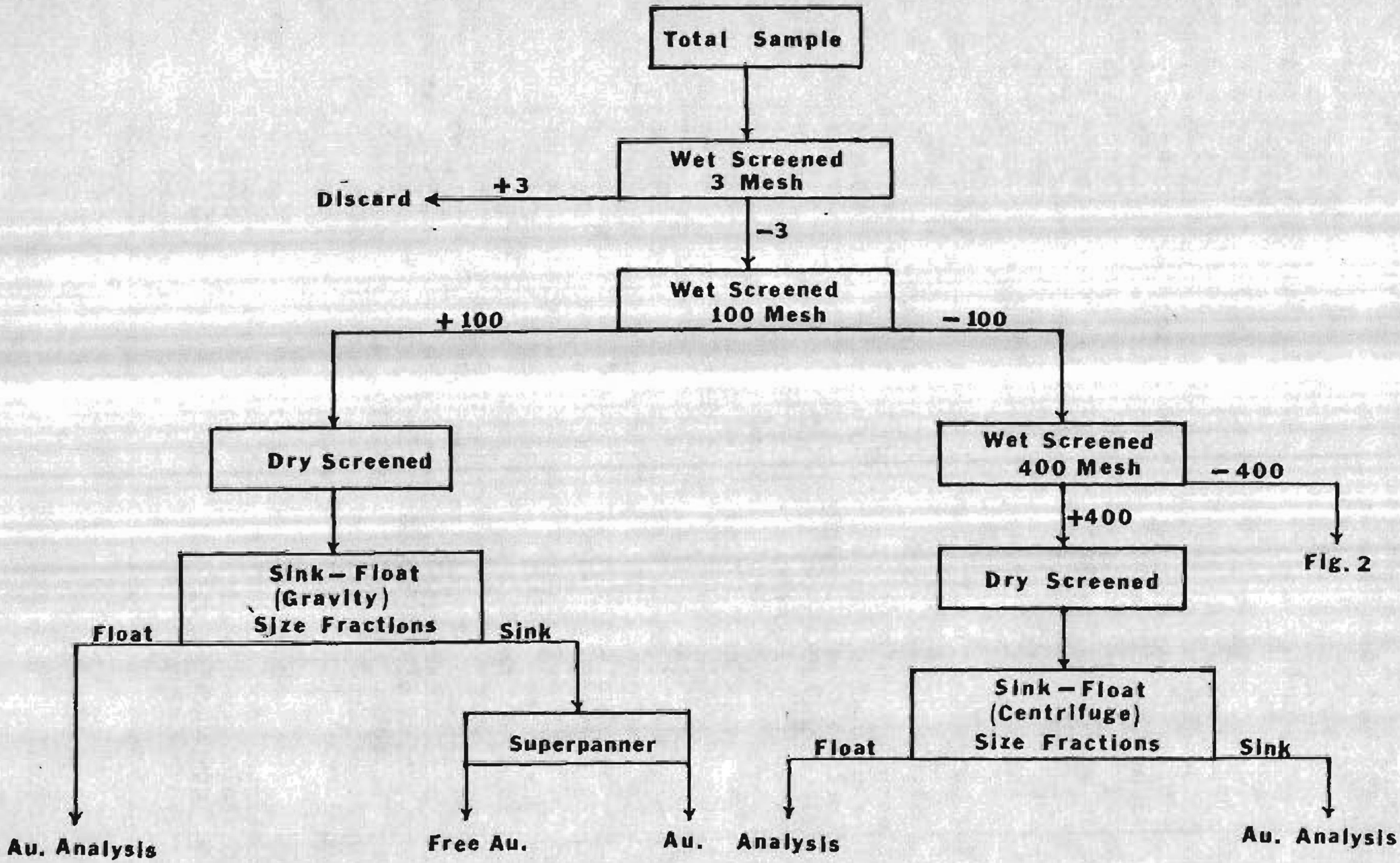
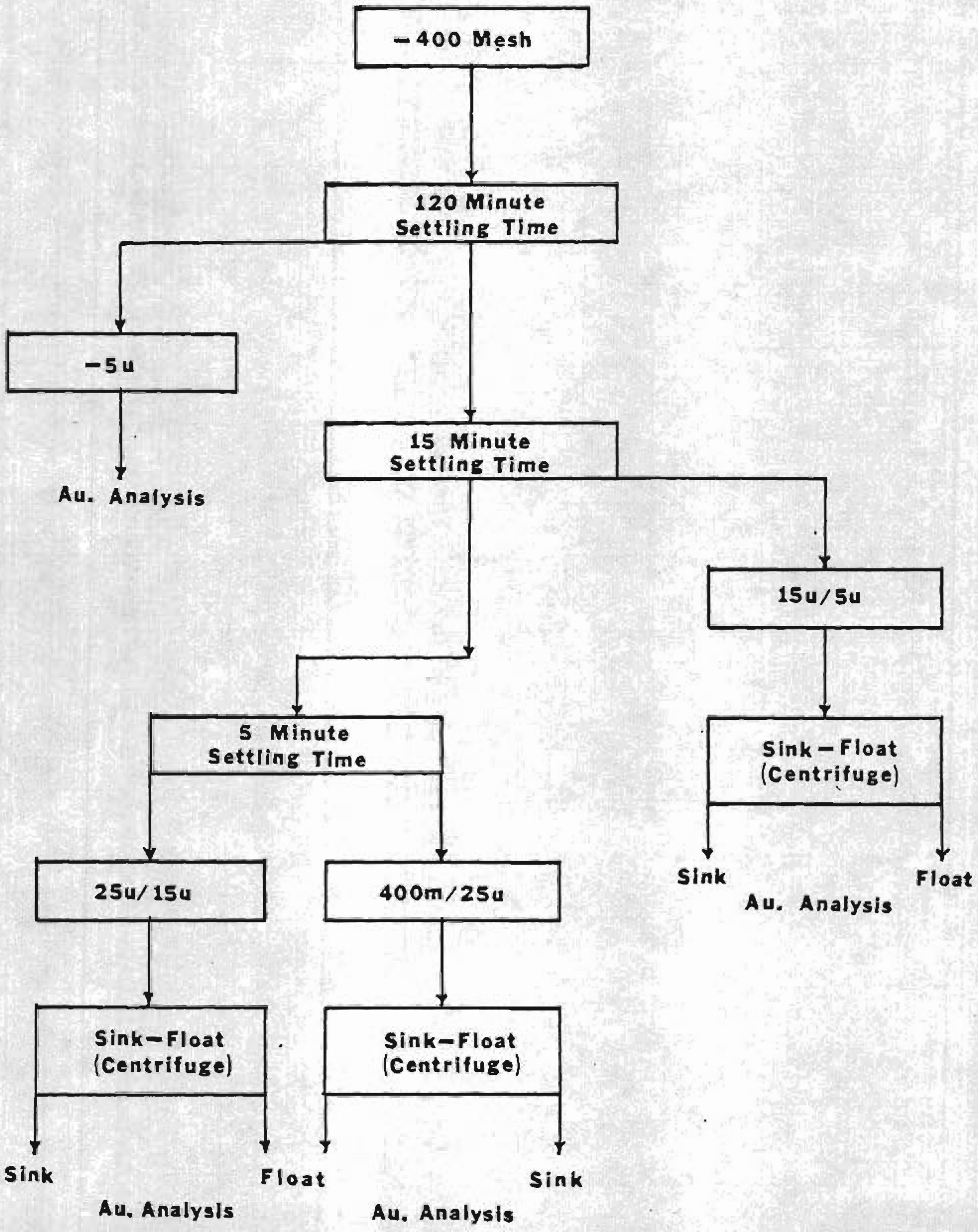


Figure 4

Sizing Procedure

Figure 5
Sedimentation Procedure



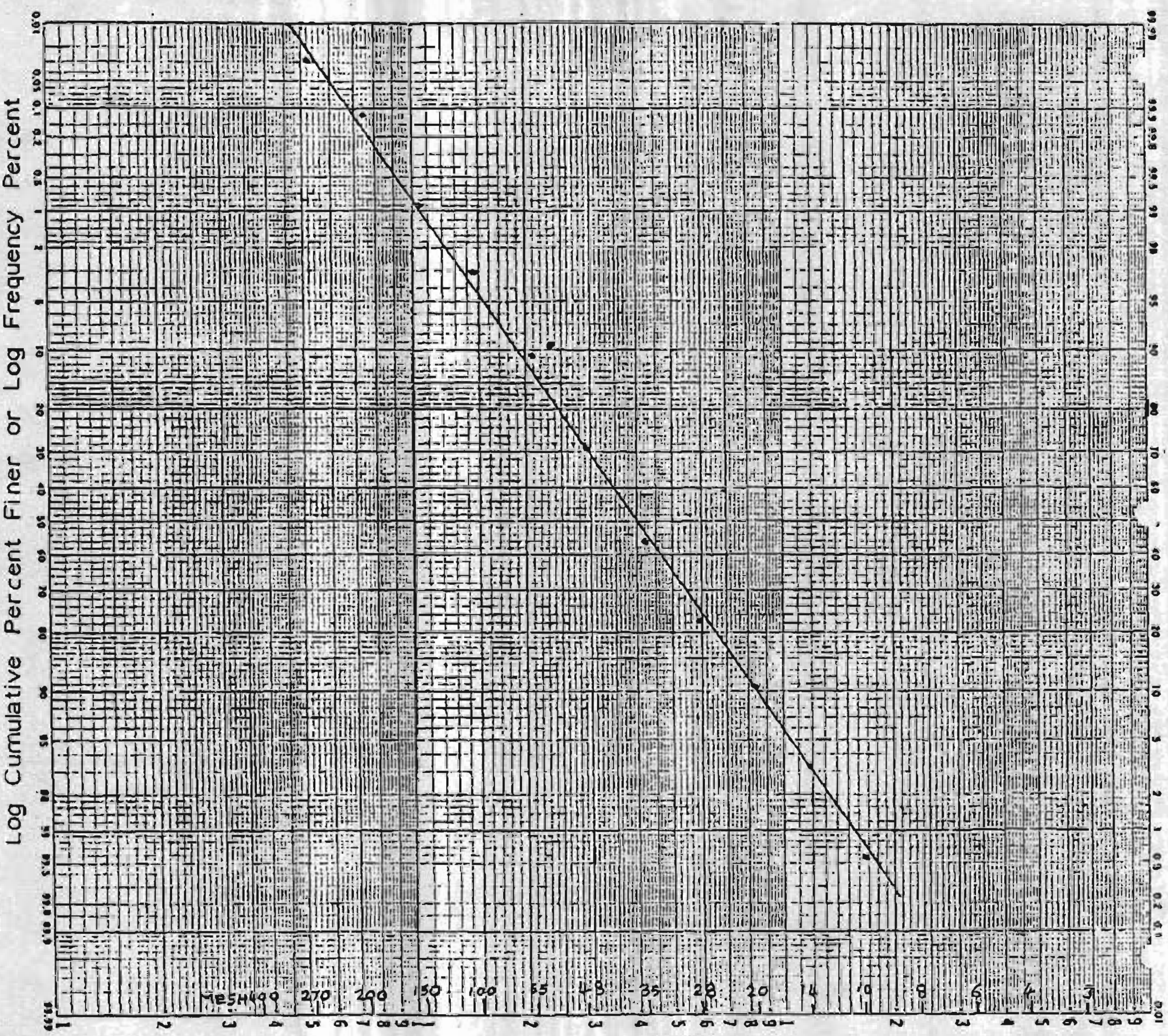


FIGURE 6 - SIZE DISTRIBUTION OF GOLD CONCENTRATED FROM SLUICE CLEANUP, READY BULLION CREEK, ESTER, OPERATOR HAROLD HASSEL

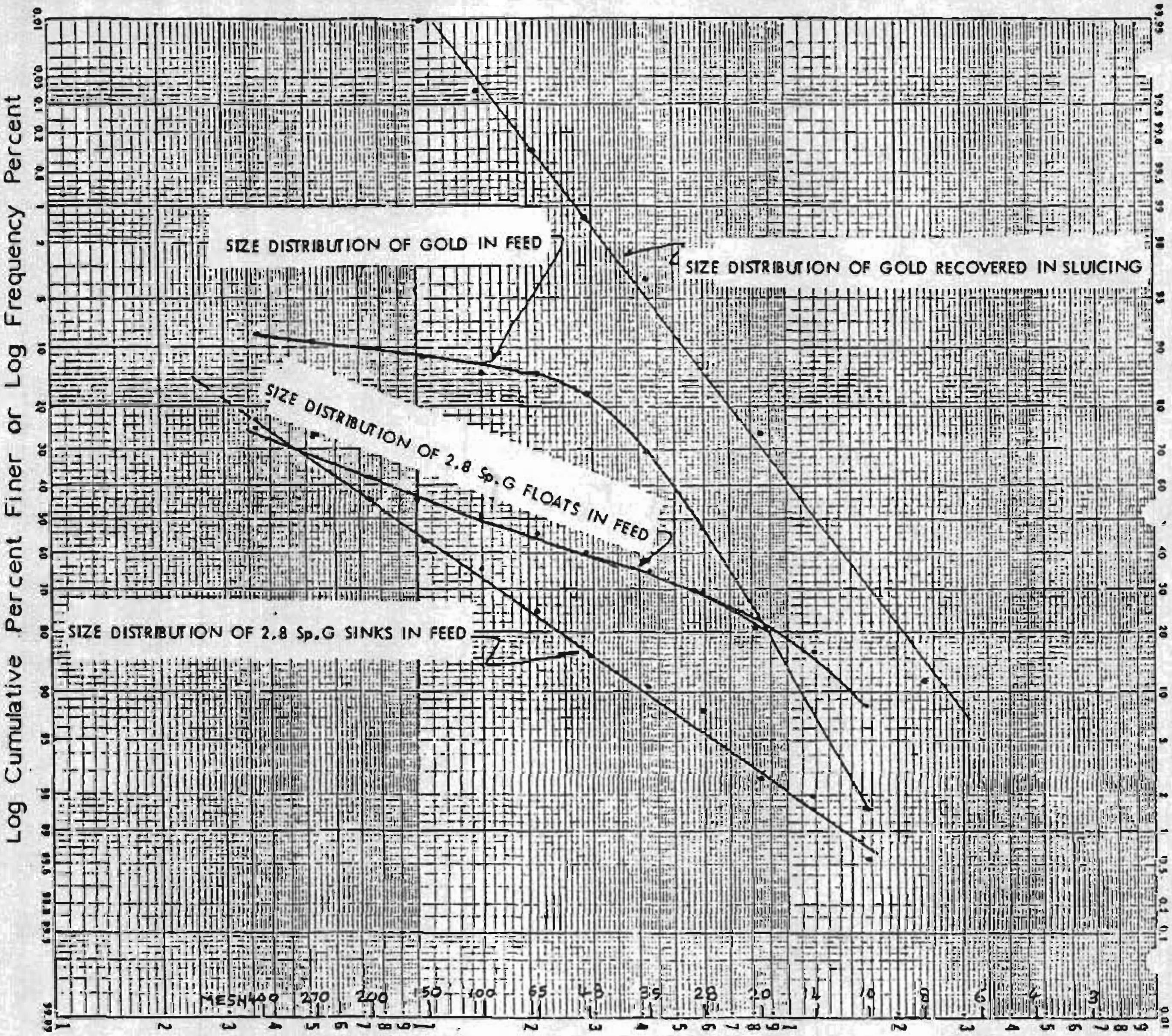


FIGURE 7 - SIZE DISTRIBUTION OF GOLD AND GANGUE, TOBIN CREEK, CHANDALAR DISTRICT, OPERATOR LATE FRANK BIRCH

Fig. 8 presents data on Boulder Creek gold, the curve, although straight at the fine end, is curved at the coarser end. The amount of gold used for size analyses was 17 oz. (522 gms).

Fig. 9 shows the distribution of gold among various size fractions of a minus 3 mesh feed sample from Livengood Creek. It shows that 2% of the gold is finer than 150 mesh. You will notice that in contrast to Chandalara gold, the 2.8 Sp.G. floats and sinks have similar distributions. The gold in the feed, however, has an entirely different size distribution. There was no locked gold in this sample.

Gold follows a definite distribution pattern and the shape of the recovered gold distribution curve could probably be used to predict losses of fine gold.

The next subject we want to talk about is shape. We wanted to determine the shape of gold particles in alluvial materials and from this, to determine the influence of shape on losses in sluicing, and also the shape of gold recovered in jigging operations. Gold particles were isolated under a binocular microscope, and shape factors were calculated as per the formula, S.F. = $c/\sqrt{ab}$. Fig. 10 shows shape factors for gold recovered from head samples and tail samples from Tobin Creek. The 20x28 particle in the tails has a shape factor of 0.09. As the size gets smaller, particles with higher shape factors are lost to the tailings. The average shape factor for 65x100 mesh gold lost in tailings is 0.37 compared to 0.65 in head. The average particle weight of gold lost in tailings is also lower than that of head due to the fact that particles lost in tailings are flatter.

Fig. 11 shows shape factors for head and tail samples from Livengood Creek. Notice that the shape factors are generally lower than for Tobin Creek, but, as was the case there, the average shape factors of gold lost in tailings increases with decrease in particle size showing that it is more difficult to recover finer particles with low shape factors. It appears that any gold with less than 0.15 shape factor is very likely lost.

In jigging, apart from settling velocity, initial acceleration of the particles is very important in separation. This initial acceleration is dependent on density of the particle only. Fig. 12 shows shape factors for gold isolated from jig concentrates. The average shape factor for the Sullivan Creek jig concentrate is lower than that for Livengood tailing which shows that jigs can recover gold with low shape factors normally lost in sluice-type recovery systems.

In some areas gold is typically not flat--one such area is Flat (Fig. 13) where the lowest shape factor is about 0.2. Chicken Creek has an average shape factor in excess of 0.6, some grains gave 0.9, indicating excellent prospects of recovery.

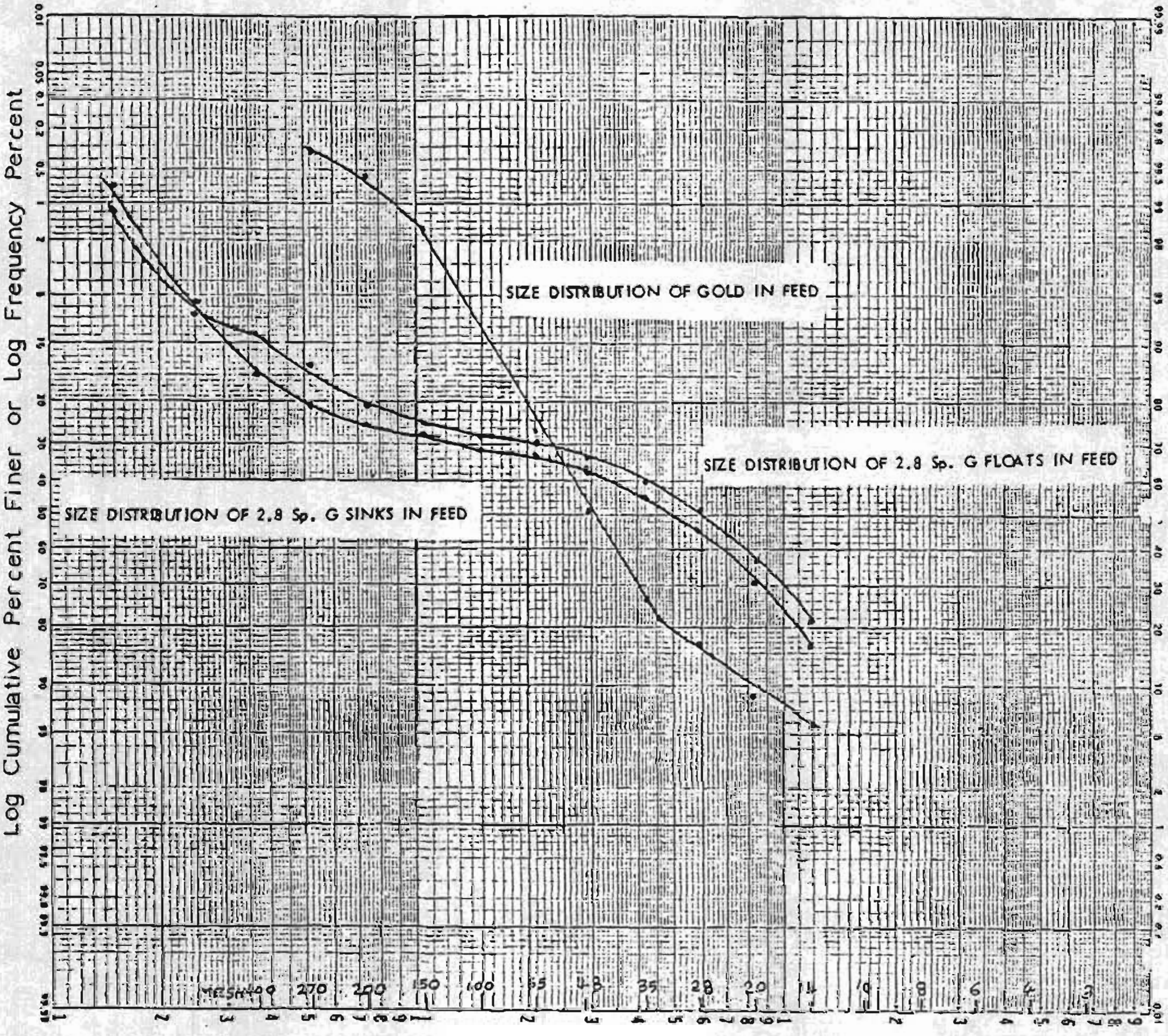


FIGURE 8 - SIZE DISTRIBUTION OF GOLD AND GANGUE, LIVENGOOD CREEK, OPERATOR CARL HEFLINGER

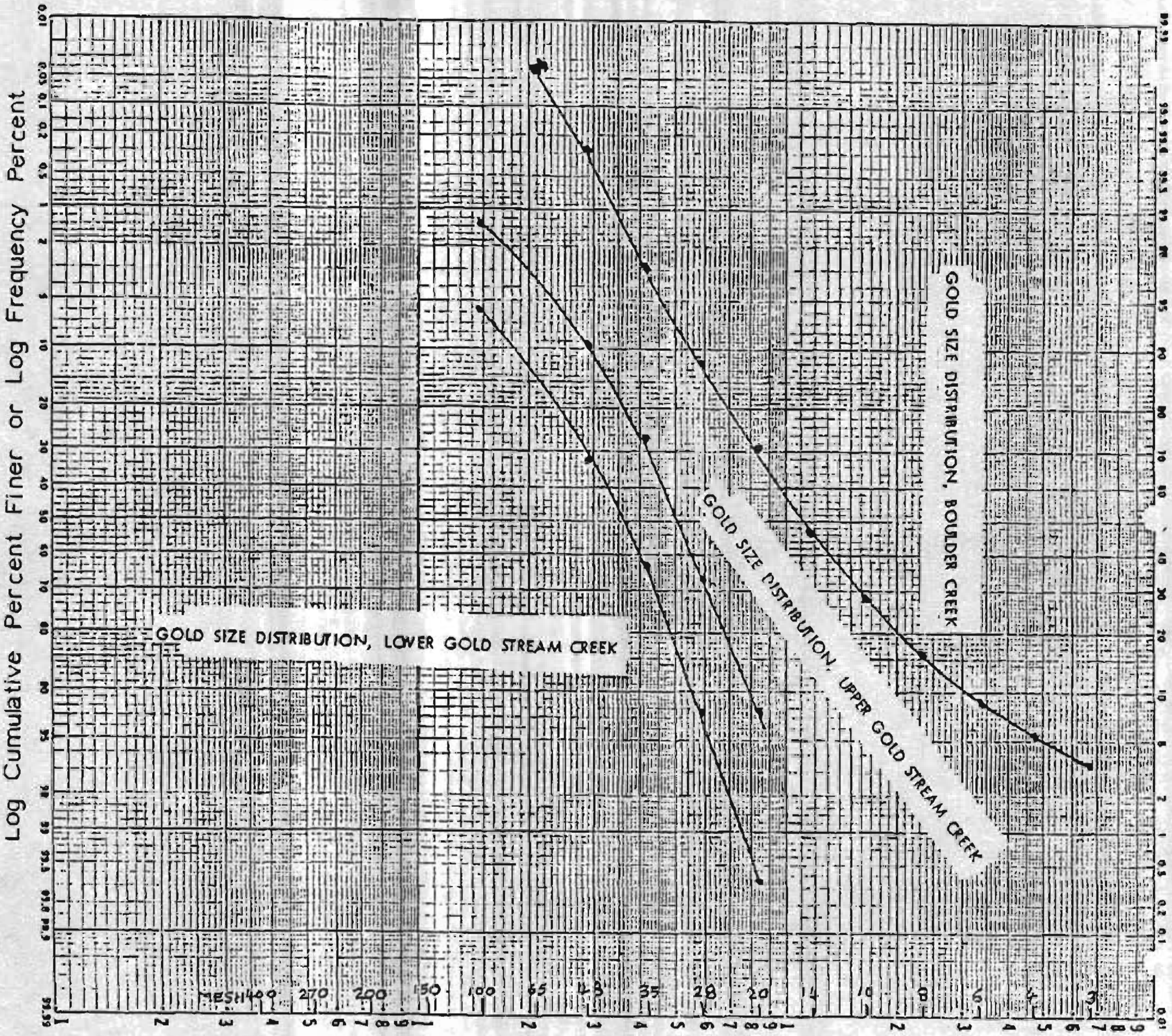
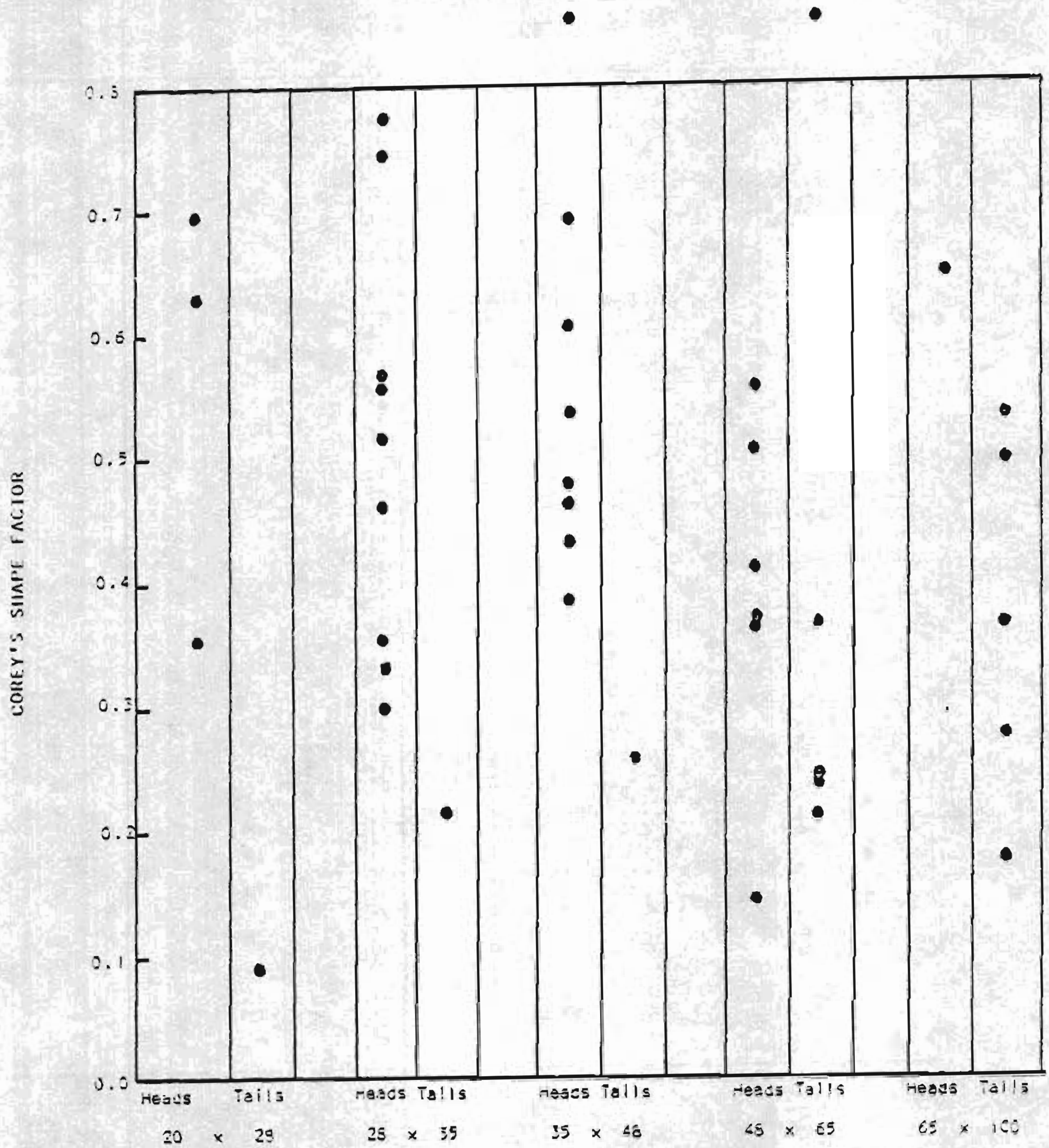


FIGURE 9 - SIZE DISTRIBUTION OF GOLD CONCENTRATED FROM BOULDER CREEK, HOT SPRINGS DISTRICT (OPERATOR GILL MONROE), AND GOLD STREAM CREEK

FIGURE 10

CHARACTERISTICS OF GOLD PARTICLES ISOLATED FROM TOBIN CREEK, CHANDALAR DISTRICT, HEADS AND TAILINGS



	20 x 28 Heads	20 x 28 Tails	28 x 35 Heads	28 x 35 Tails	35 x 48 Heads	35 x 48 Tails	48 x 65 Heads	48 x 65 Tails	65 x 100 Heads	65 x 100 Tails
Avg. Particle Wt. mg.	3.8	0.73	1.15	1.0	0.65	0.55	0.16	0.21	0.10	0.06
Avg. Shape Factor	0.56	0.09	.51	.22	0.56	0.26	.39	.39	0.65	0.37

FIGURE 11

CHARACTERISTICS OF GOLD PARTICLES ISOLATED FROM LIVENGOOD CREEK HEADS AND TAILINGS

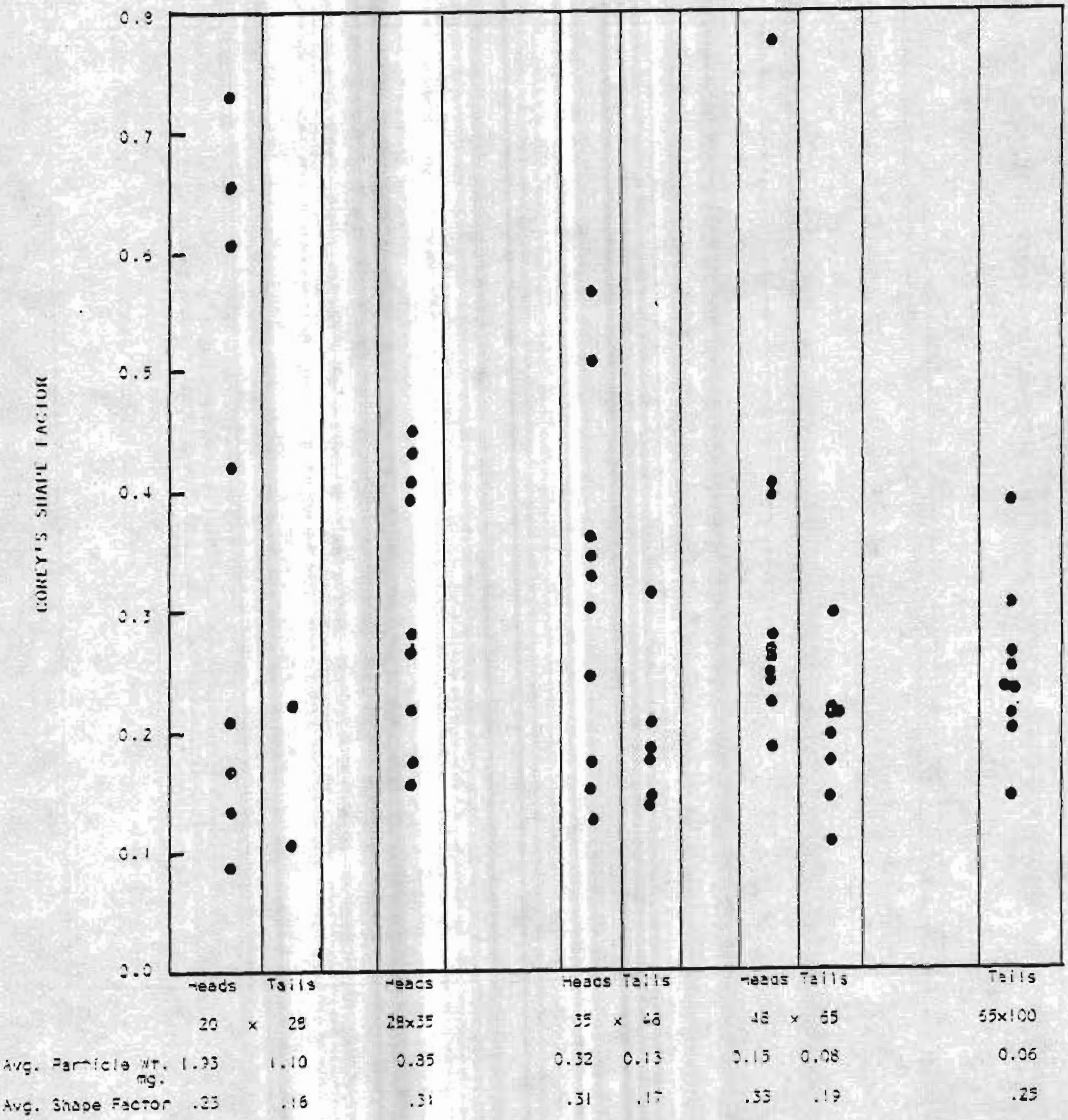
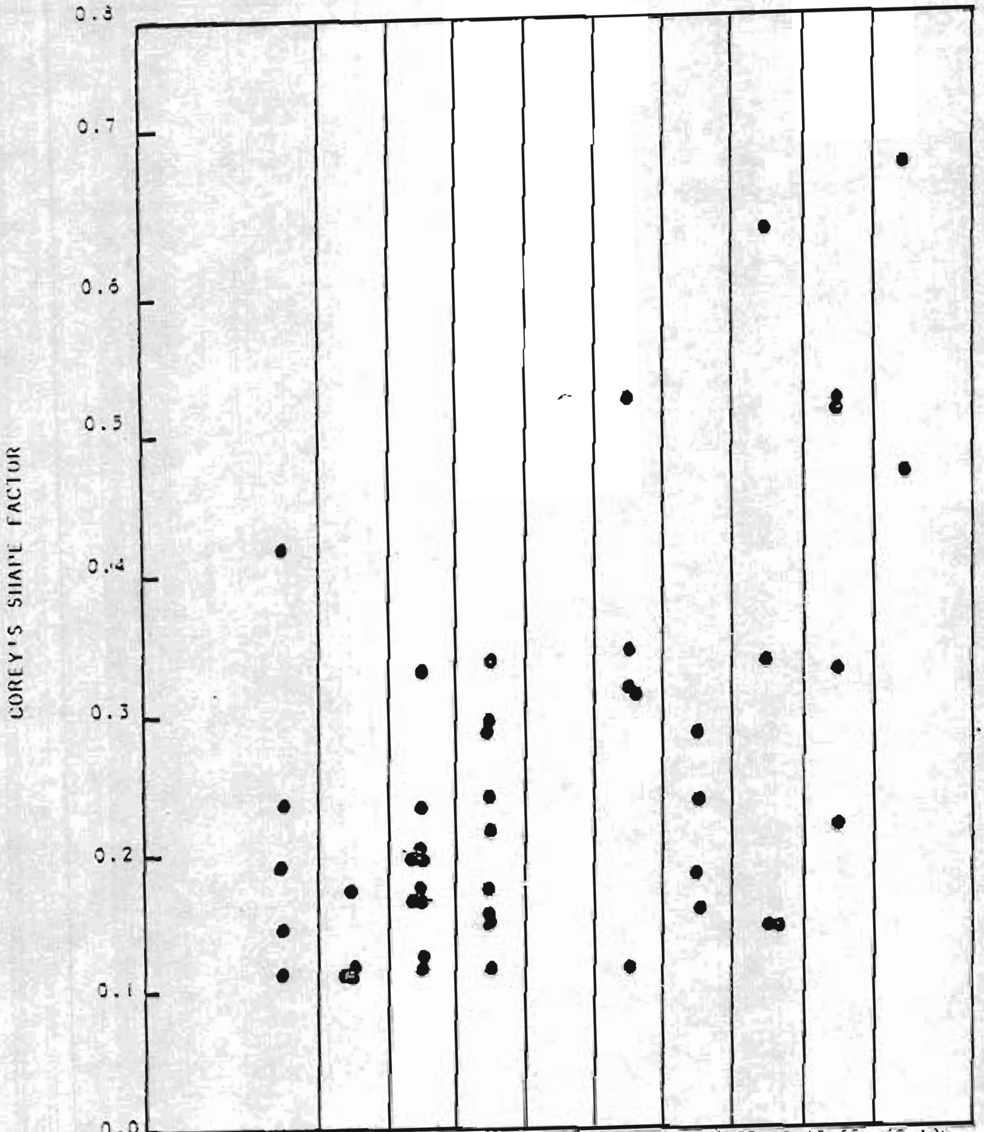


FIGURE 12

CHARACTERISTICS OF GOLD ISOLATED FROM COMMERCIAL JIG CONCENTRATES FROM TOFTY AND FAIRVIEW OPERATIONS



	28x35	35x48	48x65	65x100	20x28	18x35	35x48	48x65	65x100
Avg. Particle Wt.mg.	0.49	0.16	0.09	0.04	2.39	0.46	0.19	0.12	0.03
Avg. Shape Factor	0.22	0.13	0.16	0.22	0.32	0.22	0.32	0.40	0.58
	SULLIVAN CREEK, TOFTY				FAIRVIEW				

FIGURE 13

CHARACTERISTICS OF GOLD PARTICLES ISOLATED
FROM BED ROCK SAMPLES FROM FLAT AREA

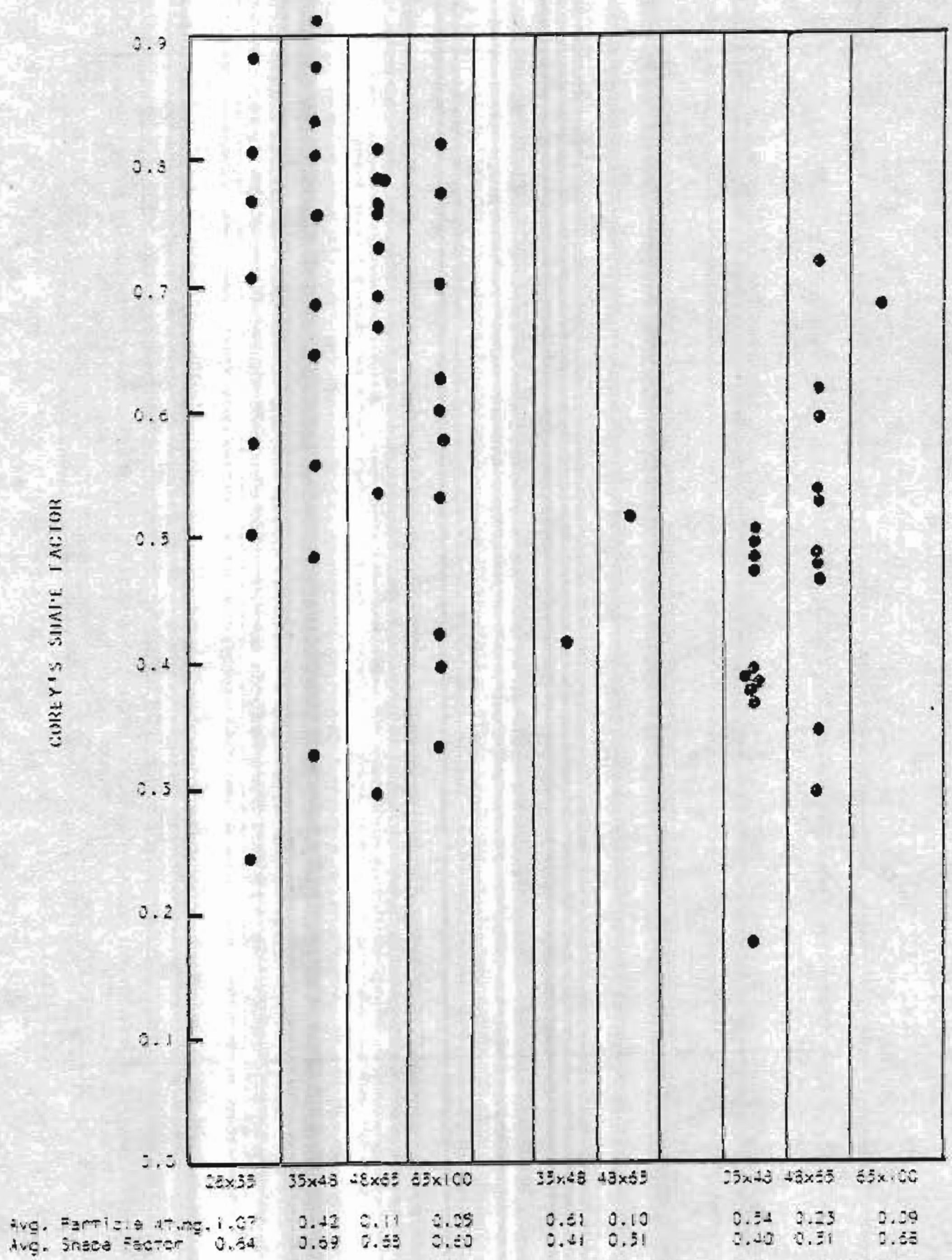
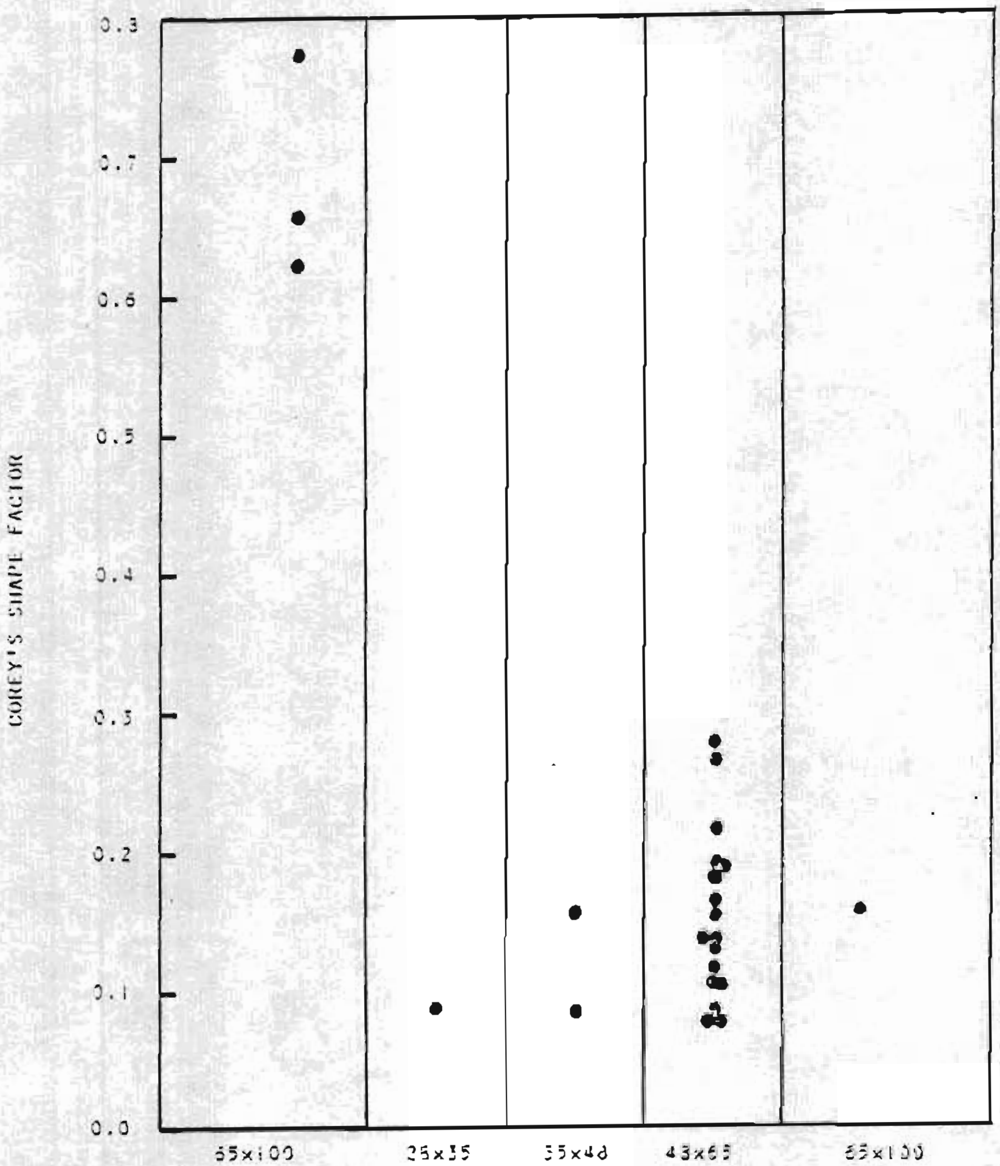


FIGURE 14

CHARACTERISTICS OF GOLD PARTICLES
ISOLATED FROM RIVER BAR SAMPLES

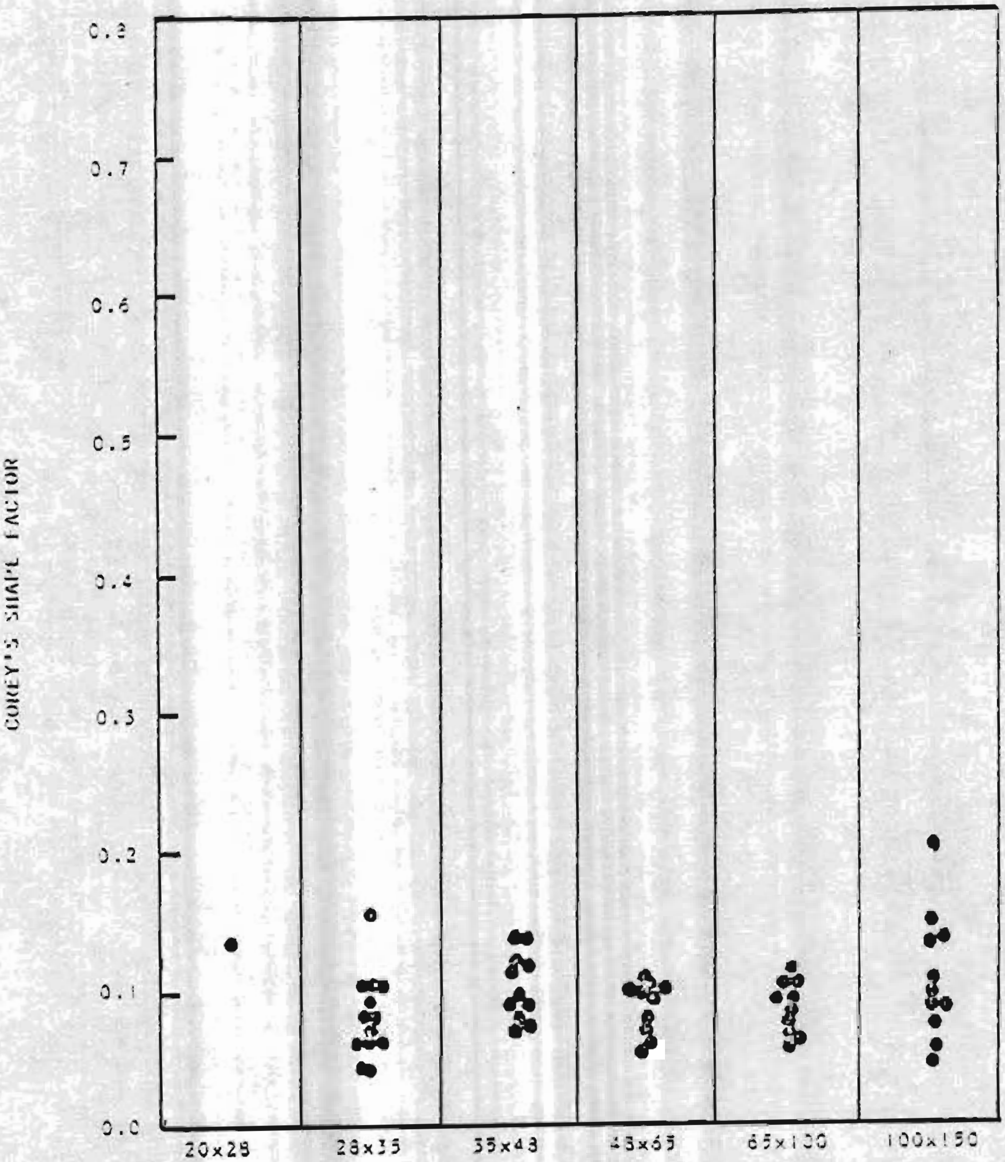


Avg. Particle Wt. mg.	0.05			0.13	0.01
Avg. Shape Factor	0.68	0.09	0.12	0.15	0.15

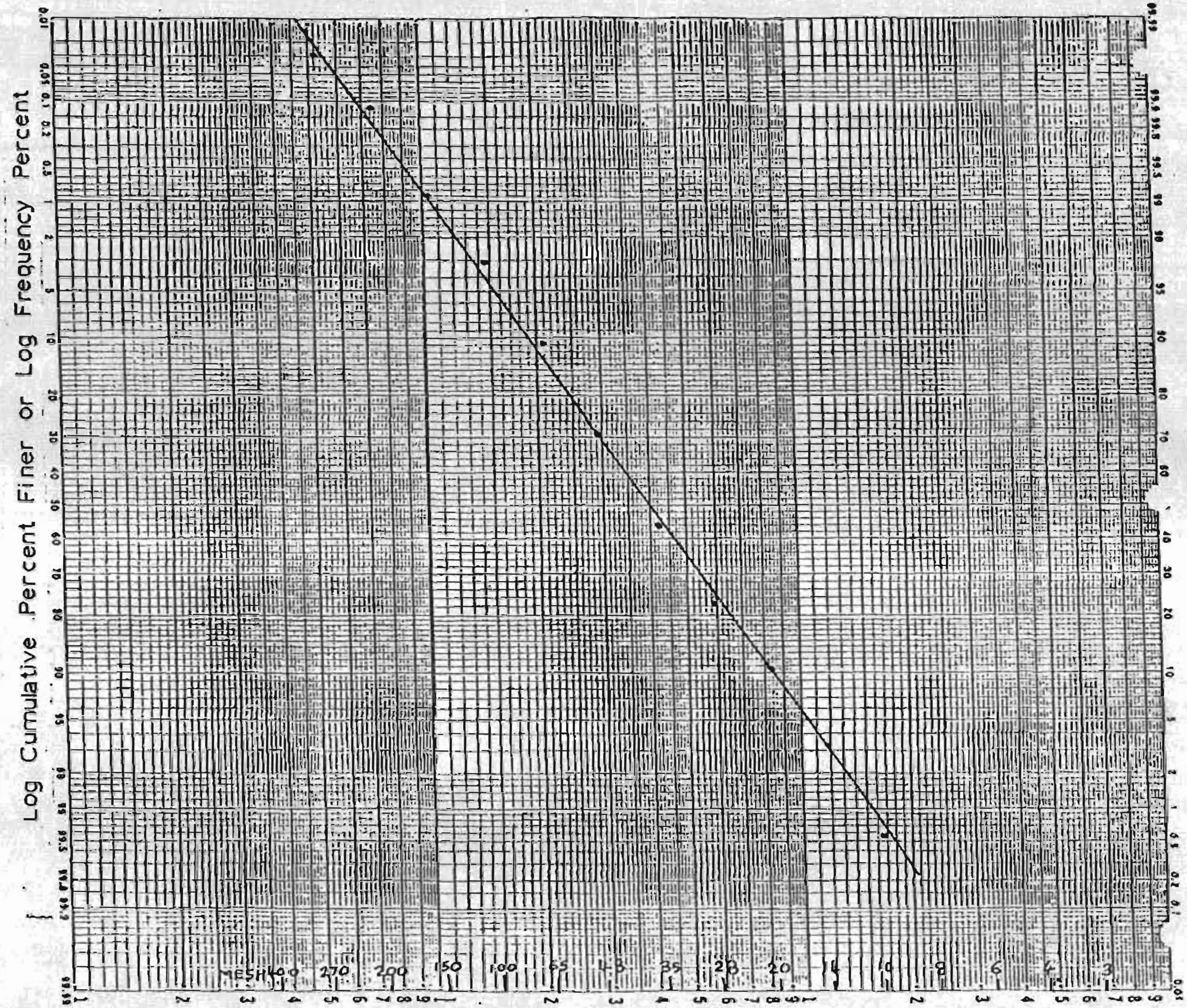
KUSKOKWIM HOLITNA

FIGURE 15

CHARACTERISTICS OF GOLD PARTICLES ISOLATED FROM YAKATAGA BEACH SANDS

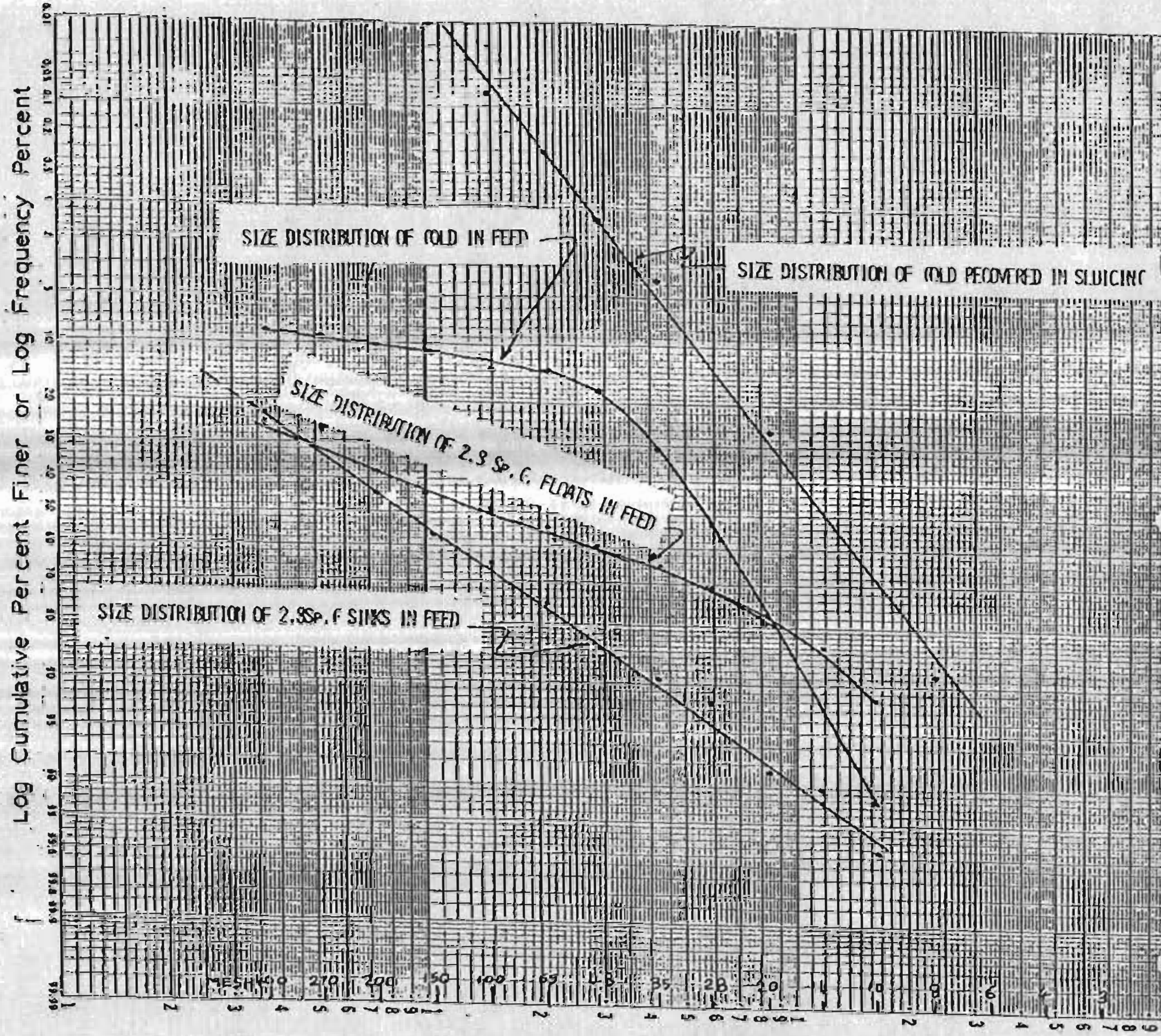


	20x28	28x35	35x48	48x65	65x100	100x150
Avg. Particle Wt. mg.	2.65	0.14	0.06	0.03	0.02	0.01
Avg. Shape Factor	0.14	0.08	0.10	0.09	0.09	0.11



SIZE DISTRIBUTION OF GOLD CONCENTRATED FROM SLUICE CLEANUP, READY BULLION CREEK, ESTER, OPERATOR HAROLD HASSEL

Ready Bullion Creek.



SIZE DISTRIBUTION OF GOLD AND GANGUE, TOBIN CREEK, CHANDALAR DISTRICT, OPERATOR LATE FRANK BIRCH

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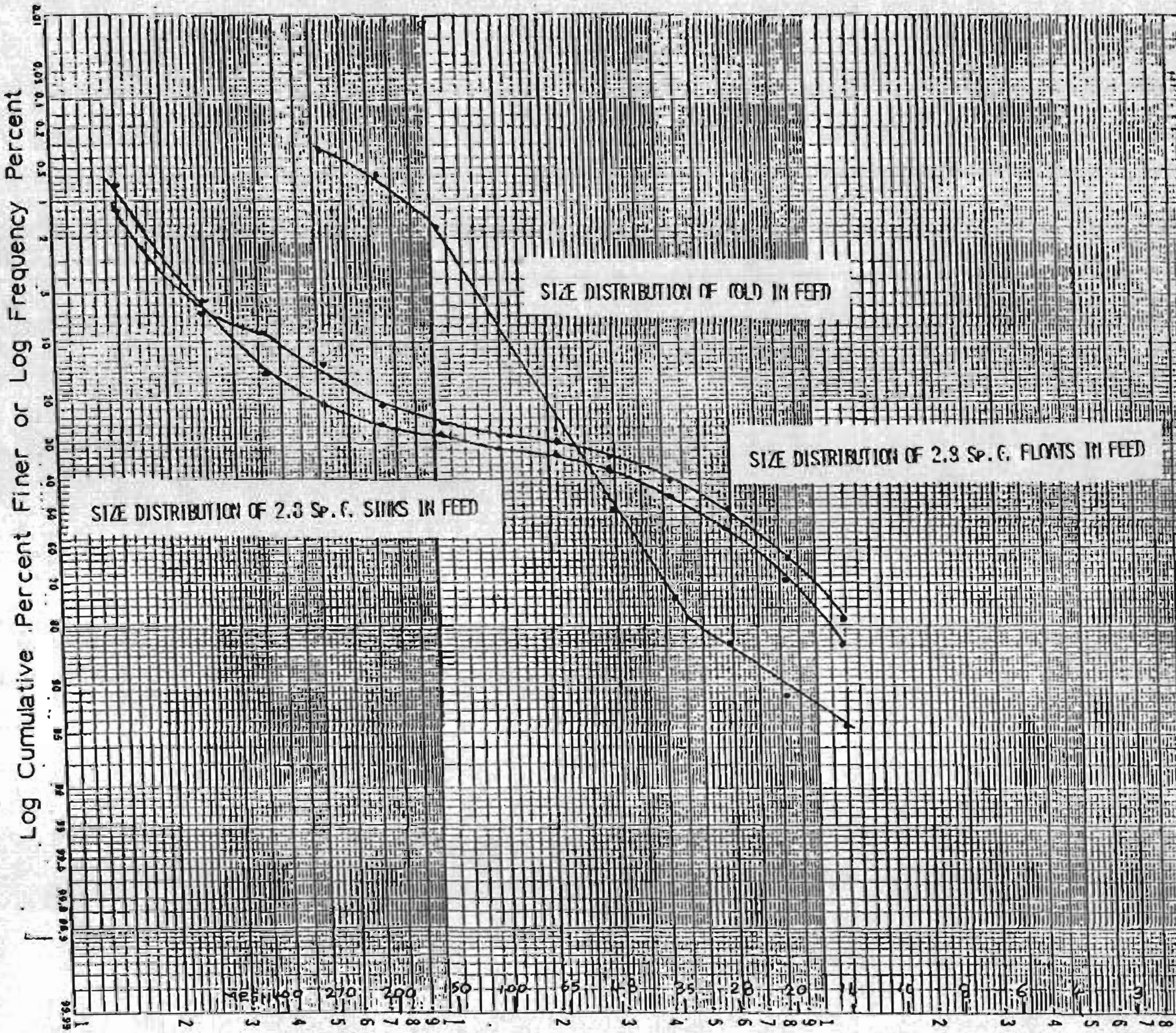

SIZE DISTRIBUTION OF GOLD AND GANGUE, LIVENGOOD CREEK, OPERATOR CARL HEFLINGER

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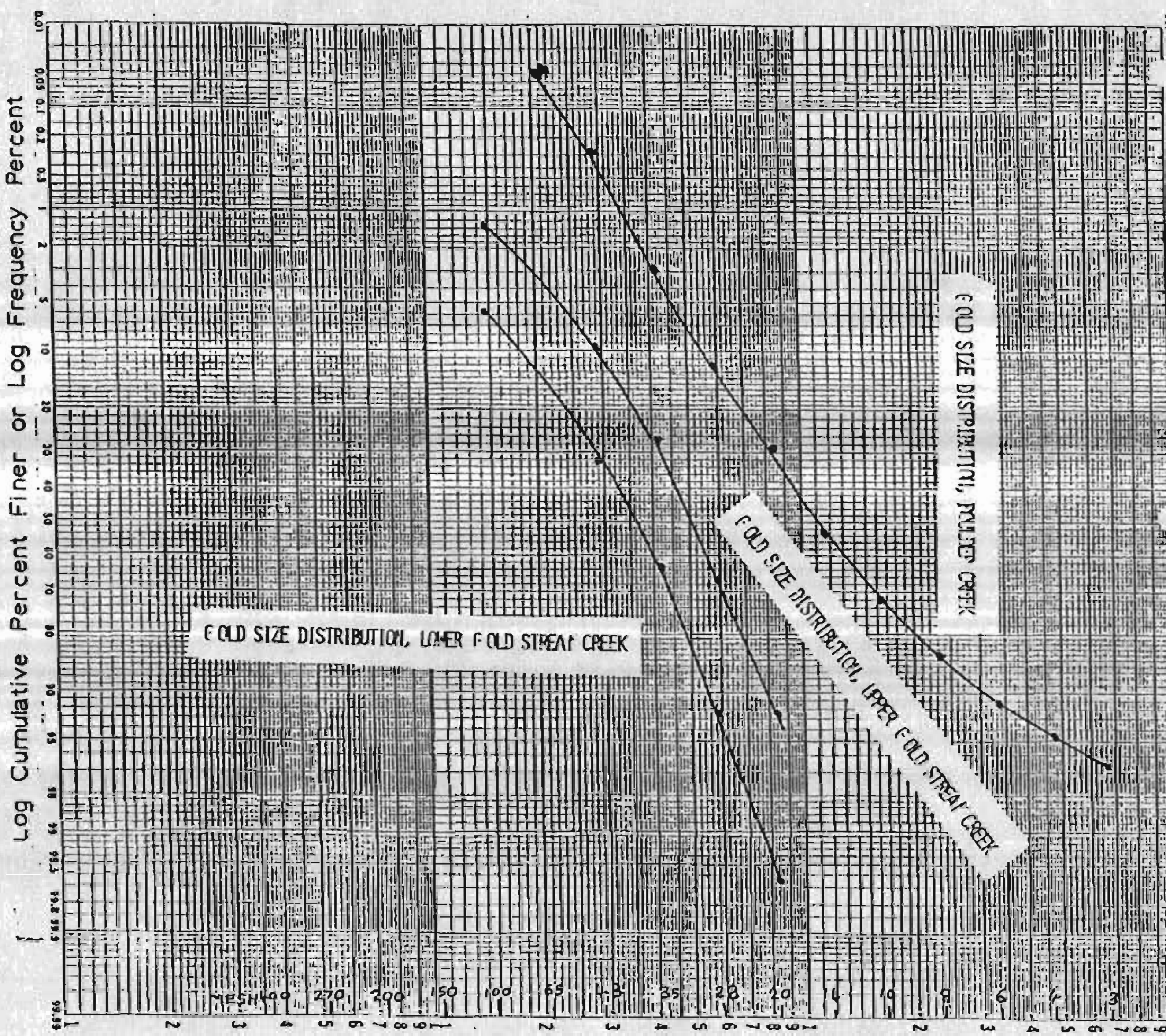
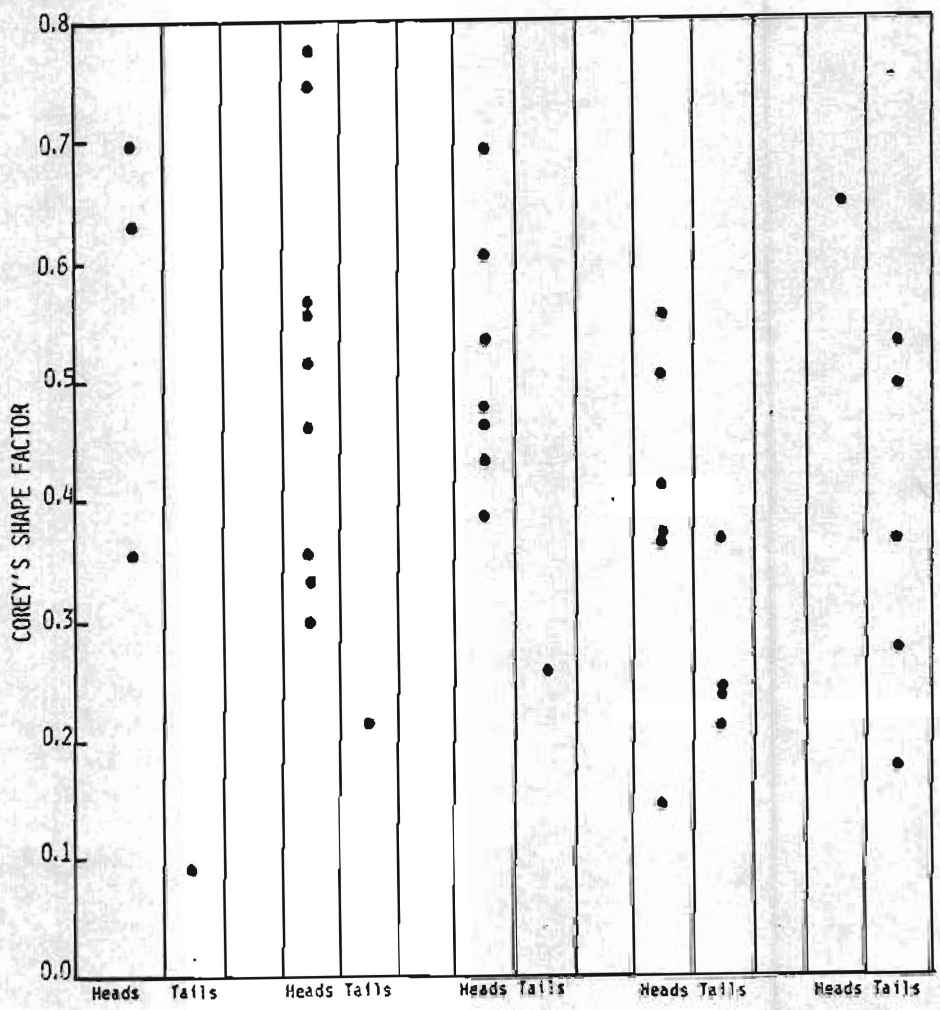
Livengood Creek



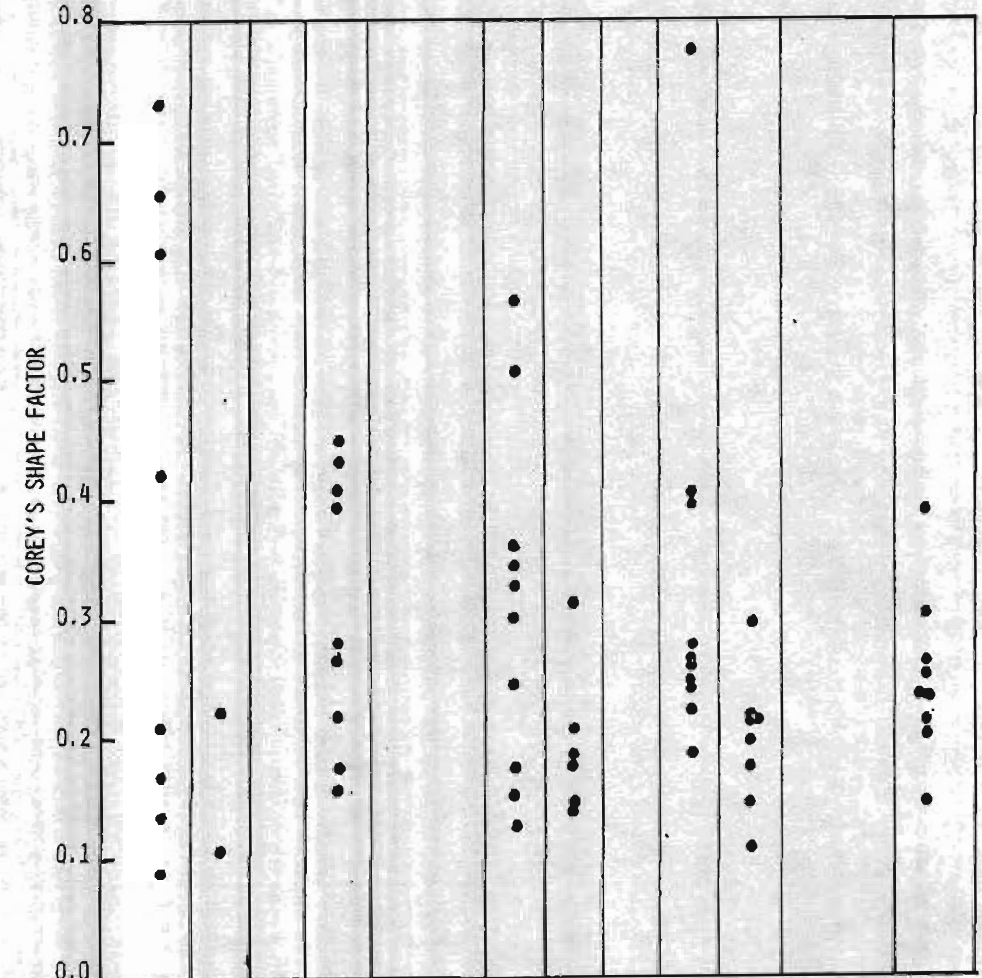
SIZE DISTRIBUTION OF GOLD CONCENTRATED FROM BOULDER CREEK, HOT SPRINGS DT., OPERATOR BILL MONROE AND GOLD STREAM CREEK

CHARACTERISTICS OF GOLD PARTICLES ISOLATED FROM TOBIN CREEK, CHANDALAR DISTRICT, HEADS AND TAILINGS



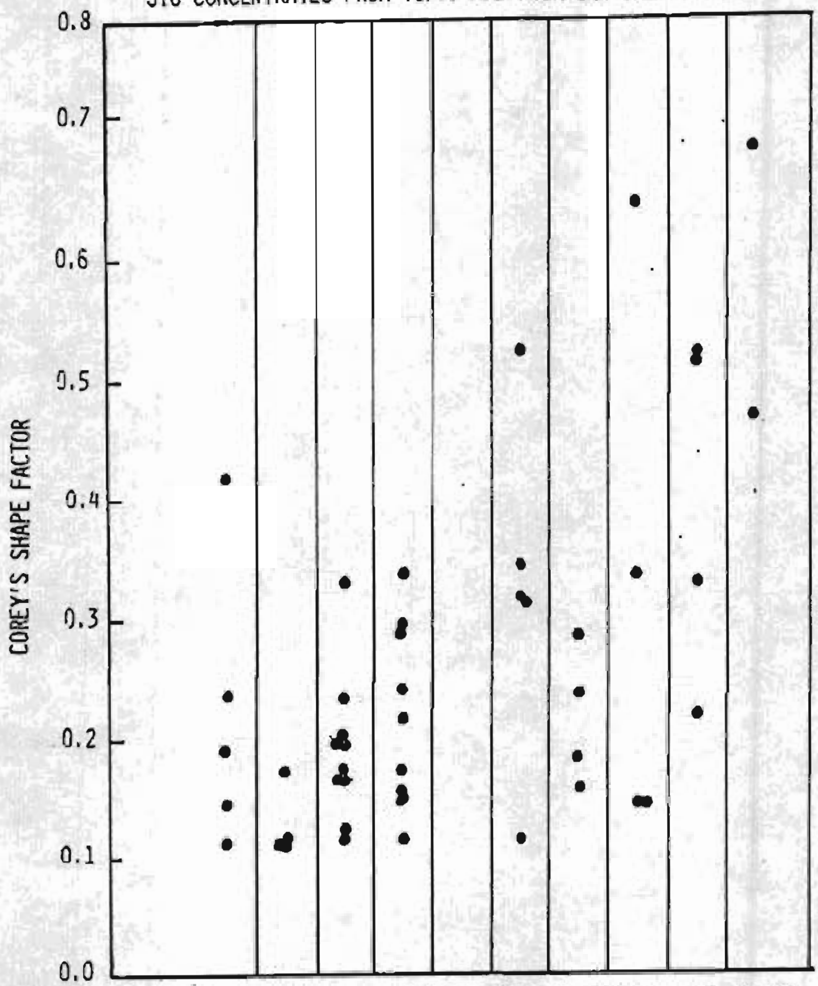
	20 x 28		28 x 35		35 x 48		48 x 65		65 x 100	
	Heads	Tails	Heads	Tails	Heads	Tails	Heads	Tails	Heads	Tails
Ave. particle wt. $\overline{P_w}$,Mg.	3.8	0.73	1.15	1.0	0.65	0.55	0.16	0.21	0.10	0.06
Ave. shape factor $\overline{S.F.}$	0.56	0.09	.51	.22	0.56	0.26	.39	.39	0.65	0.37

CHARACTERISTICS OF GOLD PARTICLES ISOLATED FROM LIVENGOOD CREEK HEADS AND TAILINGS



	20 x 28		28x35	35 x 48		48 x 65		65x100
	Heads	Tails	Heads	Heads	Tails	Heads	Tails	Tails
Ave. particle wt. $\overline{P_w}$, Mg.	1.93	1.10	0.85	0.32	0.13	0.15	0.08	0.06
Ave. shape factor $\overline{S.F.}$	.23	.16	.31	.31	.17	.33	.19	.25

CHARACTERISTICS OF GOLD ISOLATED FROM COMMERCIAL JIG CONCENTRATES FROM TOFTY AND FAIRVIEW OPERATIONS



	28x35	35x48	48x65	65x100	20x28	18x35	35x48	48x65	65x100
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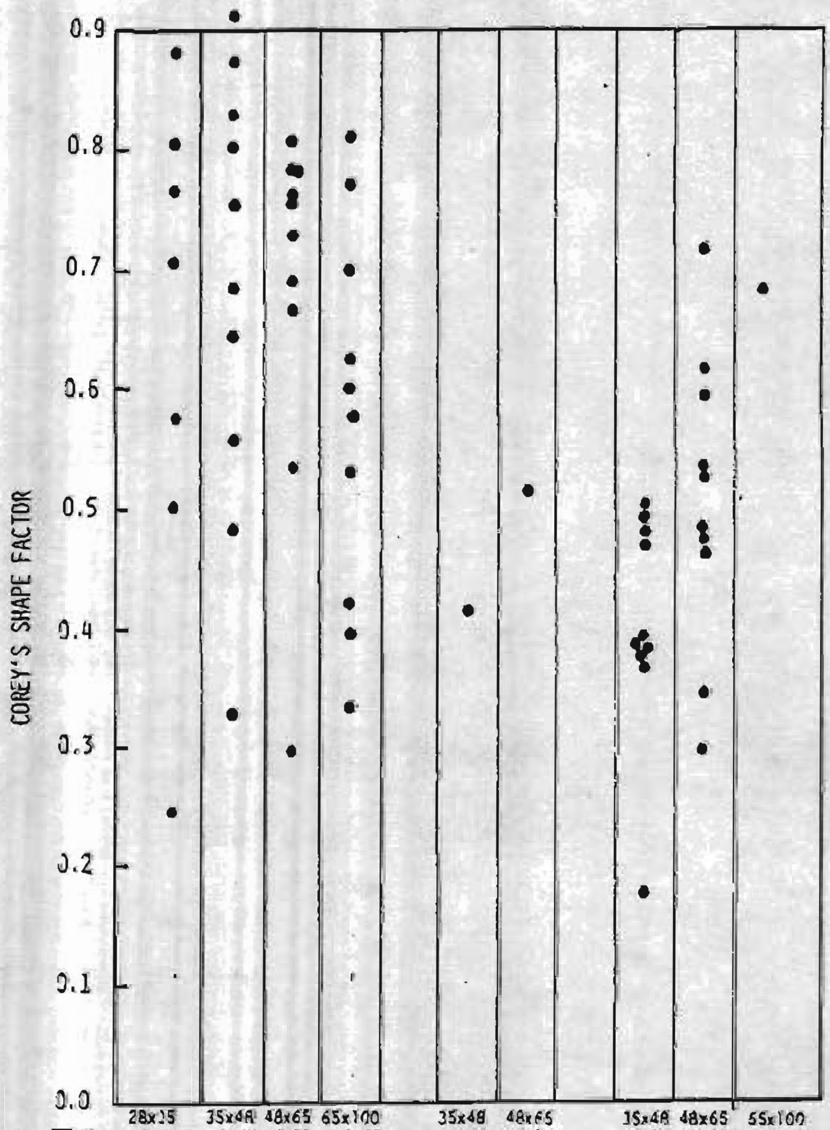
Ave. shape factor $\overline{S.F.}$	0.22	0.13	0.16	0.22	0.32	0.22	0.32	0.40	0.58

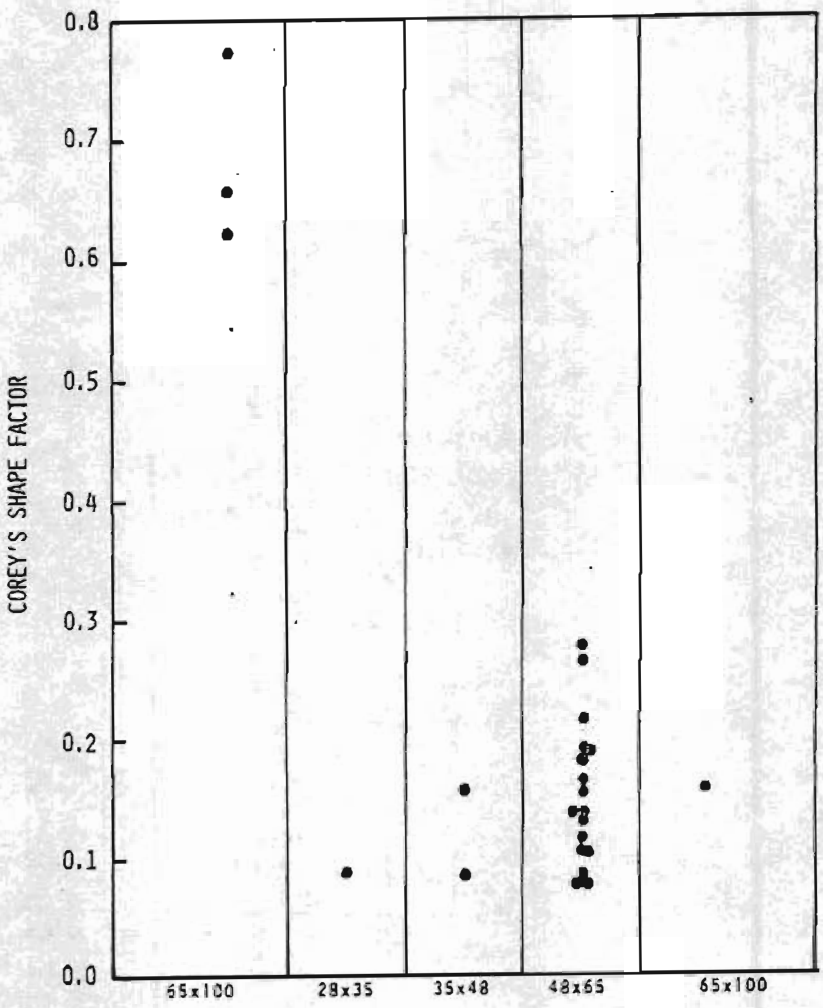
SULLIVAN CREEK, TOFTY — FAIRVIEW



	28x35	35x48	48x65	65x100	35x48	48x65	35x48	48x65	65x100
Ave. particle wt. P_w, Mg.	1.07	0.42	0.11	0.05	0.61	0.10	0.54	0.23	0.09
Ave. shape factor S.F.	0.64	0.69	0.68	0.60	0.41	0.51	0.40	0.51	0.68
	CHICKEN CREEK				WILLOW CREEK		WILLOW CREEK		

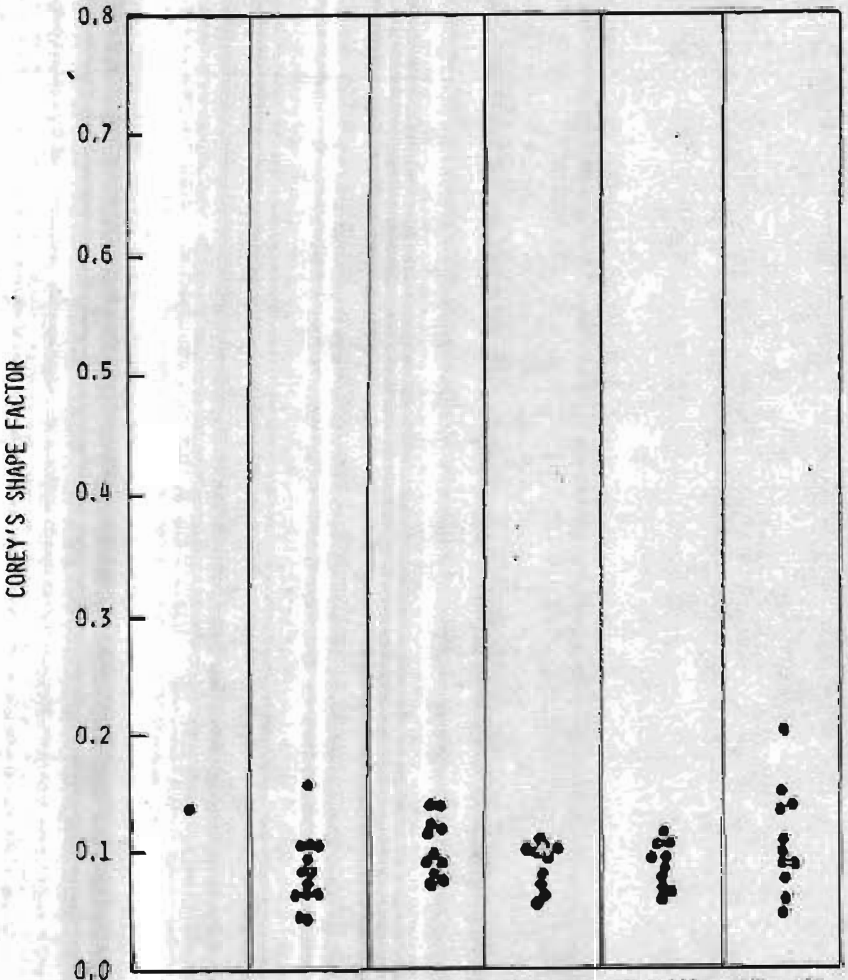
CHARACTERISTICS OF GOLD PARTICLES ISOLATED
FROM BED ROCK SAMPLES FROM FLAT AREA

CHARACTERISTICS OF GOLD PARTICLES
ISOLATED FROM RIVER BAR SAMPLES



Ave. particle wt. $\overline{P_w}$, Mg.	0.05			0.12	0.01
Ave. shape factor $\overline{S.F.}$	0.68	0.09	0.12	0.15	0.15
	KUSKOWIM		HOLTINA		

CHARACTERISTICS OF GOLD PARTICLES ISOLATED
FROM YAKATAGA BEACH SANDS



	20 x 28	28 x 35	35 x 48	48 x 65	65 x 100	100 x 150
Ave. particle wt. $\overline{P_w}$, Mg.	2.65	0.14	0.06	0.03	0.02	0.01
Ave. shape factor $\overline{S.F.}$	0.14	0.08	0.10	0.09	0.09	0.11

Fig. 14 shows gold recovered from river bars from the Kuskokwim and Holitna Rivers near Sleetmute. Gold recovered from the Kuskokwim has a high (0.68) shape factor whereas gold from Holtina is quite low, averaging 0.15. Sluicing of Holitna river bar gravels will naturally result in low recoveries.

Fig. 15 shows gold recovered from Yakataga beach sands in which shape factors are extremely low, less than 0.1, presenting an impossible situation for recovery by gravity methods. The gold is so flakey that it floats in water. Dr. Cook, however, recovered gold from this type of material very successfully by flotation.

In this paper we have tried to give the miner some facts with which he can estimate his recovery based upon size and shape of individual gold particles. It is our belief that in some cases gold recovery can be improved if the miner is forewarned that some gold will present recovery problems if ordinary sluicing is attempted. In such cases other methods may prove successful.

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SIZING OPERATIONS

James C. Barker

In typical open-cut placer operations, little attempt is made to size material entering recovery systems apart from limited use of grizzlies and undercurrents. Use of present day earth moving equipment can readily overcome the previous obstacles to sizing operations due to limited headroom above a gravity sluice.

Sizing results in accelerated settling and the most effective separation of gold takes place in a broad, slower moving, fluid stream. In a uniform stream velocity, simultaneous deposition will occur between equigranular particles of the same specific gravity and proportionately smaller sized grains of higher specific gravity.

Sizing by screening requires relative motion between the material load and the screen. The part of the load which passes through the screen is termed the passing fraction. Screen efficiency can be inhibited by rebounding or skipping, crowding and blinding. The measure of screen efficiency equates the proportion of undersize obtained (passing fraction) with the relative amount of undersize in the original feed. Ground character greatly influences screen efficiency, for instance, a free washing gravel handles much better than gravel with a substantial clay fraction. If a substantial amount of the feed falls within a size range 25% smaller to 50% larger than the screen opening size, there will be a greater tendency for crowding and blinding to occur. This is termed the critical size fraction. Screen capacity varies according to the shape of openings and their orientation relative to flow direction. Rectangular openings in grizzlies and screens aligned in direction of flow will pass more material than square or circular holes.

Grizzlies are the most commonly used basic size control method. Openings should be concave downward (e.g., where rail is used flanges should be upward facing) with a divergent down slope configuration to alleviate blinding problems. Site layout must allow for easy removal of the reject boulder pile.

Only limited use in open-cut placer mining is made of woven screens and other secondary screening systems prior to recovery, even though, in many instances, significantly improved gold yields will be obtained from a sluice product in the 1/4" to 1/2" size range.

When the relative motion is applied to the screen rather than the feed, the woven wire mesh type perform best because of their high opening area to unit area ratio. When using the sliding motion of the feed, punch plates, which aid gliding, function best. A series of progressively smaller mesh screens will protect the finer meshes from severe loading and abrasion. The scalped oversize fractions can be put through a nugget saver. Performance varies with gravel conditions, however, a 4' x 6' screen with 1/2" opening should be able to process

85 cubic yards per hour. Polyurethane coated screens appear to have better wear characteristics and a reduced tendency for clinging to clay material compared with stainless steel.

Trommels are revolving cylindrical screens through which material passes lengthwise, extensively used in dredges. Trommels vary greatly in size, but are normally set up at a slope of 1-1/2" per linear foot. An important characteristic is their ability to break down clay-bonded ground and cemented gravels with the aid of high pressure water jets, lifting bars and retarding rings. Trommels with a hexagonal cross-section have been used effectively when very coarse feed is not involved. This shape appears to impart better tumbling characteristics to the load and more effectively breaks down cemented and clay-bonded ground. Approximates of the power requirements of a trommel in horsepower can be obtained by multiplying the diameter by the length (both in feet) and dividing by eight. Rotational speed should approximate 35% of the velocity required to hold the load by centrifugal force, which in the case of a 4 foot diameter trommel would be 12 to 14 rpm. The capacity of a 4-1/2 x 24' trommel with 1/2" punch plate rotating at 12-14 rpm would be approximately 70 cubic yards per hour.

Undercurrents provide a means of fine gold recovery and usually consist of a separate assembly built into the lower part of the sluice box. Undercurrents recover fine gold which enters through a grizzly or screen device. They are usually designed with expanded wire mesh or small hungarian riffles. Care should be taken to maintain a constant moderate flow rate to avoid surging. While such systems may require daily clean up, they have been credited with saving up to 20% of the total gold yield on some operations.

In summary, improved gold recovery undoubtedly results from the use of sizing controls. A bibliography of Alaskan placer exploration, technology and reclamation is available from the Bureau of Mines on request.

SLUICE BOX ARRANGEMENTS

Ernest N. Wolff

In a placer recovery system the quantity of sediment (Qs) and the diameter of the particulate material (d) must be balanced by sufficient water (Qw) and slope to the box (S) to permit passage of the load. Therefore, if the quantity and/or size characteristics of sediment are increased, there has to be a compensating increase in the quantity of water and/or slope.

Factors which influence the type and position of a sluice include gradient of the creek, amount of water available, shape of valley, depth of ground, ground characteristics relating to clay content and size of boulders and, last but certainly not least, the gold shape and size characteristics for the particular deposit.

There are two basic types of sluices, each with a long history of application extending back before the introduction of mobile earth moving equipment. These are: 1) bedrock sluices and, 2) elevated sluices. With bedrock sluices, one of the main problems concerns disposal of tailings, a shortcoming which is minimized in elevated sluices.

BEDROCK SLUICES

The use of bedrock sluices is as old as the techniques of ground sluicing and hydraulicking. The introduction of bulldozers in the 1930's found immediate application to this type of operation. Bedrock sluices have their mouthpieces on bedrock, and in groundsluicing the tail box must also be on bedrock or above. Sluices installed at bedrock grade generally are less than 4% and have limited capacity because of slope and water velocity constraints. In the old-type ground sluicing operations water flows through the cut being mined and then through bedrock boxes. In such operations the sluicing action of the water was incapable of moving boulders which in the old days were stacked into huge piles and walls by hand (a persistent feature of many early placer districts). Where giants are used to sweep bedrock, the boxes must be set right on the bedrock itself. Under good operating conditions giants are used to mine, push material through the recovery boxes and also to stack tailings. A giant can more effectively move material into the sluice box if the ground is first broken out of the cut and pushed up by a bulldozer.

To compensate for poor gradient, boxes may be cut into bedrock. This may facilitate the passage of material through the sluice but creates problems of tailings disposal from the sump area. Deep drains are expensive to put in and using bulldozers to clean out tailings is both costly and hard on the equipment. In rare situations where the bedrock drops away steeply, or at the edge of a bench, problems of tailings disposal may be minimal and bedrock sluices will work very effectively.

If large quantities of water under gravity head are required, this means putting in and maintaining a ditch. Pumping water is expensive and is not capable of moving much dirt unless very high pressure pumps are used. Rock rakes fitted to a bulldozer blade probably constitute the best means of moving boulders from the sluicing cut.

A notable disadvantage of bedrock sluice systems is their vulnerability to flood damage.

<u>ELEVATED SLUICES</u> (sometimes referred to as <u>TRESTLES</u>)

Elevated sluices largely overcame the severe problem of tailings disposal. However, in this case, expense and effort is required to elevate the feed for entry into the system. The elevated box was developed out of the need to have workable effective recovery systems without gradient constraints.

About 25 years ago, attention was focused on combining the attributes of both systems. This was put into practice by setting the sluice box on a dirt ramp which gave it the necessary grade, without elevating it on a structure. Instead of a hopper or wings at the upper end, there was a low "sluice plate" which could be loaded by bulldozer without a very high lift. The sluice plate was loaded from the end or the side. This system is very commonly employed in current operations.

It is readily apparent that the methods used today are simply adaptations of the old hand labor techniques. The development of the diesel engine in the 1930's was instrumental in mechanizing placer mining methods. Although many of the old constraints are still there, bulldozers and loaders have allowed sluices to be located above bedrock without using elevating trestles.

SLUICE BOX AND STANDARD RIFFLES

Earl H. Beistline

The first book on mining based on field research and observations was "De Re Metallica", published in 1556 and written by Georgius Agricola. In this book, which has 636 pages and was the only authoritative text on production of metals for almost 200 years, the following statement is made (p. 330): "Alluvial mining - gold washing - being as old as the first glimmer of civilization, it is referred to, directly or indirectly, by a great majority of ancient writers, poets, historians, geographers, and naturalists."

Agricola describes a number of gold washing methods (p. 322), one being as follows: "The frame is made of two planks joined together, and is twelve feet long and three feet wide, and is full of holes large enough for a pea to pass. To prevent the ore or sand with which the gold is mixed from falling out at the side, small projecting edge-boards are fixed to it. The frame is set upon two stools, the first of which is higher than the second, in order that the gravel and small stones can roll down it. The washer throws the ore or sand into the head of the frame, which is higher, and opening the small launder, lets the water into it, and then agitates it with a wooden scrubber. In this way, the gravel and small stones roll down the frame on to the ground, while the particles or concentrates of gold, together with sand, pass through the holes into the trough which is placed under the frame, and after being collected are washed in the bowl."

Agricola has described other ideas-

1. The miner's wife working on the sluice box.
2. The use of green cloth to catch fine gold.
3. The use of knit horse hair and skins to catch fine gold.
4. Painting the sluice black to better see the gold.

Since the writing of De Re Metallica, a number of descriptions of different types of sluice boxes and accessory facilities have been written. The majority of these are descriptive in nature because of the great variations in material in the deposit and in the valuable metal to be saved. Observed information for specific operations is available and from these generalities may be developed which are of value in fabricating a sluice box. Some theoretical approaches have been used but these by necessity have various variable factors. (Ref. - Hydraulic & Placer Mining by Wilson. - Bull. 135, Placer Mining for Gold in California.)

With this in mind, a number of factors can be listed and considered when using a sluice box in a placer mining operation. These factors seem to be the nucleus of many questions that are raised by individuals.

1. Definition

A sluice box, usually rectangular in cross-section, is a simple, effective unit that collects gold by flowing water action over riffles of one type or the other and allows the washed material to be moved to a semi-final storage area.

2. Materials of Construction

Sluice boxes for many years were constructed of wood. Typical sizes of lumber for a sluice box would be 4" x 6" sills, 4' center to center; 2" x 12" x 12' bottom boards, 1" x 12" x 12' side boards, 4" x 4" posts and 1" x 4" braces (B.M.I.C. 6787, Fig. 13). False bottoms and side wearing boards may be used to take wear. In recent years the trend is toward using steel sluice boxes because of their greater stability, durability and ease of handling with modern day equipment. Metal gauge used will vary with the size of the box and the support and bracing used in construction of the unit. Thus a well-braced unit may use 1/8" steel and others may use 3/16" steel. In all cases, reinforcing should be done at upper edges of the sides. Steel boxes are bolted together with appropriate seals and lips between boxes. Occasionally the complete sluice box may be moved as a unit.

3. Length

The unit length of each box is commonly 12 feet. The total length will vary with conditions that exist in the material such as the relative amount of clay, sand, gravel, and the size of the gold particles and the amount of water available. Overall, the length of sluices varies from 36 feet to over 100 feet. In the past, some boxes have been as long at 5,000 feet. Many operations in Alaska will have sluice box lengths that are in the range of 50 to 75 feet.

4. Width

The width of a sluice box varies considerably due to variations in the type and size of gravel and gold, the amount of water available, and the capacity of mining equipment used to feed the sluice box. If the material is coarse, then a rule of thumb is to have sufficient water flowing to cover the largest boulder - hence indicating a narrow but deep box; on the other hand, without coarse material just enough water should be flowing to carry the gravel through the sluice box indicating a wider sluice box. A compromise to resolve such conditions is by sizing the material in ways discussed by James Barker (elsewhere in this volume).

Currently, a number of operators are using sluice box widths of 24" to 36". Also, some operations now have standardized on 60 inch boxes.

5. Grade

The grade of a sluice box is most often stated as the vertical drop in inches for a box length of 12 feet. The grade depends on a number of conditions such as the type and size of material and gold, amount of water available, the type of recovery units used and the width of the sluice box.

A rule of thumb is to have a drop of 12" - 15" per 12 foot box length. From this point the grade can be adjusted by observing operating conditions overall to give best recovery balanced with the quantity of material moved.

Dr. Donald Cook, in his thesis "Gold Recovery in a Sluice Box", has shown that grades up to 18" per 12 foot box length will give good results especially if the gold is not extremely small in size.

RIFFLES

Numerous types of riffles have been used in sluice boxes over a long period of time, however, at present, two main types are used more than others and these are:

Pole Riffles

Pole riffles are of several types - adjacent round wood riffles 2 - 3" in diameter and about six feet long with boards at each end, and placed in the sluice box with their length parallel with the length of the sluice. Railroad rails have been used in the same manner, usually placed right side up. Pole riffles usually help in keeping a fast velocity for the water and gravel but gold can work further down the sluice box than with riffles at right angles to the flow.

Hungarian Riffles

Hungarian riffles are transverse to the length of the sluice box and may be made in several ways. Wooden riffles with their surfaces covered with steel to take wear have been used for smaller width boxes. Angle-iron riffles are a very common type. These are constructed in units of six to eight riffles with one side of the angles nearly perpendicular to the bottom of the box and the other side on top and extending toward the lower end of the box. Some riffles are tilted slightly backwards, perhaps 10°. The space between riffles is equal to or greater than the width of the angle-iron. The width can vary from 1-1/2" to 4 inches.

Many variations of such riffles are made by miners to best meet their specific operations.

In sluice boxes with riffles a common practice is to use manila matting covered with expanded metal placed at the lower end of the sluice box. This is usually a 3' - 4' section but may be more.

Another practice that is becoming somewhat common is using some type of carpeting such as astroturf below the riffles to catch fine gold and to prevent gold from working down if there is a space between the bottom of the riffles and the sluice box.

In addition, punched plates of steel or plastic material may be used in sluice boxes. The size of hole and the spacing between holes in the punched plate will depend upon size characteristics of the load. For example, if there are no nuggets the holes can be swollen. The plates may be placed parallel to the bottom of the box three inches above the riffles. Sometimes the punched plate is placed at a slight angle with the lower end higher so that there is a step.

If amalgamation is used in a sluice box, auger hole riffles or compartmentalized hungarian riffles can be used to hold liquid mercury. These riffles will have a punched plate covering them to allow the coarse gravel to by-pass them.

WATER

Water for sluicing operations may come from a ditch or from a pumping unit. In the latter case, water may be returned.

Several authorities, (B.M.I.C. 6787 and Bull. 135, California Division of Mines), include the following table which gives common practice for the amount of water required for sluice boxes of several widths:

Width of Box - Inches	Miner's Inch of Water FROM	TO
12	25	100
18	100	300
24	200	600
36	500	1300
48 to 60	1000	3000

1 cubic foot water	=	7.5 gallons
1 miner's inch	=	1-1/2 cubic ft. per minute
1 miner's inch in Alaska	=	11.25 gallons per minute
1 cubic foot per second	=	40 miner's inches

The following table (Table I - Duty of Water in Alaskan Sluices) for Alaskan Placers shows the width, depth, grade of sluice boxes, type of riffles, water used in the box and the duty.

The duty is defined as the amount of material moved by one miner's inch of water in 24 hours.

MAINTENANCE

Sluice box maintenance should consider the following points:

DUTY OF WATER IN ALASKAN SLUICES

Locality	Sluice Box Width In.	Sluice Box Depth In.	Sluice Box Grade In. per 12' box	Type of Riffle	Water Through Sluice, Miner's Inch	Duty	Nature of Gravel
Seward Pen:							
Big Hurrah Cr.	36	18	5	Rails	900	1.20	Unfrozen, med., much flat
Little Cr.	48	24	5-7	Angles & rails	---	1.37	Partly frozen, med.
Osborne Cr.	36	24	7	Blocks & rails	750	1.20	Partly frozen, heavy
Mt. McKinley Dist:							
Moore Cr.	24	20	6	Punched plate over matting & longit steel shod	300	1.60	Unfrozen, med., round
Fairbanks Dist:							
Pedro Cr.	36	30	11	Blocks	350	1.20	Partly frozen, heavy
Pedro Cr.	36	30	5	Rails	400	0.80	Partly frozen, med.
Yentna Dist:							
Peters Cr.	30	24	6	Rails	800	0.80	Unfrozen, med.; boulders
Kenai Dist:							
Crow Cr.	52	36	6	Rails	2600	0.50	Very coarse; many large boulders
Nizing Dist:							
Dan Cr.	48	44	5	Rails longit	---	0.32	Very coarse; many large boulders
Chititu Cr.	40	36	5-3/4	Rails longit	2200	0.42	Very coarse; many large boulders, also heavy

TABLE I

1. Aligning and grading boxes
2. Replacing lining and riffles
3. Plugging leaks
4. Keeping sluice running freely
5. Maintaining steady flow of water

Gold quantity and distribution may be checked by sampling one or two particularly small sections (2 - 3 riffles) of the sluices daily, comparing results.

SLUICE BOX INTAKE

At the head of each sluice is a dump box to receive gravel that will then pass into the sluice. Feeding of gravel is accomplished with a dozer and ramp, or, in the case of an elevated dump box, with a shovel or dragline. Some boxes are constructed with elevated wings which allow gravel to be nozzled into the throat of the sluice box directly.

Dump Box

Current practice is to make dump boxes of steel. The size is adjusted to be coordinated with the type of equipment used to feed the box. Such boxes may be 20 feet or more in length and 10 feet or more wide. The bottom may be flat plate but some operators place riffles in the center of the box for about half of the lower length of the dump box and slant the feed side slightly toward the riffles. In some cases the riffles are covered with punched plates.

Manifolds with nozzle discharges are sometimes placed on one side or on the end of the box to allow water to force the gravel into the sluice.

Wings

Wings placed at both sides of and in the center of the head of a sluice box (4' - 8' high and about 10' long) allow water from a nozzle to work and push the gravels to a sluice box. Bypass water is necessary to maintain a relatively even flow in the sluice box.

Elevated Dump Box

Elevated boxes are fed with a dragline or shovel, and water for washing may be from a manifold in the box and/or from a nozzle (automatic or manual). Often a grizzly of one type or the other will receive the gravel which may allow the coarse material to be shunted off and removed by gravity, and the undersize then passes into the sluice box.

The preceding information indicates the numerous variables and the complex relations that exist in designing a sluice box to give maximum recovery and maximum capacity in a placer plant. From presentations tomorrow by mine operators we will view how these variables have been combined into operating plants to meet specific conditions of a placer gold deposit.

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FINE GOLD RECOVERY UNITS

Douglas B. Colp

There are now several fine gold recovery units or systems in operation throughout Alaska. Some of these units are more efficient than others. None, however, can claim maximum efficiencies, but all methods are an attempt by individual miners to save a larger amount of fine gold.

It is reported that none of the old time gold recovery systems used in Alaska were more than 75 percent efficient, except for some bucketline dredges. This indicates a loss of 25 ounces of gold for every 100 ounces recovered, or a loss of $1.00 for every $4.00 saved.

No miner likes to admit that his operation is loosing gold. Some will swear on a stack of bibles that his losses are zero. Others will admit to some loss but a few miners today are attempting to modify their recovery systems in relationship to their concern, experience and financial means in order to maximize recovery.

This paper is an attempt to discuss several methods that can be employed to recover fine gold that may otherwise be lost through a conventional sluice box. The writer acknowledges that most recovery units or systems will not result in the optimum efficiency we would all desire, but may help to recover a percentage of the losses that would occur if no fine gold recovery units were used. Some miners may be able to refine or modify these ideas in order to come up with a better recovery. Others may redesign their existing plant as a result of this conference session. After all, it is this type of discourse that stimulates the mind into developing more efficient practices.

The size of the deposit will primarily determine how much money will be spent on equipment and what type of gold saving equipment will be used. Obviously, a deposit of several million cubic yards will justify larger expenditures than will an equally rich deposit of several thousand cubic yards. The ultimate choice may depend on what equipment can be secured with the money that is available. No matter what equipment is used, however, a great deal of realistic planning must go into the arrangement of this equipment to make its use as economical as possible.

The size of the gold particles to be recovered must be known in order to design an efficient fine gold recovery system. Particles of gold that will pass a 10 mesh screen can be considered fine gold. Some very fine gold passing a 400 mesh screen can also be recovered. All size fractions of fine gold will come from the fine sand fractions of a placer deposit. These sand fractions will all pass a 3/8 inch screen. A most important rule of milling and heavy metal separation holds true in all fine gold recovery systems: "THERE CAN BE NO CONCENTRATION WITHOUT SIZE CLASSIFICATION".

With this thought in mind, it appears certain that any fine gold recovery system must employ methods to reduce the particle sizes of mine-run auriferous gravel deposits. Grizzlies can be used to scalp off large cobbles and boulders. A grizzly is a row of heavy steel bars which screen out the very coarse gravels and boulders. Used mine rails placed either right side up or turned upside down and welded to a heavy frame at each end make a good grizzly. The spacing between grizzly bars and the size of the bars depend on several factors:

1. Size of mine-run feed.
2. Amount of material being handled per hour or per day.
3. Amount of clay.
4. Washing mechanism above the grizzly.

If for instance one plans to mine 100 cubic yards per hour the grizzly should be 3 to 5 feet wide and 6 to 8 feet long set on about a 30 to 35 degree angle. The bars or rails should be heavy enough so that the larger boulders will not break or bend them. Sixty pound rails are used quite successfully. A 60 pound rail weighs 60 pounds per 3 foot section. If there are no large rocks or boulders in the mining section, lighter rails can be used. If huge boulders are present, larger rails may be necessary. Spacing between grizzly bars must also be determined. Two to 4 inch spacing is usually practical in most cases.

The material that passes through the grizzly bars can drop directly into the sluice box, or can be routed into a trommel screen. Trommel screens act as classification mechanisms which further reduce the size of the material before it is distributed to the sluicing area. The trommel is a long rotating cylinder composed of one or more different sized screens. The intake end of the screen is higher than the discharge end so that the material will move through the trommel. The size of the holes in the trommel is determined by the size of material to be put over the sluices. If very coarse gold is present in the placer deposit, the trommel will contain at least one section of larger size screen openings. The material coming from these larger openings will drop into separate sluices containing larger and deeper riffles. The screen size opening throughout the length of the trommel may increase from 1/2" diameter to 2 or more inches. Each size fraction will be guided into its respective sluice. The various fraction sizes should not be mixed.

The sluice box, whether it is located below a trommel or directly below the grizzly is the most important piece of concentrating equipment, because only here can gold be saved. The sluices should be constructed of at least one quarter inch steel so that the bottom is flat and smooth. Adequate bottom bracing should be used to ensure that there will be no buckling or rippling of the bottom. The sluice should be suspended so that the pitch of the box can be changed. Water coming into the sluice should be controlled so that more or less water can be used at any time. The width of the sluice will depend on its expected load. However, even for a very small operation, the box should be at least 18 inches wide. Wooden spacers can be bolted to the sides of the box to make it narrower if necessary. The sides of the box should be at least 12 inches high.

Successful gravity separation of gold in the sluice occurs only when the feed, pitch of the sluice, width of the sluice, and the amount of water coming into the box are at optimum proportions. The best way to determine these optimum proportions is to experiment. Generally, the rate of pitch or slope of the sluice should be between one and one and one-half inches drop to the foot. If the box is too wide for the volume of water available, sanding will also occur and the material will move on down the sluice in channels cut in the sand. If the sluice is too narrow the gold may not have a chance to drop to the bottom and be saved. Too little water causes sanding. Too much water will prevent the gold from settling. The amount of material fed into the sluice should also be constant. Varying amounts of feed will cause the bottom of the sluice to alternately sand up or be washed clean, and a poor gravity separation will occur. By changing these variables optimum conditions can be found. For this reason both the flow of water and the pitch of the box should be controllable.

Riffles are used in the sluice to cause turbulence in the water, which causes the gold particles to drop and become trapped. Riffles made from 1/4" x 2" x 2" angle-iron, spaced 2" apart make an ideal configuration. In sluice boxes under grizzlies, larger angle-iron riffles may have to be used depending on the grizzly bar spacing. Sluice riffles under trommel screens can be made of lighter material.

Steel punchplate over 1" angle-iron riffles works well on fine gold (10 mesh or less). In this case the punchplate is usually placed on 2" x 2" wooden supports in order to provide a 2 inch space between the bottom of the punchplate and the top of the riffle. This allows the lighter sands to escape on down the box, which prevents the riffles from sanding up. If coarser gold is present, large riffles may have to be substituted to ensure maximum efficiency. Again, this is a case of trial and error. Riffles should be constructed so they are easy to install and remove. If the sluice will save the coarse gold or the fine gold but not both, it may be necessary to use two sluice boxes. The first will have larger riffles and will be adjusted to save coarse gold. The tails from the first sluice will be rescreened to a much smaller size (maybe 3/8") and put over a second sluice. This sluice may have a flatter pitch and will be adjusted to save fine gold.

A highly efficient method of saving fine gold is to use a good grade of indoor-outdoor carpet on the bottom of the sluice box. Indoor-outdoor carpet has definite advantages over burlap, wool blankets, coca matting, plasticized hogs-hair material, etc., which have been and may still be used on some operations. Being a plastic, the carpet does not rot or fall apart as do other materials. The "nap" or surface fibers do not "wilt" when they become wet. It is easily cleaned with a garden hose or they can be hung up and air dried. Because indoor-outdoor carpet is of plastic material, the fibers do not absorb moisture, therefore, only the material on and in the rug has to be dried. Although the initial cost of this carpet may seem high, ($5.00-$8.00 per square yard), its efficiency and long life makes its use more economical than other materials.

Two screen analyses of gold taken from a sluice box are shown below. The first tabulation is a screen analysis of gold from a sluice box with nothing under the riffles. The second is the screen analysis of gold from the same sluice box using indoor-outdoor carpet.

Screen Analysis - Without Carpeting

+ 4	Mesh	12%
-4 + 10	"	10%
-10 + 20	"	49%
-20 + 28	"	20%
-28 + 35	"	6%
-35 + 60	"	2%
-60 +100	"	1%
-100		0%
		100%

Screen Analysis - With Carpeting

+ 4	Mesh	9%
-4 + 10	"	8%
-10 + 20	"	45%
-20 + 28	"	19%
-28 + 35	"	9%
-35 + 60	"	6%
-60 +100	"	3%
-100		1%
		100%

These screen analyses of the gold from two consecutive cleanups of the same sluice box set at the same grade and processing ground from the same mining section, are a graphic example of the fine gold recovery, with and without using indoor-outdoor carpet. Ten percent more gold smaller than 28 mesh was recovered by using this type carpet. This sluice box could probably be improved on with very little cost, in order to obtain an even better recovery of fine gold.

If a sluice box cannot be designed to recover most of the fine gold in any given placer deposit, undercurrents may be employed. As has been mentioned earlier in this paper the minus 3/8" sand fraction can be channeled into a second sluice or an undercurrent. The pitch or slope of this undercurrent is usually a little less than the main sluice. Its width depends on the volume of material discharging through the 3/8" holes in the punchplate grizzly. Both the amount of water flowing into the undercurrent and slope of the undercurrent should be controllable. Indoor-outdoor carpeting is placed on the flat undercurrent bottom and overlayed with punchplate. The punchplate serves two purposes. First, it holds the carpet flat against the bottom of the sluice. Secondly, the holes in the punchplate cause a riffling action, or a turbulence, in the water and in the sand being carried by the water. It is this turbulence that allows the gold to be dropped from the flow of sand and to be picked up by the fibers of the carpet. Punchplate with square holes seems to make the most effective riffle. Round holes work, but not as well. Punchplates which are one-quarter to 3/8" thick, with one and one-quarter inch square holes, one-half inch apart, work very successfully. The rows of holes should be staggered. In this way, all sand must pass over fiber-filled holes. These punchplate sections should not be any larger than can be handled by one man.

In a large operation with a lot of minus 3/8" sand, the undercurrent may have to be several feet wide in order to handle the extra volume. In order to hold down the carpet on wide undercurrents, 1/2" bolts are welded to the bottom of the sluice along the edges of the punchplate. The bolts should be placed about 2 feet apart, to form a line of bolts up and down, in the direction of flow along the undercurrent. Holes are drilled in 2" x 4" lumber so that the lumber can be placed over the row of bolts. When dropped into place, the 2" x 4" covers the edges of the punchplate. Washers and nuts are then put on the bolts and the lumber is pulled down until it forces the punchplate into the carpet. The separation of gold from sand in an undercurrent is the same principal, "GRAVITY", as with angle-iron riffles. Most of the sand moving down through this sluice is quartz, feldspar, mica and other relatively light material. A small percent, usually less than two percent, is magnetite or "black sand", hematite, ilmenite, etc. A very small percent is gold. It is the difference in specific gravity of the gold and the other materials that makes the separation possible. Gold has a specific gravity of about 19. The lighter quartz fraction has a specific gravity of less than 3. The black sand fraction has a specific gravity of about 6. Therefore, gold is about 6 times heavier than the quartz fraction and more than 3 times heavier than the black sand fraction. This means that as the material moves down over the punchplate, the gold will tend to settle into the carpet fibers and the lighter fraction will be washed on through the sluice.

The same factors can prevent the undercurrent from working as were previously discussed earlier in this paper, such as pitch of the undercurrent, amount of fine sand and the volume of water being used. Adjustments must be made accordingly.

The carpets need to be changed usually only once every week or 10 days. The carpet should not be left in the undercurrent long enough for the holes to be filled with gold, because then some of the gold will be lost. Heavier accumulation should always be found at the upper end. Gold at the upper end should also be coarser. The amount of gold should diminish and become finer as it moves down the sluice. If there is as much gold on the lower half of the sluice as there is on the upper half, the undercurrent is not operating properly. Corrective adjustments will then have to be undertaken. If the pitch or slope of the sluice, the amount of feed and the volume of water are found to be correct, then the sluice length will have to be increased in order that all of the gold will have a chance to settle out. Excessive black sands will also tend to clog the punchplate openings, which in turn prevents the fine gold from accumulating. Should this occur and in the event corrective measures such as increasing the grade of the sluice, adding more water, etc. do not help, then it may be necessary to clean up every 2-4 days depending upon the amount of clogging.

Expanded metal can also be used over carpeting in lieu of punchplate, providing it is securely held down. Quarter-inch thick metal works quite well. This lath type metal consists of a latticework of diamond-shaped openings (about 3/4" x 1-1/2") separated by raised metal strands that have a decided slope in one direction. When installed as riffles, with this slope leaning downstream, eddies form beneath the overhangs, thus creating conditions well suited for saving fine gold.

Jigs are another mechanism that can be used to save fine gold. This is a machine in which heavy minerals are separated from sand or gangue minerals on a screen in water by imparting a reciprocating motion to the screen or by pulsation of water through the screen. Where the heavy mineral (such as gold) is larger than the screen openings, a concentrate bed will form on top of the screen. Where the heavy mineral particles are smaller than the screen openings, a fine-size concentrate will be collected in the hutch below the screen. These machines now have high capacities and make a clean enough concentrate for direct barrel amalgamation or table feed. The capacity of some jigs on classified feed is about 1 cubic yard per hour per inch of bed width.

Amalgamation is another method to extract fine placer gold by treatment with mercury. Mercury is a heavy (Sp. Gr. 13.5+) silver-white metallic element, useful in placer mining because of its chemical affinity for gold. Mercury placed in the riffles, or in a mercury trap, forms a gold amalgam which is removed during the cleanup operation and then retorted in order to separate the mercury from the gold. The gold product is referred to as "sponge", which is sold directly or is melted into a bar.

Mercury is usually not used in the upper part of the sluice box because it is economically beneficial for an operator to recover as much free gold as possible. Since free gold can be sold to anybody that wishes to buy gold at the world market price, the operator will usually realize 10 to 20 percent more for his gold if it is not treated with mercury. Treated or melted gold, on the other hand, must usually have a "fineness" run on it, to check for impurity, and the seller is paid only the actual weight of the gold and not for the weight of the impurities within the gold. Gold with the fineness of 1000 is pure gold. If the fineness is 800, the material is 80% gold and 20% impurities. Fortunately, the impurities usually consist mainly of silver, for which the seller will be paid, but at a much reduced price.

When mercury is used, the riffles below the center section of the upper sluice are charged. The upper riffles in an undercurrent are also usually charged. Only clean retorted mercury should be used.

All splashing or spattering should be avoided, otherwise minute globules of mercury are formed, which will float away. More mercury is added from time to time as required to keep a clean surface of mercury exposed. A common charge may vary from a few pounds to 2 or 3 flasks (76 lbs. each) for large undercurrents. Mercury in some sluices and undercurrents is contained in traps. These traps can be made by cutting a 2" x 12" plank to fit transversely in a sluice. One and one-half inch holes are bored into the plank one inch apart with a ships auger to a depth of about one and one-half inch. Rows of holes throughout the length of the 2" x 12" are staggered so that the particles of sand containing the gold cannot flow over the trap without falling into these holes. The holes are about half-filled with mercury. Rectangular slots one and one-quarter inch wide and two and one-half inches long are sometimes used in the 2" x 12" trap instead of the round hole design.

Unused mercury in the traps or loose in the sluices often becomes "sick". This is because the mercury becomes coated with a film of some sulfide. When the sick mercury becomes separated into globules, they refuse to reunite and will not amalgamate with gold. In this case, the mercury can be treated with small amounts of metallic sodium to increase its affinity for gold. Care must be exercised in how much metallic sodium is placed into the mercury. Too little does no good, too much will allow the mercury to adhere to any iron metal it contacts. Rubber gloves and goggles should be worn by anyone mixing metallic sodium with mercury to prevent being burned by possible splattering. It should be mentioned here that all placer gold will not amalgamate in a sluice box or undercurrent. If the gold is coated with an oxide it will not unite with mercury. Therefore, tests should be conducted to determine if the gold in a particular placer deposit will amalgamate prior to attempting to use mercury for trapping gold in a proposed recovery system.

Other fine gold recovery units such as the use of Bowls and Spirals will be discussed in a separate paper by Donald Cook.

The cleanup procedures for sluicing operations that use indoor-outdoor carpeting, jigs, mercury, etc. are quite different from normal sluice box cleanup methods but cannot be covered in this paper. It should be emphasized, however, that anyone contemplating an operation using any of these methods to save fine gold should look into various cleanup techniques in order to save himself hours of work and to assure maximum recovery.

THE NUMBERS GAME

Alan C. Epps

Pre-1970's, Alaska contained some 6.9 million acres in Parks and Monuments plus some 24.6 million acres of military lands (including PET-4) which were unavailable for private mining interests. That left approximately 343.5 million acres available to mineral entry. How does this compare to what exists today?

EXISTING WITHDRAWALS AS OF APRIL 4, 1979

	Millions of Acres
Wild and Scenic Rivers	2.3
204 (e) of FLMPA	54.0 (a)
Parks and Monuments	51.8
Fish & Wildlife Refuges and Monuments	30.4
Forests including Monuments	20.7 (b)
Military	2.6
Pipeline	2.2 (c)
NPR-Alaska (PET-4)	22.0
Other	.5
TOTAL	186.5 (d)

(a) 38 million acres of this are in process to become Fish and Wildlife Refuges under 204 (c) of FLMPA.

(b) 11 million acres of the Tongass and Chugach are withdrawn under 204 (b) of FLMPA for wilderness study.

(c) A portion of the pipeline withdrawal--approximately one million acres--is open to mineral entry.

(d) There is some overlap in this total with the 2.3 million acres of Wild and Scenic Rivers, but the others are additive.

About 6% or some 19 million acres of this are open to mining with some 175 million acres closed to mineral entry today.

It is important to remember that we do not have the situation of 15 to 20 years ago when virtually 90% or more of Alaska was open to mineral entry. Today, nearly one-half of Alaska is closed to mineral entry. Withdrawals for Native selections are over and above this.

What are the current alternatives in the U.S. House of Representatives?

THE UDALL BILL (H.R. 39-79)

	Millions of Acres
Wild and Scenic Rivers	2.0
Parks and Monuments	49.8 (a)
Fish and Wildlife Refuges	89.4 (a)
Forests	23.4 (a)
Military	2.6
Pipeline	2.2
NPR-Alaska (PET-4)	22.0
Other	.5
TOTAL	191.9 (b)

(a) Includes pre-existing areas.

(b) 85 million acres would become new wilderness.

About 6% or some 11 million acres of this would be open to mining with some 180 million acres closed to mineral entry.

THE HUCKABY BILL - H.R. 39 Amended (Interior Committee)

	Millions of Acres
Wild and Scenic Rivers	1.5
Parks, Monuments and Preserves	52.7 (a)
Fish and Wildlife Refuges	63.5 (a)
Forests	23.7 (a)
Conservation Areas, BLM	3.4
Recreation Areas, BLM	1.0
Military	2.6
Pipeline	2.2
NPR-Alaska (PET-4)	22.0
Other	.5
TOTAL	173.1 (b)

(a) Includes pre-existing areas.

(b) 50.8 million acres would become new wilderness.

Some 9% or approximately 15.4 million acres open to mining with everything except Parks and Wilderness potentially open at Secretarial discretion, which could mean some 90 million acres open.

Under this proposal, the State of Alaska would receive the lion's share of her selected lands. This is especially important from a minerals standpoint, which will be dealt with a little later.

THE BREAUX BILL - H.R. 39 Amended (Merchant Marine Committee)

	Millions of Acres
Wild and Scenic Rivers	1.5
Parks, Monuments and Preserves	39.3 (a)
Fish and Wildlife Refuges	106.3 (b)
Forests	23.1 (a)
Conservation Areas, BLM	2.0
Recreation Areas, Fish & Wildlife Service	1.2
Military	2.6
Pipeline	2.2
Other	.5
TOTAL	178.7 (c)

(a) Includes pre-existing areas.

(b) Includes pre-existing areas and makes the National Petroleum Reserve into a Refuge.

(c) 53.7 million acres would become new wilderness.

Some 62% or some 111 million acres would be open to mining with 67.7 million closed.

Under this proposal the State of Alaska would also receive most of its selected lands. This proposal mandates that Refuge areas would be open to mining under the 1872 mining laws. Further, oil and gas exploration and development would be done by the private sector, instead of government.

Amendments which appear possible over on the Senate side--assuming a pro-Alaska bill passes the House--include language to provide for mill and water rights as well as extending time for establishing valid existing rights. This latter includes some clarification of "discovery".

Both the Huckaby and Breaux bills have improved access provisions over present existing law, although these could stand some improvement for the Alaska situation. I have not read the Breaux language but it is my understanding that some improvement has occurred.

From a Minerals standpoint, there are a number of State selection areas which are very important. Within the additions to Mt. McKinley, the Chulitna area is outside the park, with the Kantishna and Dunkle mine areas set up as special three year mineral study areas.

Southern Brooks grants to the State all out-of-court lands and almost all other State selections. Further, the "Boot" area is treated as a Recreation area for Title IX on access, which is very important for this area.

The State selections in the Chandalar area are granted. The State selections within the Yukon-Charley were not granted, but the State is pushing to be granted the Coal Creek and Woodchopper areas. Within the Circle area, the State was granted more selected lands.

It has been an interesting process to watch in Washington, D.C., as the energy picture has changed over the last few months. From a multiple-use standpoint, whether for recreational, mineral, or otherwise, it has been piggy-backed onto the energy issue, and will likely continue to be so.

CENTRIFUGAL FORCE IN GOLD RECOVERY SYSTEMS

Donald J. Cook

The recovery of placer gold from clay, sand, gravel, boulders and associated heavy minerals in an alluvial deposit is dependent primarily on the specific gravity difference between gold and the other components that constitute the deposit. In some cases this may be aided by the characteristic of gold to amalgamate with mercury.

It is those physical properties of gold such as specific gravity, shape, size and extreme malleability along with its inertness to chemical reactions that have assisted the natural processes of erosion, transportation and deposition in the formation of placers from a lode source. The natural processes can be catagorized as having taken place in a horizontal flow, a vertical flow or a centrifugal flow of water as the transporting media.

Certain physical properties of gold will, unfortunately, also be detrimental to the concentrating process, whether natural or man made. Mineral particles exposed to erosional forces undergo continual comminution, but gold particles subjected to the same forces will become rounded and almost always flattened to some degree. Extremely fine and/or paper thin particles are buoyed up by water action, and may be carried long distances by a swift stream. The same action is therefore possible in a sluice box which must also act as a transporting device for much larger particles.

The systems currently used by man are adaptations and refinements of the natural processes. As examples, the sluice box and riffles commonly used as a recovery system employ the same principles as transportation, deposition and concentration as would be found in any flowing stream. The jig operates on a vertical flow which accentuates the differences in the settling velocities of solid particles, and the principle of centrifugal force is also applied by man as well as in the natural process.

Gradient, velocity, volume and load usually vary in the same stream so that erosion may be going on in one part and deposition in another. This is especially true at the curves where a measure of centrifugal force causes an increased stream velocity on the outside of the curve and a decreased velocity along the inside, as shown in Figure 1.

SPIRAL CONCENTRATION

As shown in Figure 2, the Humphrey spiral concentrator can be visualized as a series of stream curves stacked one on top of another. This system takes advantage of the concentrating action that results from a change in velocity between the outer and inner curve of the channel.

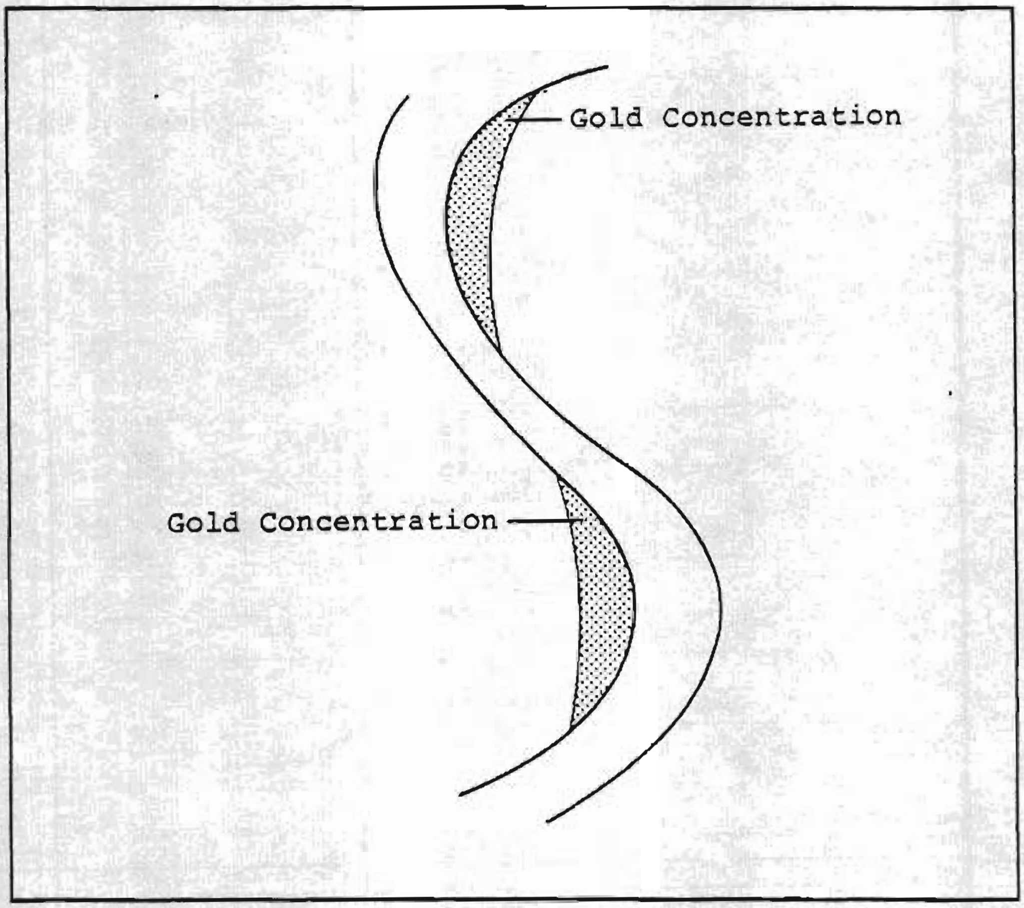

Figure 1

Sand Bars Formed at High Water

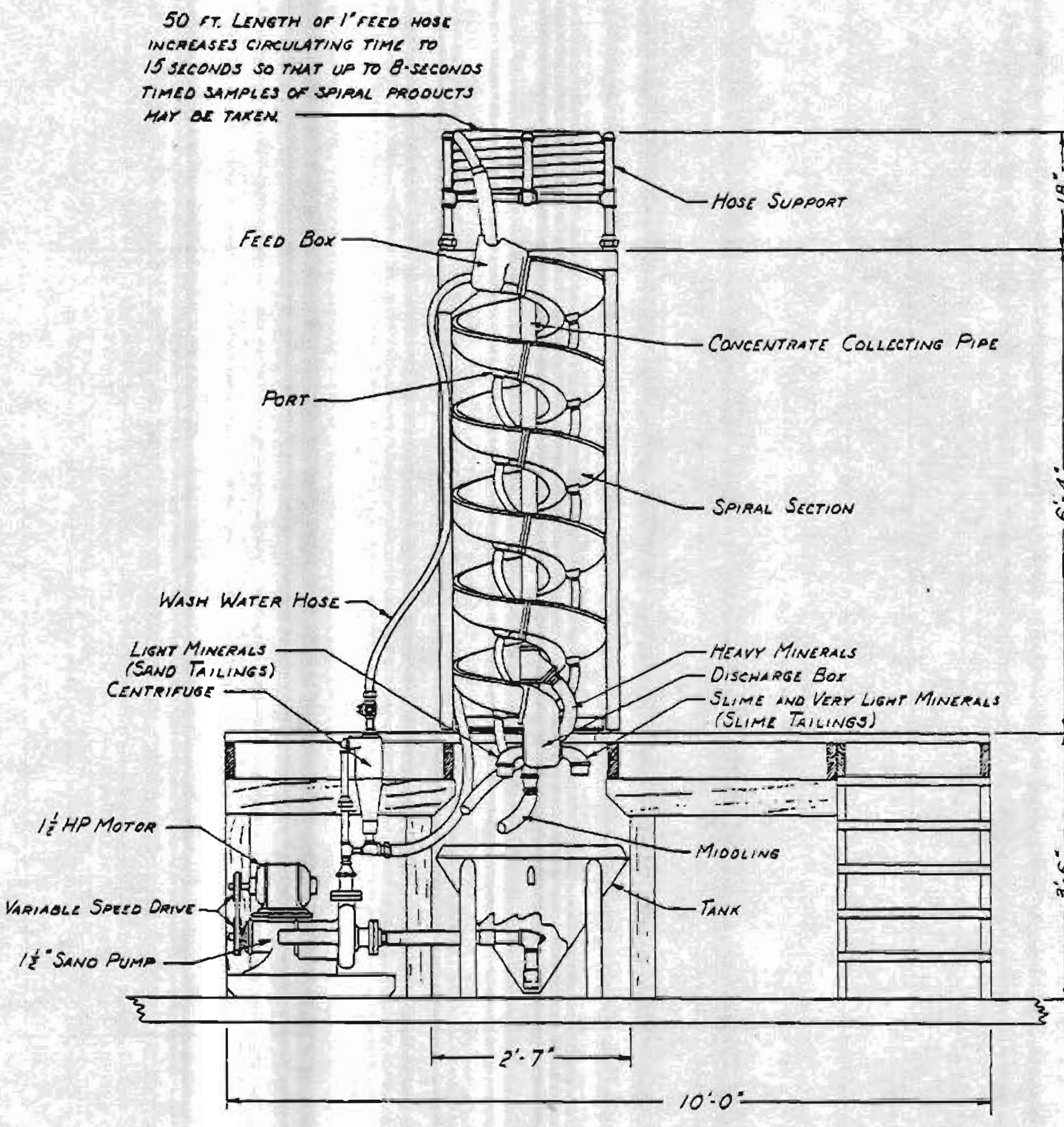

Figure 2 - Humphreys Spiral Concentrator Closed Circuit Test Unit

With the flow of water and solids down the spiral channel, centrifugal force piles water up on the outer rim of the spiral until the stream reaches an equilibrium between centrifugal force outward and gravitational pull downward. The combination of centrifugal force and frictional drag results in a concentration of heavy minerals along the inner curve, as shown in Figure 3. The results may be compared to a natural stream channel, but man made controls of channel shape, stream velocity, particle size and pulp density allow a higher degree of concentration that can be removed on a continual basis.

Spiral capacities range from 1.5 to 2.0 tons per hour for most ores, but may vary considerably depending upon feed characteristics. The slurry generally consists of 20 - 40% solids by weight with solid particle size ranging from 10 to 200 mesh.

The use of spirals in alluvial deposits has been confined generally to the bulk concentration of heavy minerals from beach sand deposits. Use in stream type placers would require a constant flow rate of properly sized material. The occurrence of flat, flaky gold would result in losses as their buoyant characteristic allows them to be swept into the higher velocity area at the outer periphery of the channel.

BOWL CONCENTRATION

The concept of combining centrifugal force and amalgamation for gold recovery is not new. In fact, a search of the literature will reveal that centrifugal amalgamation was considered prior to the turn of the century. The basic principle of utilizing centrifugal action to obtain forced amalgamation of gold into a mercury layer was employed in the early devices with design and mechanical changes developed in later units.

The Gilkey Bowl, as a later development, utilized the basic principle, but employed modifications in mechanical operation, feeding and discharge systems and incorporated a peripheral screen in the mercury layer.

As shown in Figure 4, the centrifugal amalgamator is essentially an open-mouthed bowl balanced around a drive spindle with speed of rotation governed by the diameter of the belt driven drive pulley. A recessed channel around the inner periphery of the bowl presents a surface of mercury held in place by centrifugal force as the bowl spins. The feed slurry enters the bowl through a delivery pipe which terminates just above the bowl floor. This slurry accelerates toward the bowl periphery and flows up and over the mercury surface exiting over the top of the bowl where it is channeled by gravity to a discharge pipe at the bottom.

As there was some evidence that fine gold losses were occurring in their dredging operations in South America, Pato Consolidated Gold Co. installed a 36" bowl as a test unit on one of their dredges, and simultaneously a subsidiary company, Consolidated Purchasing and Designing, initiated a laboratory testing program here at the University using 6" and 12" diameter bowls.

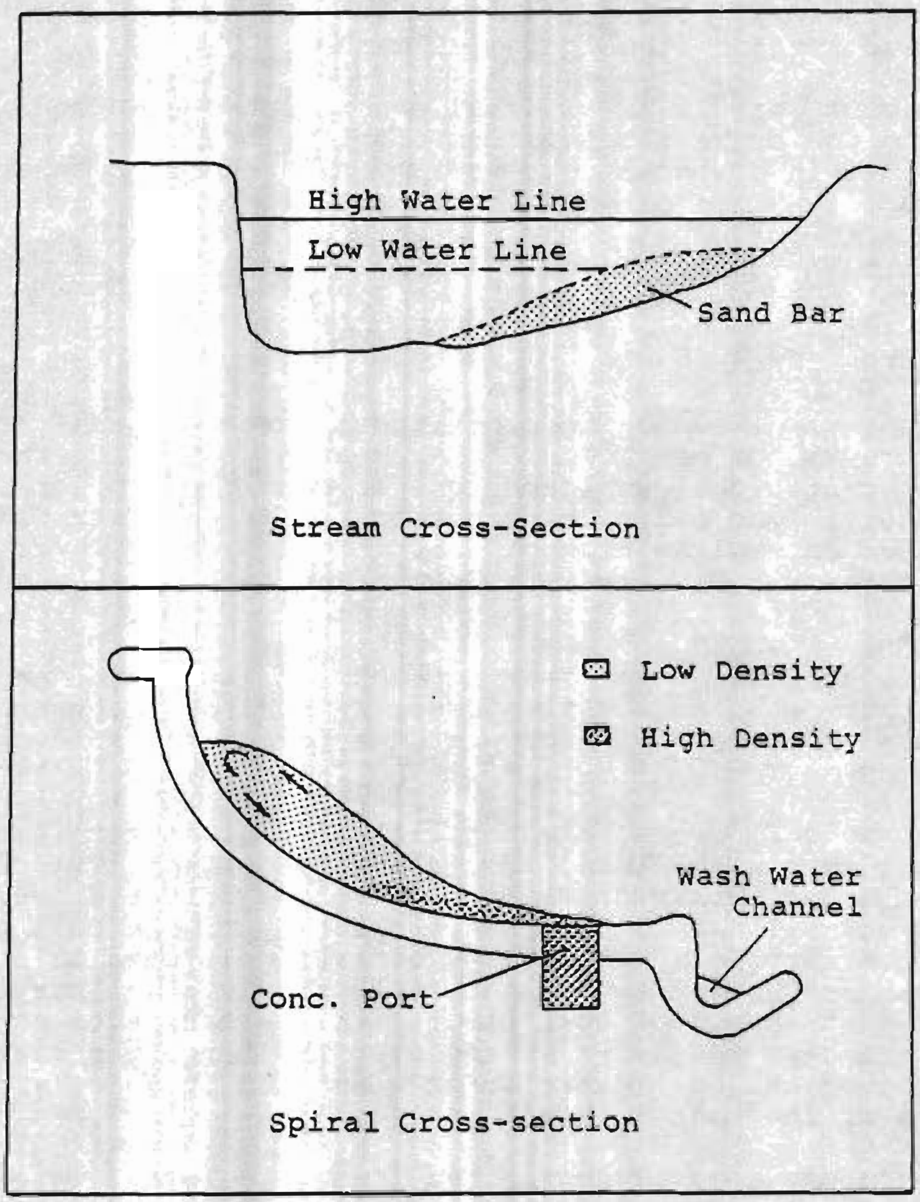
High Water Line
Low Water Line
Sand Bar
Stream Cross-Section
Low Density
High Density
Wash Water
Channel
Conc. Port
Spiral Cross-section

Figure 3

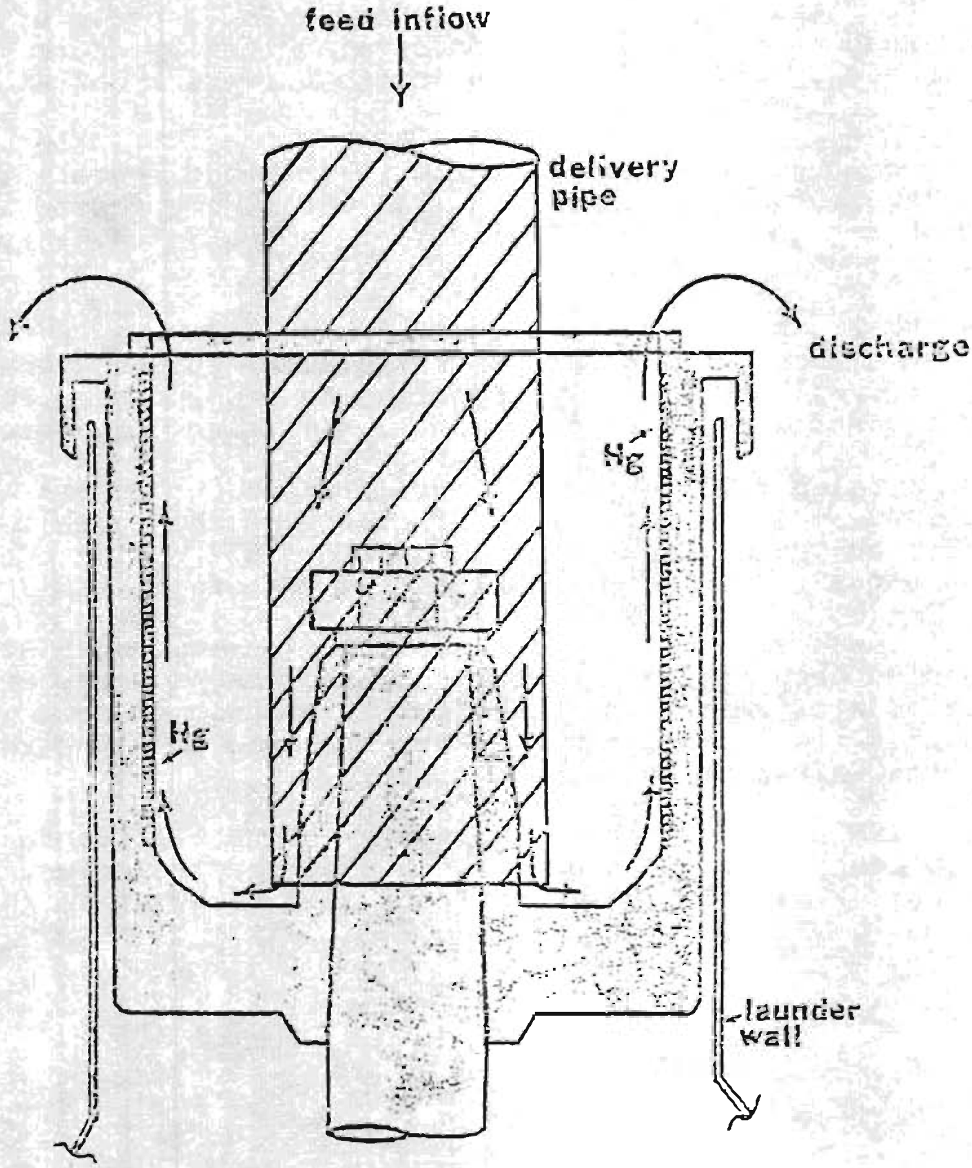

Figure 4

Gilkey Bowl Cross-Section

The laboratory program was designed to determine the effects of operating parameters on the bowls ability to recover gold from a slurry without mercury losses. The bowl parameters included: rim speed, slurry feed rate, pulp density of slurry, particle size of solids, particle size of gold, specific gravity of solids, volume of mercury in the channel, gold shape and bowl configuration.

The results of these tests indicated that the bowl is capable of high gold recovery when proper control is exercised on feed rate, feed pulp density, feed classification and rim speed. For details of recovery as influenced by the above mentioned parameters, you are referred to a thesis by William Anderson in the University of Alaska Library.

As a result of the above mentioned study, a second phase investigation was initiated whereby the 6" and 12" bowls were tested in a closed circuit operation, as shown in Figure 5, and a 36" bowl was installed as a test unit on an operating dredge at Nome, Alaska.

The latter operation, shown in Figures 6 and 7, removed a portion of the minus 1/4" slurry from the end of transverse sluices 2 and 4. The capability of sampling the bowl discharge was incorporated to allow determination of flow rate, pulp density and size classification.

Due to the surging feed conditions normally encountered in a dredging operation, and the portable inefficiency of the installed screening device, pulp densities varied from 2% to 57% solids by weight and flow rates ranged from 32 GPM to 198 GPM of slurry.

In spite of these adverse conditions, it was determined that fine gold losses do occur in the conventional sluicing system, and the bowl was capable of recovering a substantial amount of this gold. For details on this testing program, you are referred to a thesis by Joseph Wang in the University of Alaska Library.

Indications are that with proper parameter control as to feed rate, size, pulp density and continuity with a staged operation, as suggested in Figure 8, the bowl is capable of gold recoveries in excess of 90%.

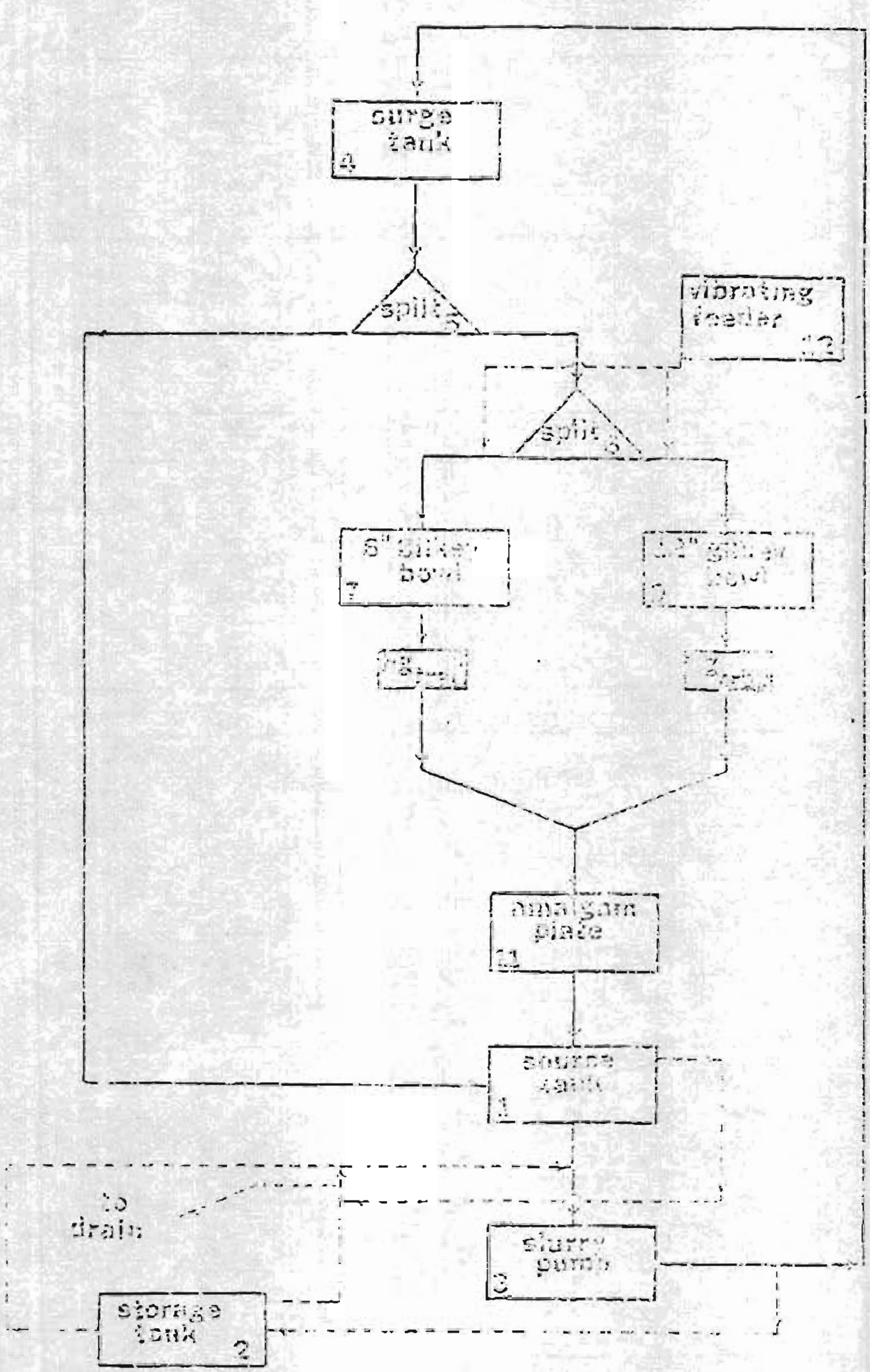

Figure 5

Closed Circuit Operation

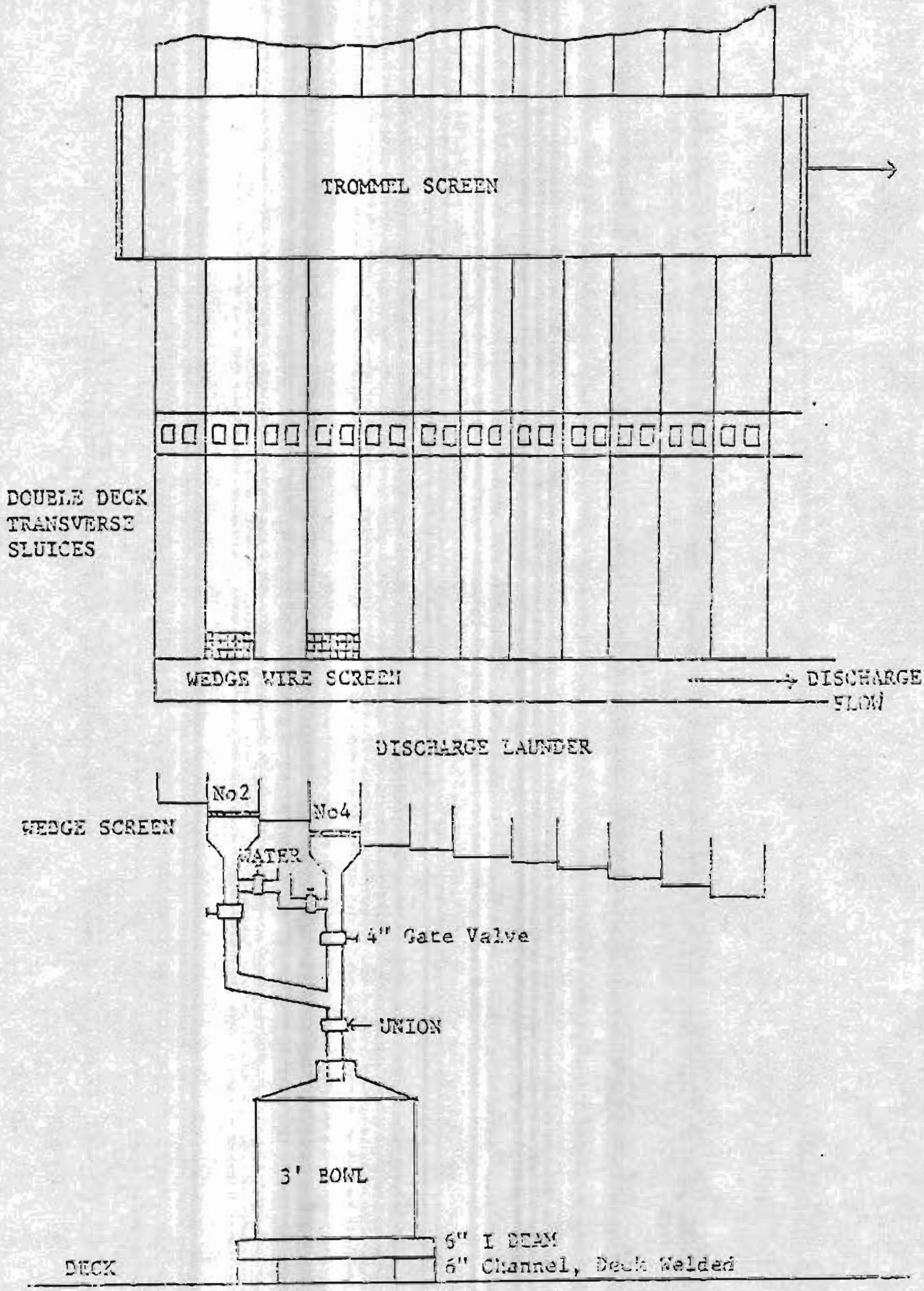

Figure 6

Dredge Installation

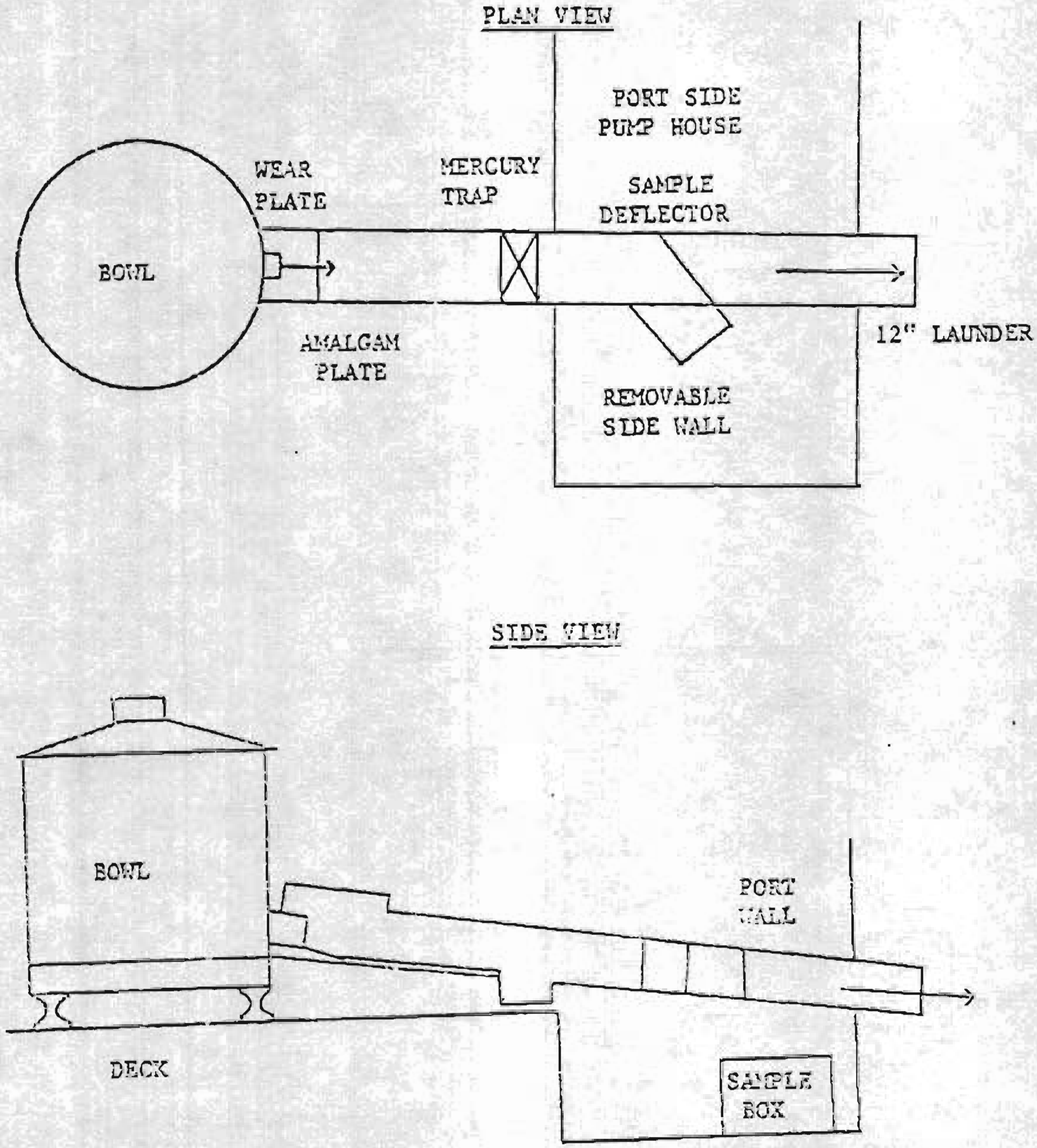

Figure 7

Sampling Scheme

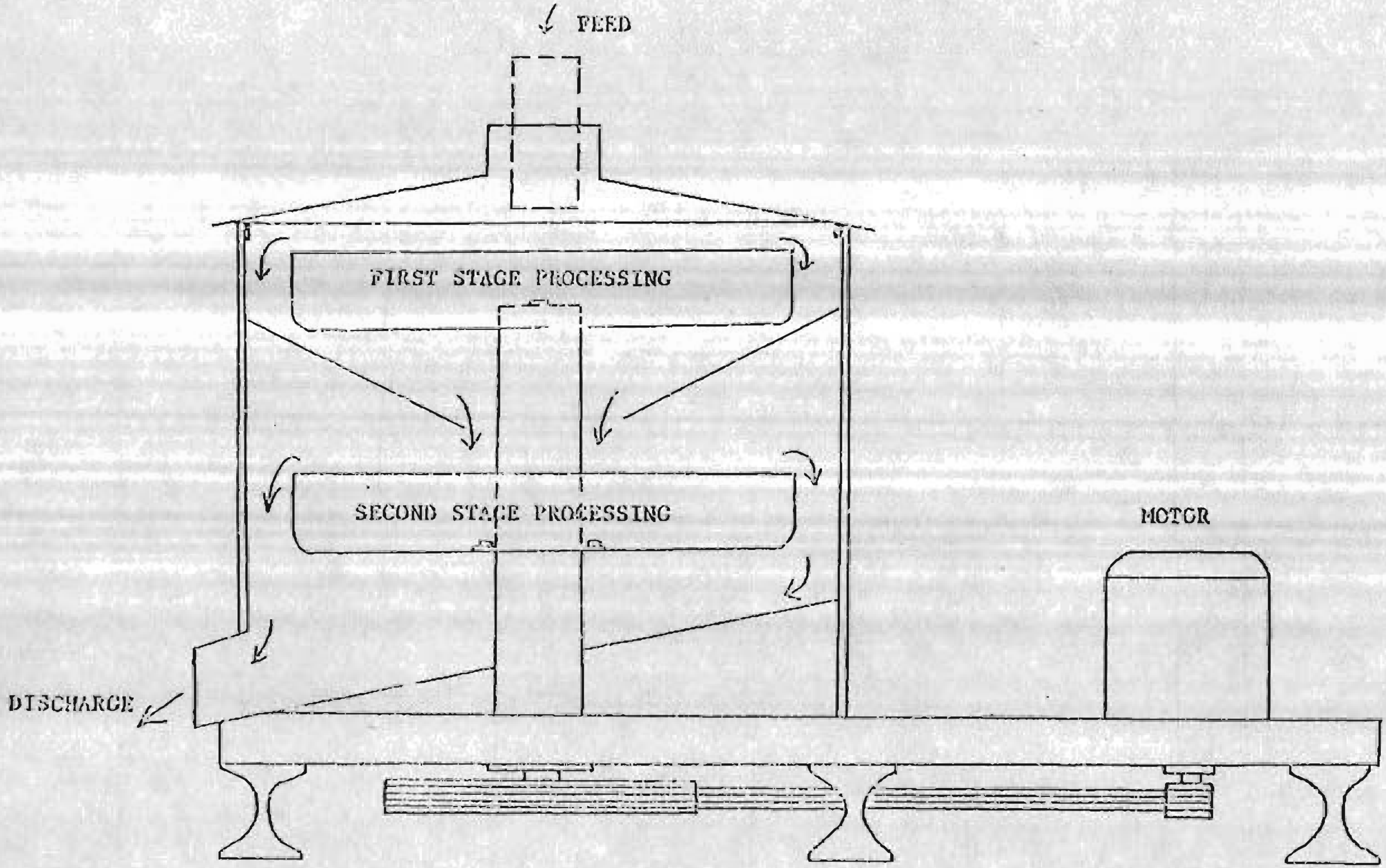

Figure 8

Two-Stage Processing

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CLEAN UP PROCEDURES

Joseph Thomas and Tury Anderson

Presented by Earl H. Beistline

Clean up is the procedure of recovering the valuable product from the sluice box. The frequency at which this is done depends upon many factors relating to the mining plan and ground characteristics. In some operations a clean up is done only on completion of the mining of a cut whereas on others partial clean ups may be conducted fairly frequently. There is no hard and fast rule. Test panning of material in the sluice box will provide a check on whether or not gold is tending to work its way down the box. Obviously, if gold is tending to migrate downwards, a clean up may be indicated.

Prior to starting a clean up related to an overall mining plan, a check should be made to ensure that all ground intended for sluicing has been put through the box. The collection area and intake box should be cleaned of all gravel. This is also an opportune time to test the tailings for possible gold losses. (A frequent check should be made of tailings as a matter of routine to gauge recovery efficiency.) A good controllable supply of water should be at hand during clean up plus a variety of equipment. The latter should include:

1. Pinch bar 2-1/2' x 1/2" square
2. Square faced shovel
3. Ball hammers and small sledges
4. Paddle to work over contents of the box
5. Scoop
6. Whisk brooms
7. Buckets and dishes
8. Rubber gloves
9. Gold pan
10. Wash tub
11. Sponges
12. Strong box

The sluice box is cleaned up in several sections. Wedges and other constraining devices to hold the riffles in place are loosened and the riffle sections are washed clean before being lifted clear of the sluice box and stacked handily where they will not impede progress with the clean up. The contents of the sluice box can then be shoveled into heaps in the sluice box following which the paddling procedure can begin. The paddle (an ice scraper or straight hoe make good paddles) is used to rake through the material in the presence of an even flow of water within the box to gradually work off the lighter fraction. Obviously, more than one person can paddle the box contents at any one time within the section of the box being cleaned. Paddling will continue and as gold appears it can be pushed to one side to be scooped up. Once gold starts to move down the box the residual concentrate can be picked up and put into containers to await further concentration. The process is repeated for the entire sluice box. Always leave a safety riffle at the end of the box as a precaution against possible loss of gold during the clean up.

In boxes lined with matting or astroturf, the lining can be rolled up and removed in sections. The sections can then be washed in a large drum or in a part of the box itself where water has been dammed up. The recovered concentrate is further processed to recover the gold. Magnetic minerals can be removed by a hand magnet and it may be possible to pan down to a fairly clean product. Where there is an abundance of fine gold particles, mercury amalgamation may be needed to recover the product.

The gold, if recovered in discrete form, is dried and blown over to remove dust. It can then be screened into different size fractions prior to selling. Coarse nugget gold commands premium prices.

The efficiency of the sluice box can further be tested by weighing the fractions taken from each segment of the box. You need to know where the gold is concentrating in the box - if, for example, significant amounts of gold are recovered from the lower sections of the box, considerable losses of fine gold are probably occurring.

Black sand concentrates can be processed in an amalgam barrel. This is charged with concentrate, mercury, lye and water and agitated for several hours. The contents are then passed over an amalgam plate.

As a test of mining efficiency the operator will certainly need to test the gold recovery against estimates obtained during prospecting. If everything is in balance the factor expressed as R/E, (Recovery)/(Estimate), will approximate unity. Serious divergencies either way will indicate that something is wrong - attributable to a wide range of possibilities.

In any event, the operator needs to compare clean up recovery with the volume of gravel processed in order to establish a value per cubic yard.

Retorting to separate the gold from mercury can be done in the field with basic apparatus. The retort vessel containing the amalgam charge is very carefully sealed prior to heating and distillation. The retort is often lined with unglazed paper to prevent metal fusing to the base of the vessel and quite commonly amalgam is wrapped in paper prior to loading. The retort should be loaded no more than 2/3 full and very carefully sealed. A pipe leads from the top of the retort and is inclined downward through a water jacket, which accelerates condensation. The discharge outlet is maintained just below water level in the collection recepticle. A suitable check can be undertaken to determine when the retorting process is complete. The recovered mercury, of course, is reusable. The same furnace used in retorting can be used to process the sponge gold into bullion bars. This is done by heating the sponge gold in a graphite crucible with a flux comprising 2-1/2% borax and 5% soda (expressed as a weight percentage of the sponge gold). The flux constituents combine to produce a good slag containing some of the contaminants. The molten metal is poured into prepared molds and allowed to cool. It is usual to coat the molds with soot to inhibit sticking. The bullion blocks can be assayed to determine their fineness and worth.

NEW DEVELOPMENTS IN CLEAN UP

John Miscovich

Presented by Walter Wigger

Perhaps tired of daily clean ups on his property near Flat due to the presence of scheelite, John Miscovich, a lifelong practical miner, searched for a less labor-intensive way of recovering the saleable commodities.

The idea which emerged during the past winter is innovative and ingenious. It has been tested on experimental models and found to be effective and this season will be extensively field tested on the property near Flat.

The idea basically consists of cutting sections out of the base of the conventional sluice box and inserting an astroturf belt. Two or three such belts could be built into the length of the sluice box. The belt travels at 90° to the longitudinal axis and, hence, streaming direction of the box at an adjustable speed (2' per minute was tried in the experimental model). With this principle, instead of flowing across a static area of astroturf as occurs in a standard box, fresh astroturf is fed in at one side and, having travelled across the box catching heavy grains, is removed from the system. Clean up is a continuous process since the loaded astroturf now passes through a washing tank to liberate and recover the concentrate. The washed astroturf passes under the box and enters as fresh feed, completing the cycle.

The box is constructed using 1/2" punch plate even with the top of the riffles. Punch plate can be varied depending upon gravel conditions. In time, as the system develops, it may be possible to get away from the use of riffles in a box entirely.

Test runs have been made with finely divided gold and scheelite-bearing material from the Golden Horn property. The system was effective in recovering very fine grained scheelite. The system may have particular application in the recovery of very fine gold and especially in finely divided multi-commodity type deposits.

An obvious advantage of the system is that high value concentrates can be removed daily from the site, which is a significant benefit in these times.

GOLD MARKETING

Merl Thomas - Alaska Gold Sales

Tony Hart - Johnson Matthey (Canada) LTD.

World Marketing of Gold

Estimations of the production of newly mined gold for 1978 total 47 million ounces. Of this figure, Russia will mine, but not necessarily market, 15 million ounces and the Free World an aggregate of 32 million ounces. The biggest and newest gold mine, the United States Government (though not producing newly mined gold), aims to sell between 20 and 30 million fine ounces through G.S.A. and I.M.F. auctions.

Initial concern for the ability of the market to absorb gold being auctioned off has long since faded and, in fact, there are perhaps twenty or more major accounts with the capability of absorbing the total offering of a particular auction. The pattern of recent sales has been one of bids for gold greatly in excess of the quantity on offer.

South Africa is the largest producer of newly mined gold, estimated in 1978 at 23 million ounces. South Africa refines its own gold and has recently done an excellent job of marketing in the form of the Krugerrand. Between 7 and 8 million are produced annually, each containing one fine ounce of gold. Rising from insignificance a few years ago, the Krugerrand has become internationally acceptable and a key form of gold acquisition helped by a well-executed $5 million dollar per year advertising campaign.

Russian production can and is frequently withheld since no pressures exist within that country to maintain cash flows and distribute earnings to investors.

Canada is the third largest producer with 1.7 million ounces in 1978. The production of a new one ounce bullion coin, the Canadian Maple Leaf, will absorb as much as one million ounces.

The United States in 1978 produced between 1.1 and 1.2 million ounces and following the initiative of Senator Helms will also produce a new bullion coin which will also be highly acceptable.

In 1978 approximately 60 million ounces came onto the market. Where did it go? A breakdown of usage would be:

Jewelry	32 million ounces	Italy alone fabricated 7-8 million ounces, mainly as 18 ct. chain
Electronics	2-1/2 million ounces	Computors Calculators
Dental Usage	2-1/2 million ounces	
Official Coins and Medallions	4-1/2 million ounces	Krugerrands, Etc.
Fake Coins	2 million ounces	Flourishing trade centered in Beirut and Jedda
Sundry Industrial Usage	Not Specified	

For all usages there is a significant and characteristic recycling or retention of the metal in usage. 97% of all the gold produced throughout the world is still in effective use -- a total of 80,000 tons of metal which could fit into a cube with sides 16 yards long! 60,000 tons have been mined this century and 40,000 tons or 50% of total global historical production since World War II. All this gold is still around.

Enormous quantities of gold are traded daily in the metal exchanges but where does it come from? Obviously there is insufficient gold to satisfy daily turnovers of 4 million ounces in London in one day and 3 million ounces in Camex. The same gold is repeatedly bought and sold on a short periodicity around the world. Johnson Matthey deals around the clock from trading rooms in London, North America and Hong Kong buying and selling gold often in very large quantities on behalf of clients. The inventory is never built up or depleted but is kept in balance; for each ounce bought, one is sold. Staggering amounts of money are involved in this trade which essentially is a barometer of the performance of currency, primarily the dollar. For many people, gold is still the basis for currency.

The Federal Reserve Bank in New York has underground vaults with cages representing the treasury gold holdings of different countries. Transactions are enacted involving physical transfer of gold bullion from one cage to another - instruments of international trade.

Smuggling is another major outlet for gold, especially into underdeveloped and eastern countries where gold is highly coveted. This trade through the Middle East may account for as much as 20 million ounces per year, much of it destined for Turkey, India and Pakistan where high premiums can be obtained. A feature of this trade is the small bar which can be readily and conveniently moved around. Johnson Matthey produces a popular 10 ounce bar in this category.

The price of gold is "fixed" twice a day in London at 10:30 am and 3:00 pm by five persons assembled in the board room of Rothschilds. Prior to each fixing they confer by telephone with their dealing rooms; a fix being struck when all five reach agreement. The London fix is the basis of the spot market.

The futures market deals in metal for future delivery and many mines sell part of their production in this way. A deal represents a committment to sell at a determined price on a future date; for producers it amounts to insurance.

Having spoken at length about the glitter of gold, Mr. Hart cautioned not to loose sight of the risks involved. There are factors which can depress prices, an unlikely example being the possibility of massive sales by the U.S. government. Such a step could be taken without congressional approval.

RECENT DECISIONS AFFECTING PLACER MINING IN ALASKA

J. P. Tangen

Brief Overview of the Legal Structure

Under the laws of the United States, the Secretary of the Interior is charged with administering mineral deposits on the public domain. The general mining laws of the United States give the public the right to extract valuable minerals from the public domain. This law, however, does not give the general public the right to speculate in land, or even the right to have a recreational cabin. If there is no mineral value within area in question, there is no right.

The United States Department of the Interior has the power and the duty to examine the validity of mineral claims and eject people who do not have a valuable mineral deposit within their claims either because the claim has been mined out or because it never contained such a valuable mineral deposit. Validity is usually contested in one of two situations. In the first instance, the claim holder is seeking the patent to the land from the United States. In the second instance, the United States wants the land for some other purpose. The second situation is the focus of the discussion contained in this paper for it ties in now with current developments in the Alaska National Interest Lands controversy.

Normally the way a validity contest starts when the Federal government wants the land for some other purpose is that a complaint is filed. In order to establish a *prima facie* case, the Federal government needs only present a mineral examiner to state that he has examined the claim and that in his opinion, a reasonably prudent man would not be justified in expending his labors on this deposit in that he could not do so profitably. Normally these procedures are before an administrative law judge who is an employee of the Department of the Interior. Frequently the miner whose claim is being challenged elects to appear *pro se*.

Because the *pro se* claimant may not understand the legal ramifications of this proceeding, he frequently relies on factors which do not justify his possession of the claims. For instance, he may argue that he has lived on the claims for many years, that he has made a little money from time to time from the claim, that he is just getting started, or that he has an interested party looking at the claim and that he will be making a profit in just a few short years.

At the conclusion of the administrative hearing, the administrative law judge renders an opinion. Rarely does the government appeal administrative decisions against it because it rarely has to. In the case of an adverse ruling the burden is on the claimant to pursue his appeal to the Interior Board of Land Appeals (IBLA). The IBLA decides approximately 125 mining cases per year, normally in favor of the government. For instance, in the mining cases decided in 1978, there were virtually no reversals of the administrative decision below.

This tends to underscore the necessity for the miner to prosecute his case successfully at the first stage, a point we will return to later.

After the IBLA has reviewed the decision and rendered an opinion, the claimant can seek relief in the Federal District Court. The District Court, however, will refuse to look into the facts of the case but will, instead, only examine the administrative record to determine whether the Board was arbitrary or capricious or made substantial errors in law. After the District Court has reviewed the case, the next stage is the United States Court of Appeals and after that is the United States Supreme Court. Very few cases ever make it as far as the Court of Appeals, and virtually no cases go beyond the Court of Appeals to the United States Supreme Court. The last pronouncement the Supreme Court of the United States rendered concerning mining rights was in the case of the United States v. Coleman decided in 1968.

The Current Setting

Against this backdrop, the stage is set for two significant developments, one of which is unfolding now and the other is just beyond the horizon. The first development obviously is the withdrawal of over 120 million acres of land, with more to come, from mineral entry and location under the general mining laws of the United States.

There are two clear dangers associated with these withdrawals as far as valid existing rights are concerned. First, in some instances it is necessary to cross the withdrawn land in order to get access to existing claims. The right of access is not so clearly defined as the right to mine. Clearly, rules and regulations which inhibit the right of access effectively preclude the right to mine; however, there are no courts which have said that to date.

The second significant point which logically follows from these withdrawals is that there will be Federal mineral examiners on those claims located within the withdrawn areas within the near future. Those Federal mineral examiners will be on the claims primarily for the purpose of determining whether there is a valuable mineral deposit on the claim and if they determine that there is not, they will invalidate the claim and attempt to cause the claimant to be ejected.

When the mineral examiner comes to the claims, the claim holder must persuade him that he has a valid claim. He must establish the validity of the claim by his records and workings or risk losing his right to the claim. What is shown to the mineral examiner must demonstrate that the claim was valuable not only at the time of its location and at the time of its withdrawal, but also at the time of the examination.

Even a brief review of the cases demonstrates that the typical claim holder has underestimated the significance of the mineral examination, and by failing to persuade the Federal mineral examiner that he has a valuable mineral discovery, he has risked having the validity of his claim challenged and has started down the long and expensive road of trying to vindicate his right to his land. The prudent claim holder who knows that a mineral examiner is coming will have a mining engineer of his own on the property at the time that the mineral examiner comes and will take pictures and make notes or recordings of everything the Federal mineral examiner says and does. The alternative will be to wind up before an administrative law judge arguing that the mineral examiner did not look in the right spot or adequately consider the evidence. An argument preordained to lose.

Mining Law Reform

While the Alaska National Interest Lands situation is undoubtedly going to give rise to some interesting cases in Alaska, and while we may hope that the cases which are decided in the future will bode better for the miners in Alaska than the cases which have been decided in the past, we need to bear in mind that there is another threat on the horizon which will affect the mining in the state wholly as much as the National Interest Lands controversy. The dark cloud on the distant horizon, of course, is the proposed reform of the general mining laws of the United States. Many people believe that the mining law of 1872 which has served us so well for so many years should be reformed. Year after year reform bills are introduced into the Congress of the United States and already this year Senator Henry Jackson of Washington has introduced such a bill again.

Organizations such as the American Mining Congress, the Citizens for Sound Mining Law and the Coalition for Responsible Mining Law have staked out positions on this issue. It is difficult not to acknowledge that there are problems with any law which, as it is construed, permits the Department of the Interior to sit as judge, jury and prosecution witness on claims challenges. But mining law must be reformed only under the most rigorous conditions, for if the preservationists get their way, the present patent-location system will be exchanged for a lease system under which no one will be able to operate.

Recent Alaska Cases

A brief note is in order at this point about four IBLA cases decided in 1978 on appeal from the Alaska State Office of the Bureau of Land Management. All of these cases were challenges of claims filed on withdrawn lands. In two of the cases, the case of Harry Wilson and the case of Sally Lester, et. al., the claims were located on lands that had been withdrawn pursuant to Public Land Order 5250. PLO 5250 cited for its authority Executive Order 10355. This Executive Order in turn cited for its authority the implied power of the President to withdraw lands and the so-called Pickett Act. The BLM Organic Act (FLMPA) which was passed in October of 1976, ratified the withdrawals that were made under the implied authority of the President and the Pickett Act up to that date. However, it repealed both the implied authority of the President to make further withdrawals and the Pickett Act itself. Presumably, Executive Order 10355 became a dead letter as a result of that repealer.

The PLO 5250 withdrawals, however, withdrew the land from metalliferous mineral entry. Since the public land order was made prior to the passage of the BLM Organic Act, Wilson and Lester were found to have their claims on withdrawn lands. In that circumstance, the claims were declared invalid and the appeals were denied.

In the case of Janelle Deeter, the claims were located on land that had been tentatively approved for State selection. The record reflects that the Deeter claims had been staked in 1966. In 1977, the BLM declared the Deeter claims invalid and this appeal followed. On appeal the IBLA ruled that the State selection withdrew the land from mineral entry but until a patent was conveyed to the State no rights could attach to the land under the mining laws of the United States. The essence of that holding is that Federal claims located on TA land are void from the beginning. State claims, however, located on TA land are not valid until the land is actually patented to the State.

In the fourth Alaska case, the Virgin case, the claims were located on land prior to the passage of the Alaska Native Claims Settlement Act, but the location notices were not filed until after the date of the Act. The Court in that case ruled that the claims, which were located on native selected lands, were null and void because the location was not complete until the notice was filed.

Some Other Recent Cases

Of the numerous other cases decided by the IBLA last year, one of the most recurring fact patterns, after challenges to discovery, arose under the recordation requirements of FLMPA. The statute requires that claims located after the effective date of FLMPA must be filed with the BLM within 90 days after location. The BLM has demonstrated that it will construe its statutory mandate in the strictest terms and will reject location notices which are imperfect in any way, including being filed in the wrong office or even not properly signed. The argument is that the Bureau simply has no discretion under the law.

A few isolated IBLA cases which were decided last year deserve special attention.

In the case of United States v. Joseph and Ferris Larsen, the claim holders were evicted from their homes and their claims because of the finding that the claim was not sufficiently mineralized. The claim holders protested that the Forest Rangers had watched silently while the cabin was put in place. The IBLA said "Forest Rangers have no authority at all to dispose of government property and cannot by their conduct cause the government to lose its valuable right." Accordingly, the Larsens lose.

In the case of United States v. Paul and Buel Fisher, a complaint was initiated against the Fishers and they responded by saying first, that the administrative law judge, as an employee of the U. S. Department of the Interior could not be impartial. The IBLA responded by saying that the argument has already been addressed in U.S. v. Bass, a case decided in 1972. Accordingly, that argument is rejected. The Fishers then argued that the Due Process Clause and the Equal Protection Clause and the Privileges and Immunities Clause of the Constitution of the United States are all violated by the Department of the Interior furnishing the judge, the jury and the chief witnesses in the case. But the IBLA responded by saying that in the United States v. Stevens, a case decided in 1974, the Board stated that:

> "The mere fact that the witness, the administrative law judge and the members of this Board are employees of Department of the Interior does not establish the unfairness of this proceeding."

The Fishers then argued that they had been denied the right of a trial by jury in violation of the Seventh Amendment to the Constitution of the United States, and the IBLA responded by saying that this argument also is without merit for statutory contests of mining rights were unknown at the common law and the Seventh Amendment to the Constitution of the United States which provides for a right to a trial by jury does not extend to such administrative proceedings.

Naturally, the Fishers lost on all counts.

But the worst case of 1978, bar none, was the case of Wesley C. Miles, Sr. According to the IBLA opinion, at the close of the proceeding Miles:

> "stated that he did not want the claim, that he wished to withdraw his answer to the contest complaint, that the allegations in this contest complaint could be considered admitted and that the ... claims could be considered null and void."

He went on to say:

> "It will take a while to get the concentrate and the buildings and stuff off there. Then I don't care what happens. You can have it."...

Later on Mr. Miles reconsidered his rash statements and asked that the decision declaring the claims null and void be reversed. He stated on the appeal that "due to a combination of constant harrassment by the Forest Service and repeated serious thefts and vandalisms, ... he was so disgusted that he could not properly present his case." The decision, he claimed, was the result of a nine year conspiracy against him. The IBLA said Miles loses.

The Future

At this point, a word or two about the future of the placer mining industry in Alaska is appropriate. Clearly, some day the National Interest Lands issue will be resolved. Probably this resolution will be to no one's satisfaction. Today in Congress we have a bad choice between the legislation proposed by Mr. Udall, legislation proposed by Mr. Huckaby and the legislation proposed by Mr. Breaux. None of these bills remotely approach anything which anyone in the mining industry can reasonably support. The Alaska Miner's Association is on the record in opposition to any of these bills being used for anything more than a mark-up vehicle. But what will result, if anything, from this year's efforts in Washington remains to be seen. We can only say that it will be bad, whatever it is.

When the National Interest Lands issue is resolved, we will still have to confront reforms to the mining law of 1872. The industry is under severe attack and only through unity can it hope to survive. What is encouraging about mining law reform, at least, is that the danger is perceived not only in Alaska but throughout the West. This is not the case in the issue of the National Interest Lands legislation, which everyone outside of the State simply regards as an Alaskan issue. The suicidal drive of the preservationists community to bring mining in the United States to a halt can and must be stopped. More and more, however, the pressure is going to be upon the small miner in Alaska and in the other public land states to get involved in the fight.

For the present, it is my view that those who own unpatented placer claims should seek patents as quickly as possible. Patent applications are difficult, expensive and time-consuming. When they are brought forward in a hostile atmosphere, these drawbacks are exaggerated. But patent is the way to go to avoid unending harrassment from the opponents of mining. Even then, the miner may not be able to avoid all trouble. However, his position is substantially enhanced.

CASE HISTORY STUDIES

Presented by Mine Operators

This session was devoted to the presentation by mine operators of case histories based on operational experience.

WOBBLER FEEDER METHOD OF CLASSIFICATION

John Thomas

A wobbler feeder is an eccentric grizzly made from elliptical steel bars which rotate 90° out of phase in a manner which causes the material feed to move in the direction of rotation. The operation utilizes a medium sized commercial unit consisting of 14 bars each 24" long contained in a 6' long grizzly unit manufactured by Universal Engineering Corporation of Cedar Rapids, Iowa. Since the unit was built to handle dry feed, wear plates were later added to protect bearings following initial failure and a marine silicone-base grease was used for packing.

A cat is used to push up material into a pile from which it is worked by monitor onto a slick plate and into the wobbler system. Using this method, a constant feed rate is achieved. A 6" diesel pump provides water for the monitor and sluice box.

The eccentric roller motion of the bars moves the gravel through the system separating the finer fraction, minus 1-1/2" in this case, from the coarse oversize which emerges and is discarded. The minus 1-1/2" material falls through and enters the recovery system. The system can process 60 to 80 cubic yards per hour and can cope with very large rocks. The operation utilizes a relatively small 20' x 34" sluice box with conventional hungarian riffles and spray bars to augment water supply. Very little gold is recovered from the end of the box which is regarded as evidence of high efficiency.

A 24' stacker with 16" belt is used to dispose of tailings. This unit is powered by a 2 h.p. electric motor while the wobbler utilizes power from a 5 h.p. industrial electric motor.

The cost of the wobbler feeder ex-factory and excluding power unit is approximately $36,000 and the shipping weight approximates 6,000 pounds.

The advantages of the system are believed to be efficient and improved gold recovery using less water than many other systems.

Large nuggets are not a feature of this operation, however, if they did occur they would tend to hang up on and be squeezed through the bars.

ELEVATED BOX WITH GRIZZLY

Walter Wigger

The recovery system on this operation was built on-site from available materials. The sluice box was constructed from two 50' long 12" channel bridge beams. These were adapted by cutting and, when welded with a base of 3/8" plate, formed a 32" wide box. The 8' x 12' slick plate for the system was made from off-cuts from the bridge beams cut up into 12' lengths and welded together. The system incorporated an 8' x 12' open bottom hungarian riffle system made from 3-1/2" x 4" angle-iron (1/2" thick) incorporating a 2" separation and a 10° tilt, the same as in the box itself. A platform, 5' x 8', was built on one side from which a monitor, equipped with a butterfly valve for instantaneous control, was operated.

An advantage of this system is the reduced quantity of water needed compared with the normal unsized operation. Better recovery of gold and a reduced tailings disposal problem are additional major advantages. The minus 2" sluice feed fraction passes through the grizzly into a tapering chute which has a 32" square discharge opening into the head of the box. Two spray bars extend from the bottom of the chute to help maintain sufficient water flow through the box. The water depth over the riffles is maintained at about 1" which represents a water usage of 800-900 gallons per minute. The oversize, constrained by the grizzly, slides to the side into another chute.

The riffles in the box are constructed in convenient size sections which, during clean up, can be readily slid and stacked in the box. No wedges are used to hold riffle sections in place. Astroturf is used over the full length of the box.

In constructing an elevated grizzly from scratch, it is essential to put in the bridging at an angle.

The operation utilizes a gravity water head in excess of 100' supplemented by a recirculating pumped water system. The capacity of the latter is in excess of requirements and, in fact, a bypass system sends some of the pump water up to augment the gravity feed system. The settling system is very effective in clarifying the water discharge.

SCRAPER HAUL TO SLUICE BOX

Scott Haskins

Scott Haskins, who mines in the Circle district on Harrison Creek, described his operation which uses scrapers for stripping. Harrison was a virgin creek and the initial setting up took about three weeks and involved hauling in 15 major loads of equipment and materials.

The deposit averages 8' to bedrock with the upper six feet carrying values of approximately $2 per cubic yard (base price $200/oz.) compared with the basal gravel and bedrock surface which averages $3 to $3.80 per yard. Because of the values contained in the surface material in the form of fine gold, the operation was conceived to attempt to recover these values.

In the operation to date, no pre-sizing has been attempted and this has contributed to the relatively poor recoveries of gold from the stripped ground.

At the outset, scrapers were used to strip 200,000 square feet (about five acres), and this was accomplished in 24 days. Using one scraper, a throughput of 2,500 yards per day was achieved. Experience showed that scrapers were ideal for stripping on this deposit but could not handle bedrock conditions where a cat was used for heaping gravel. The scrapers, especially when cat assisted, can readily peel frost and therefore pockets of frozen ground did not cause serious problems.

Water is abundant in this creek and the operation employs a low head large capacity (10,000 gpm) pump. The sluice box is made from old riveted 42" Penstock 1/2" pipe obtained from Canada (Alyeska pipe would also be ideal) joined with angle-iron to 3/8" bottom plate. The box is 59' long in two sections which are locked together with a pin arrangement. The walls are built up to accommodate the surge and high water slurry throughput. 2-1/2" angle-iron was used to make hungarian riffles which have round bars welded to them to facilitate passage of very large rocks.

Modifications for next season include the use of a scalper to produce a -3" feed and some thought is being given to using a trommel recovery unit.

The operation was only successful in recovery of about 22% of the estimated gold present in the stripped ground. Stripping costs were estimated at 81 cents/yard and the recovered gold was worth 44 cents/yard. Thus, the gold revenue paid for about 50% of the stripping. With improved recovery incorporating sizing, the stripping part of the operation could show a profit. If, for example, 70% of the values as opposed to 22% were recovered a handy profit would be made (at $200 per ounce gold).

Costs are higher in the bedrock and basal gravel mining phase due to lower volumetric throughout, however, since the gold is decidedly coarser, the recovery factor is much higher. Costs during this phase are above $1.00 per yard, about 25% more than the stripping cost.

Providing that intended modifications to the recovery system achieve improved recoveries, this operator intends continuing to sluice and recover gold from the strippings rather than following the conventional practice which realizes no revenue whatsoever.

[1] Breakdown - Based upon 2,500 cubic yards per day. Plant rentals: Scraper: $50/hr.; Cat: $45/hr.; 3 yd. Loader: $30/hr.; crew of 5.

Costs per cubic yard:

Scraper -	.16
Cat -	.18
Loader -	.12
Labor -	.24
15% Override -	.11
	$ .81

TROMMEL WASHING PLANT

George Haskins

George described his operation on Porcupine Creek, Circle District, which uses a trommel washing plant.

In view of the depth to bedrock and the narrowness of the payshoot, much attention is focused on delimiting the limits to be mined by drilling. This is done in spring and fall, before and after the mining season, using a 29T Bacyrus Erie drill machine. Sampling holes are drilled using 7-1/2" casing shoe and a 6" casing string. The bedrock is 15' to 18' below surface with pay ground sitting atop bedrock ranging from 4' to 6' thick. The drill machine has been modified by using a diesel power unit and installing hydraulic rams for rapid leveling. Setting it up takes approximately 15 minutes and on past experience it takes about 6 hours to complete and sample a hole. A rocker box is used for concentrating the sample which is hand-panned through the final stage. On Porcupine Creek holes are drilled on 50' centers with fill-in holes at 25' centers in the pay which averages 70' wide. Previously on Yankee Creek, which has a very narrow payshoot, holes were drilled on 16' centers.

In the mining operation itself a dragline is used for stripping. This is an ideal method because of the steep hillside and very restricted room. Occasionally, in extremely tight situations, a scraper was used to remove strippings from the mine site. The dragline is relatively small but with its 1-3/4 yard bucket and good breakout power can easily handle 100 yards per hour. The stacking height is about 18'. An overall stripping cost of 50 cents per yard compares very favorably with alternate methods. The operation utilizes a trommel washing plant which if purchased new today would cost about $200,000. This particular unit was built in 1935 and is still running on original bushings and tires. The unit is powered by a 30 h.p. hydraulic drive motor. Lack of mobility can be a major problem and silting in at a site frequently occurs. In setting up the trommel, which weighs 100,000 pounds, care must be exercised to stabilize and level the unit.

A cat is used to deliver gravel to the dragline which feeds the trommel hopper 13-1/2' above ground level. Perhaps contrary to expectations, screen wear is not severe - a set of screens lasting three to four seasons.

Discharge from the hopper is onto a slick plate and into the trommel. A spray bar which runs the full length of the trommel helps to wash off most of the fines in the first seven feet of travel. Breakdown of bonded clay material is very effective. This trommel, which is 6' x 25', can readily handle rocks up to 42" in size.

The material passing through the trommel screens falls into boxes immediately beneath and about 90% of the gold recovered on this operation is trapped before ever reaching the riffles which splay outwards from the trommel axis.

During final cleanup a rocker box is used. A new innovation this season will be the introduction of a stacker to handle tailings. This change will release a cat and operator for other work, and, in the process, reduce costs by as much as 50 cents per yard.

Water in this operation is something of a problem. Recirculation, via a series of settling ponds and a pump pond, is resorted to delivering some 3,500 gallons per minute to the washing plant.

The economics of the operation vary with throughput. Before introducing the tailings stacker on a 100 yard per hour throughput, costs amounted to $2.60[1] per yard. At 130 yards per hour, the theoretical optimum, costs would run about $2.00 per yard. During the past season, average performance was 110 yards per hour. With the introduction of the conveyor stacker, costs will be trimmed to $1.90 per yard on a 100 yard per hour basis and to $1.46 per yard on a 130 yard per hour throughput.

[1]Figures calculated on the basis of $50 per hour for cats and $100 per hour combined for dragline and trommel.

BOOMING

Jim Fuksa

Jim Fuksa, one of the very few miners who use the boomer method of mining, described his operation on Friday Creek in the Kantishna District. The method can be used to greatest advantage in narrow restricted creeks with steep gradients where coarse gold in nugget form is known to occur. One aspect of this type of operation is that no mechanical equipment is used and the method is applicable to creeks containing very little water.

Booming basically consists of damming the restricted drainage, then, using controlled water discharge from the dam, ground sluicing the area below the dam. The bedrock surface is cleaned up in this manner and coarse gold is picked off by hand.

In an entertaining presentation, well-illustrated with slides, stages in the construction of two dams built on Friday Creek were described. In the initial phase of construction the dam must be keyed into the bank and stream bed. Potentially weak spots are carefully plugged using tundra moss as a caulking agent. Facings consist of lumber frames and wood and metal sheeting with the fill space in between loaded with rock and earth fill. Tundra moss is used for packing joints, crevices and as a facing material, held in place by stones, on the upstream side.

Control over the water discharge is important and is effected through a top or bottom discharge gate. This operator designed an automatic closing bottom discharge system utilizing a spring loaded pivot device in his latest boomer. The automatic system was designed to function in 6' of water but due to poor influx this level was rarely experienced.

It is important to build in a discharge chute to carry water clear of the gate and dam wall to prevent back-cut erosion.

The dimensions of the most recent boomer built on Friday Creek were 7' high by 9' wide and 48' long measured on top of the wall. The gate was 6' by 8' constructed from 2" planks and 1/2" plywood activated on a 2" pipe pivot. The position of the pivot was determined by measuring up 1/3 distance and then up 1/4 distance and splitting the difference from the base of the gate.

Booming does not involve the use of any costly, energy consuming heavy equipment and is a method which can be employed on a one-man operation under the right circumstances.

SLUICE PLATE MINING

Fred Heflinger

Fred Heflinger, who has worked claims in the Livengood and Fortymile Districts, described aspects of mining using a sluice plate.

The sluice plate was first used in the 1930's at a time when mobile mechanized earth moving equipment was introduced into placer mining practices. Before this the common sluicing method utilized a monitor to feed gravel into the sluice box which had wings constructed of wooden boards to facilitate feeding. It was common practice to set boxes into bedrock and, besides being slow, the method had the added disadvantage that coarse gold became trapped in bedrock cracks and crevices at the head of the sluice box. It seemed common sense to use a steel collection plate, which is basically what the sluice plate is, in the collection area for feed material at the head of the sluice box.

The sluice plate is in effect a large steel box wider than the sluice box to which it is connected by tapering wings. In this operation the sluice plate was fabricated from two 6' x 6' truck beds joined and mounted on skids. A false bottom was built up to accommodate a riffle section in the middle part of the sluice plate which was the same width as the sluice box. A punch plate, flush with the level of the false bottom, overlies and protects the riffle section. The punch plate has 5/8" diameter holes and besides providing a glide surface for the passage of large boulders, performs a degree of classification of material at the same time protecting the underlying riffles from excessive abrasion. Adequate clearance between the riffles and the punch plate must exist to enable the undersize load to pass freely without blinding.

Water can be introduced by ditching or through pipe discharge under natural or pump head into the sluice plate. If a ditch is used for water delivery this is usually via an artificial channel constructed around the cut being mined. Ditch delivery can be used where stream gradients are relatively steep involving minimal amounts of ditch construction.

If a pipe delivery water system is used this is usually through a manifold constructed from 4" pipe to which has been welded a row or configuration of small diameter outlet valves (nipples). Water emerging through the valves has a high discharge velocity and readily breaks down the feed material for processing through the sluice box. Manifold design can create a discharge with a strong swirling action for breaking down clay-rich ground. Direct water feed from a ditch has little capability for breaking down bonded material. Manifold outlets are positioned on the side of the sluice plate opposite to the feeder ramp up which the gravel is pushed by a cat. The sluice plate should slope slightly away from the feeder ramp towards the manifold.

Modifications on the basic sluice plate design are possible. The system, which basically processes unclassified material, suffers from certain disadvantages inherent in all systems where no sizing is attempted.

Fine gold losses will be experienced due to the high throughput of water needed to move large boulders through the system. Boulders create turbulence contributing to the loss of gold. The system has the advantage of cheapness and because of this is suitable for getting a miner with limited assets into production.

DRAGLINES INCORPORATING A CIRCULATING WATER SUPPLY SYSTEM

Al Kangas

A zero discharge water recycling system works effectively and overcomes many of the problems created by restrictions. The traditional practice of stacking overburden on the previous cut is no longer used.

In this operation, which employs four draglines, overburden is put up on the bench at the side of the cut. This creates room for the settling pond. Sluice boxes discharge into the settling pond from which water is pumped back through the system. A dragline is used to remove tailings and prevent silting up of the pond. The operation also employs one dragline to pitch ground up to enable another to feed the hopper. In terms of recovery methods, there has been little real advance this century.

A large operation in California processing 15,000 cubic yards daily to produce sand and gravel with by-product gold was recently visited. Extremely fine gold was being recovered in this operation in which sizing played an important role. A unique suspended riffle system above astroturf with amalgam traps in the box was employed. The sluice box square footage area was much more than normal (a figure of 1,800 square feet was stated). The system is credited with improving gold recovery by a factor of 4.

In many operations, the extent of the fine gold losses can only be guessed at but are substantial. This operator intends using larger boxes in his recovery system.

In reply to a question, Mr. Kangas estimated a round figure cost, taking into account lost production and equipment purchases, of $400,000 to $500,000 to establish the operation.

FINE GOLD RECOVERY IN YUKON PLACERS USING THE ROSS SLUICE BOX

Loren Ross and Terry Plummer

Loren Ross, a mine operator, and Terry Plummer, an equipment manufacturer, described activities on three properties in the Yukon Territory with specific reference to operating results with the Ross sluice box. This successfully adapts the undercurrent principle, which has been used in placer mining for many years, to relatively large scale operations typical of some Yukon and Alaskan deposits. Significantly, the Ross sluice box uses about the same quantity of water as a conventional system but processes about twice the volume of material. High throughput ratios are achieved by setting the box at a relatively steep gradient, commonly 3" per linear foot, or about twice the gradient of conventional sluice boxes. Internally, velocities are slowed at key collection centers utilizing gradient changes and sheeting action thus facilitating the settling out of fine gold particles. The box achieves excellent classification of material without the use of mechanical screening devices.

Two of the properties currently being mined were drilled during the period 1933 to 1936. Current operations are recovering between 60% and 100% more gold than the drill estimates. This compares with recovery factors of between 3% and 10% over drill estimates obtained when the properties were dredged. Whilst much of the improvement should be attributed to the dry mining method whereby drainage is maintained below cut level as opposed to wet digging and dredging in which considerable gold losses are known to occur, nevertheless, some considerable credit must be accorded the Ross sluice box which has shown itself to be a very effective fine gold recovery system.

On Henderson Creek, which is characterized by relatively coarse gold, the major benefit derived from the introduction of the box was the ability to handle larger volumes of gravel. Improvements in fine gold recovery were also experienced. Prior to using the Ross box, about 14% of the product was above 14 mesh. Now, the percentage of gold comprising this very coarse fraction is much less due to a significant increase in the recovery of fine gold. On the two main properties, gold recoveries overall have improved 35% and 25% respectively since the introduction of the Ross box.

Eureka Creek is another property characterized by extremely fine gold. A few years ago, alot of effort was devoted to attempts to improve recovery using conventional sluicing - all to no avail. Although the system has only been in operation for a limited time period, indications are that recoveries have improved an impressive 300%. The gold in Eureka Creek is so fine that amalgamation is used to recover gold from the clean up concentrate.

There is ample evidence to show that the Ross box has performed extremely well in a variety of ground conditions.

The box can be adapted to a variety of feed systems. In the larger models the purchaser has the option of two sizes of dump box designed for D8 and D9 feed rates respectively. A horizontal manifold directs pressure water contrary to the slope of the dump box. Good washing action with the ability to break up sticky material in the dump box is achieved. A controllable water jet can be used to move larger rocks and overcome hang ups. Rocks up to 40", which is the clearance height to the manifold, will pass through the system.

The material moves from the dump box to the primary distribution center where good size classification is achieved. Fines are removed for controlled washing in the side channels whilst the coarse material passes centrally through the main channel equipped with open riffle sections to trap coarse gold. From the primary distribution center the load is thinned and spread out over the secondary recovery area which extends for about 10'. Approximately 20-25% of the water flows down each of the side channels in which fine gold is recovered. Fines will only get into the main channel as a result of poor loading of the dump box which could induce blinding of the primary punch plate. The effectiveness of the system for recovery of fine gold is attested by the operating results from Black Hills Creek where over a two year period following the introduction of the system, 82% of the fine gold was consistently recovered from the first sections of the side channels.

Clean up of the undercurrent system varies from property to property depending upon ground characteristics - clean up procedures can be used as an indicator of payable cut off.

Whilst the Ross sluice box is not claimed as a panacea for all situations, it does have some undeniable attributes:

1. Has no moving parts, hence requires very little maintenance.
2. It is very easy to set up, minimizing down time.
3. Processes twice as much ground using same amount of water as a conventional sluice.
4. It achieves excellent classification and hence greatly improves fine gold recovery without recourse to mechanical screening devices.
5. Very robust construction standards withstand severe handling and flood conditions.

Three sizes of box are manufactured to cater for different scales of operation.

Capacity Rating	Overall Dimensions (Feet)	Weight (Lbs.)	Cost (Canadian $)
50-100 cubic/yd/hr	22	10,500	19,000
300 cubic/yd/hr	40*	34,500*	35,000*
600 cubic/yd/hr	40*	38,500*	40,000*

*Dimensions, weight and costs reflect models with largest dump box configuration.

In the largest models the dump box is in two sections for ease in handling and transportation.

Because of the high throughput rates, economies of scale are achieved when using the Ross box under optimum conditions. In the Yukon operations the mining cost ranged from 80 cents to $1.50 per cubic yard expressed in Canadian currency. The variation is attributed to varying bedrock conditions and gravel characteristics.

The Ross sluice box is manufactured by the Ross Machine Shop located in Rosedale, B.C. Terry Plummer is the President of the company. Sluice boxes in various stages of production are generally available for inspection at the works.

THE CLAIM RECORD SYSTEMS OF THE STATE
DIVISION OF GEOLOGICAL & GEOPHYSICAL SURVEYS

Cleland N. Conwell

Alaska's mining claim recording system is unique. In fact, we have the only central recording system for mining claims in the United States. In this short address I will try and present to you the when, where, and what of the mine recording system. Then emphasize what we do not do, followed by a brief discussion of our future plans. In closing I will present a brief discussion of the historical perspective on mining claims and other services available to the public through our office.

WHEN - In 1953 the State legislature appropriated money to establish a central recording and filing system for all recorded mining claim notices, assessment work affidavits, other documents affecting claim ownership. Since that time these files have been kept and are updated monthly after receiving the recorded mining documents from the district recording offices throughout the State.

WHERE - The central mine information recording office is located on the campus of the University of Alaska. This is the nerve center for the system. However, in addition to the central recording office in Fairbanks, there are three sub offices. One each in Ketchikan, Juneau, and Anchorage.

WHAT - Mining claim location notices, assessment work affidavits, or other documents affecting mine ownership are received by the Fairbanks office. They are then classified and filed. A record is placed in our Minfile system. The new mining claims are plotted by inch measurement on USGS quadrangle maps on a scale of 1 to quarter million and given an X, Y coordinate to pinpoint the location of the mining claim. The USGS coordinate system which we use is described in USGS Bulletin 1139. In addition to giving the claims the X, Y coordinate for our Minfile system, the information is also provided to the U.S. Bureau of Mines which makes an annual update on quadrangle maps showing the actual location of either the individual mining claims as a small circle or, in the case of a large block of mining claims, the outline of the block.

As new claim notices are received, the notices are first recorded in a Kardex system. The cards are then continually updated as new information, assessment work, lease sales, etc. are received.

All of the mining claim information, new claims, affidavits of assessment work, ownership and, if known, the type of mineral, is prepared for a Minfile computerized system and is updated monthly. This information is printed on a microfiche to enable the public to quickly review claim data. It is also available on a subscription basis. The Anchorage office receives and issues the microfiche on the subscriptions. The microfiche films are sent to each of the three suboffices where they are available for public use and viewing. And, again, here we are unique. This is the only agency in the United States which does provide this type of information on a readily retrievable basis for public use on both State and Federal mining land.

WHAT WE DO NOT DO - We act only as an information office and as a central recording system. We do not take any part in the determining of whether the claims have been filed properly, whether they are valid, whether overstaking occurs, whether the claims have been filed on the wrong lands, or any disputes that may arise between individuals. In other words, the information is available in our office to anybody that wants to come in and review the system, or to abstract information on any claim or group of claims. However, the authority for legal work remains the recording offices.

I also want to stress that we try to obtain maps for public review on land status. We will try to help on land status, but the source of information on Federal lands is the BLM. For information on State land status, the State is divided into 3 regions, - northern, south-central, and southeastern regions, and status plats are kept in Fairbanks, Anchorage and Juneau with the DNR, Division of Forest, Lands, and Water Management.

FUTURE PLANS - The office at the present time is microfilming -- not microfiching -- all of our claim information which will be processed for distribution to the three branch mining information offices. This will enable people in Juneau, Ketchikan, and Anchorage to avail themselves of the same information we have located at the present in Fairbanks. The microfiche is a rapid method to search for information, whereas the microfilm is a continuous-scale reproduction of the actual document. The microfiche film and microfilm are in similar jackets for viewing.

You may be interested that all this work is essentially handled by our two overworked and underpaid ladies who processed, in the course of the last year, 21,154 new mining claims and the assessment work on some 50,942 affidavits of assessment work. This gives a total of 72,096 active claims in the State of Alaska during 1978. The ladies microfilmed approximately 114 thousand images and stuffed 4,950 microfilm jackets.

The mining information section had direct public contact with over 4,000 visitors in 1978. Half of these visited Fairbanks.

In addition to the mining claims, a great deal of public information is also available. There are geological information libraries and files in each of the offices, and there are unpublished open-file reports and historical documents. Many of the documents are short geological reports from the territorial days. Representatives from mining firms and consultants will often spend several days searching information, particularly in the Fairbanks office. In addition, a great many requests are answered by mail and by telephone. Information offices supplied a great deal of information to the State and Federal agencies. Again, the records were used exclusively to research.

HISTORICAL PERSPECTIVE - From 1872 until 1977 all mining claims were recorded in a recording district. That was all that was necessary on Federal lands. In 1976 the Bureau of Lands Organic Act was passed. Subsequently effective January 27, 1977 regulations were issued describing the recordation of mining claims, and the filing evidence of assessment with the Bureau of Land Management. The State Division of Lands issued regulations effective September 4, 1974 in the Alaska Administrative Code requiring registration with the Division in addition to the local recording offices.

Today you must file the mining claim and assessment work with: 1] the recording district, 2] on Federal land with the Bureau of Land Management, and 3] on State lands with the Department of Mineral and Energy Management in Anchorage. On Figure 1 the mining districts, recording offices, and the office addresses are given.

CONCLUSION - In closing I think it is only fair to remind all people interested in mining claims, that the law of 1872 still applies. It is possible to locate a new mining claim, but the locator should be aware claims can only be located on public domain not withdrawn for other uses, and for locatable minerals only, that is, gold, silver, and so forth. A mining claim should not be located for common minerals such as sand and gravel or for leaseable minerals such as coal, oil, and gas. The same is true with the State. The State has withdrawn many areas from mining location on State lands. These areas are published in the Alaska Administrative Code by the Division of Lands. Again, I want to emphasize that the central recording system is a source of information. If the claim is not recorded properly, if you have overstaked another person, if the land wasn't open for claiming or staking, are not decisions we will make. We simply maintain the records, however, they are open to inspection. If you get a letter from the Federal government saying your claim is invalid, then that must be taken up with the Bureau of Land Management. Or, if a similar letter comes from the Division of Mineral and Energy Management, you will have to take your problems up with them. We do not take sides in any of these disputes.

We feel, however, that our recording section does provide a very important and extremely useful function. We have the only office which provides the miner, the prospector, and the general public with mining claim information on both Federal and State lands. There are some people who do feel that, in terms of saving time and funds, and of helping prevent other problems, the DNR mining information offices might have been the logical choice to handle the regulations of mining claims on State lands.

Nevertheless, I again want to emphasize that we are a recording office and we do not enter into disputes between the miner, the State or the Federal government, or between a miner and another miner who has overstaked his claim. We do appreciate all the splendid cooperation we have had in the past from the miners and hope to continue serving them in a worthwhile manner.

I will appreciate any comments, whether good or bad, on the service we try to supply.

FACTORS THAT MAY AFFECT THE SELECTION OF FUTURE PLACER GOLD RECOVERY UNITS

Donald J. Cook

A look into the future requires a crystal ball or some intangible power which I seem incapable of generating. Therefore, I am forced to adhere to facts as I see them with some assistance by looking backward to see what events influenced gold production over the past century.

If we first take a brief look at historical events, we find that the production of gold in Alaska was influenced by new discoveries, price fluctuations, changes in technology and political events. As these variables had an overlapping effect in certain time periods, it is advisable to show annual production as dollar value (Figure 1) and troy ounces (Figure 2).

New discoveries and the establishment of mining districts had the most pronounced effect as noted in Figure 2. The annual production, in troy ounces, climbed dramatically with each new discovery over the first thirty years, and reached a peak in 1906.

The decline in production over the next twenty years was just as dramatic. This was due primarily to no new discoveries; depletion of the more easily worked, higher-grade placer ground and the advent of World War I. As a result, an extreme low production period occurred in 1926.

From the 1926 low, a rapid increase is noted over the next 14 year period. Several simultaneous circumstances caused this sharp rise in production figures. A large increase in lode mining activity was a contributing factor, but the major elements were initiation of mechanization in the placer operations correlated with a boost in the price of gold to $35 an ounce in 1933.

These contributing factors resulted in the troy ounces produced by 1940 reaching a position equivalent to the former 1910-15 level, as shown in Figure 2. The total dollar value production by that year reached an all time high in excess of $25 million, as shown in Figure 1.

As an estimate, 75% of this total increase is a direct result of the price raise, and 25% is due to increased quantity of gold as reflected by mechanization. During this period, small scale hydraulic operations were being replaced by mechanical systems using draglines and bulldozers, and larger scale dredging operations were initiated. By the peak year of 1940, fifty-two dredges were in operation along with 162 small to medium scale mechanized placers utilizing some 50 draglines.

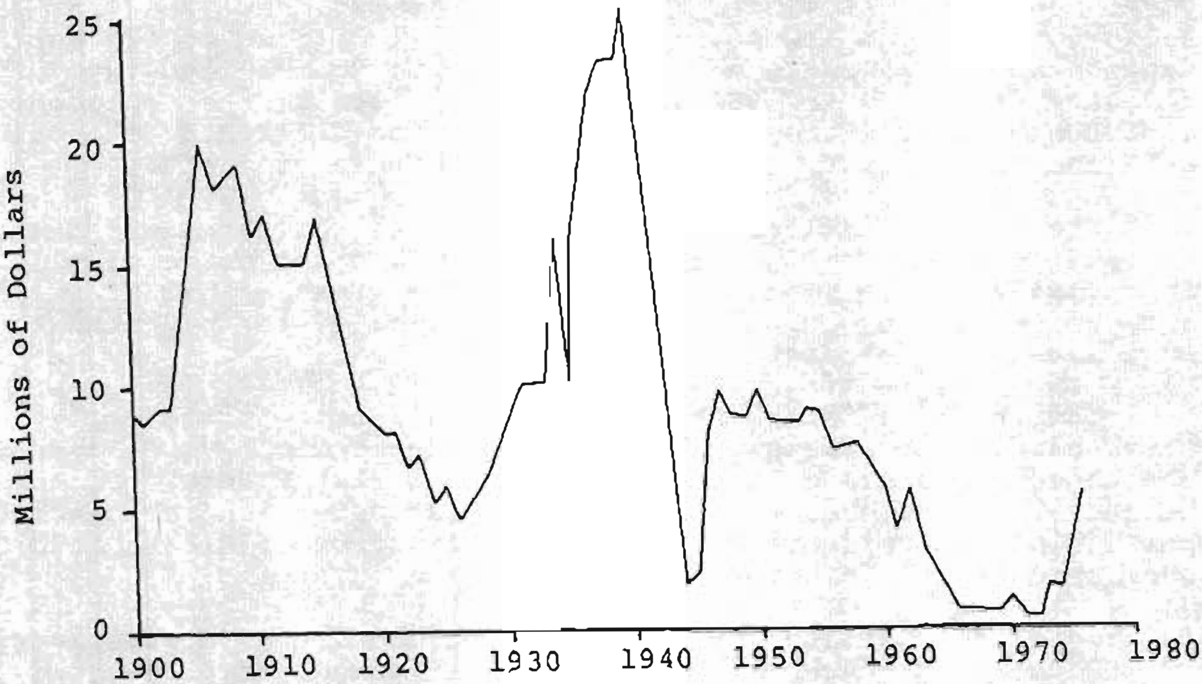

Figure 1 - Dollar Value

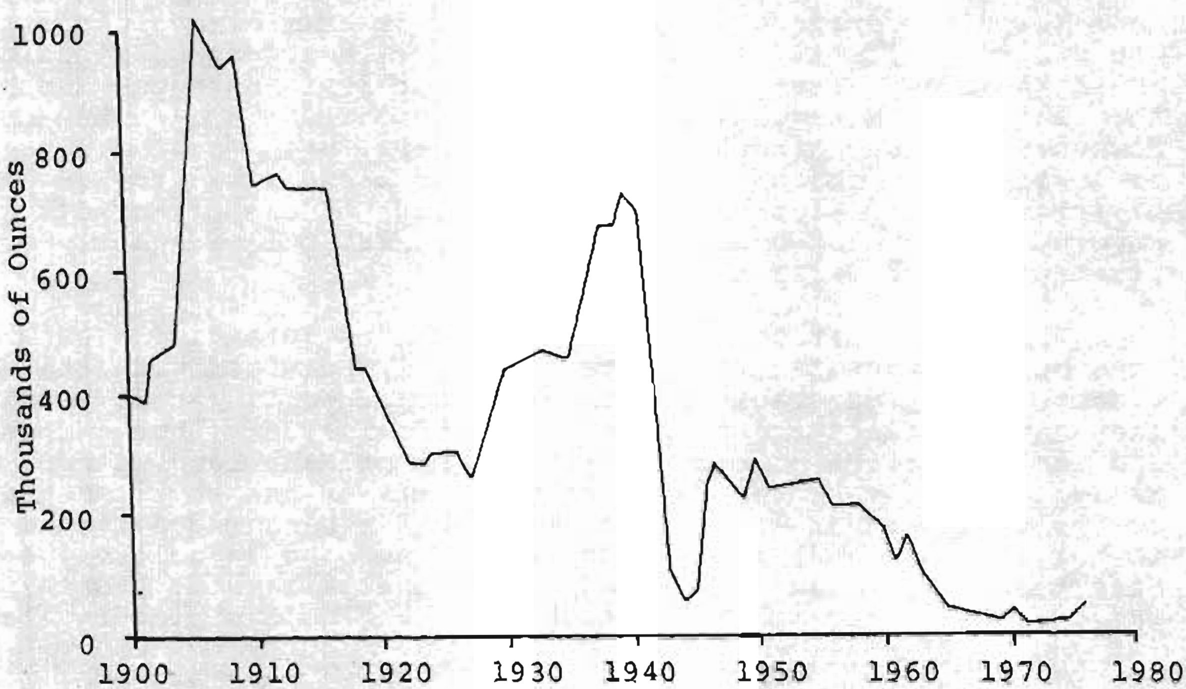

Figure 2 - Troy Ounces

War Production Board Order L-208 virtually stopped gold mining by October 1942, but prior to that a shifting of labor to higher paid government projects closed many smaller operations. The year 1944 shows a fifty year low point, but a gradual lifting of the War Production Board ban again gave some incentive to the industry. The recovery from 1944 to 1950 was not abrupt because the replacement of equipment was slow and costly, and labor was difficult to obtain with the availability of higher pay in defense projects.

The gradual decline from the 1950 level was a result of the squeeze between ever increasing costs and a fixed price of gold. Some smaller scale placers were able to survive because of the ability to selectively mine the higher portions of the pay streak, but an all time low production was reached in 1971-72.

The increase in the price of gold, starting in the early seventies, has caused a renewed interest in placer mining. As a result, the annual production figures have taken a slight upturn in ounces produced, and a more abrupt rise in dollar value. A substantial portion of this rise is due to the reactivation of Alaska Gold Company dredges in the Nome area.

Total gold production over the past century is approximately 30,100,000 troy ounces of which 1,153,589 ounces were recorded prior to 1900. Placer mining accounted for 70.4% of the total with the balance of 29.6% attributed to lode mining.

A look at historical events may be interesting, but will give no present or future benefits unless they are analyzed for cause and effect. Therefore, let us return to the four factors that appear to have the greatest influence on gold production.

New discoveries and the establishment of mining districts had the greatest effect. The ability to work lower grade extensions of these known deposits may be possible, but it is extremely doubtful that major new discoveries of the past magnitude are on the horizon. However, by-product recovery from potential base metal mining and exploration for deposits under continental shelf waters are possibilities for new sources. Tentative steps in the latter direction have been attempted over the past few years, but have not proven fruitful to the present time.

Price fluctuations have always given an incentive to the industry, but unfortunately they are intimately entwined with the adverse effects of unpredictable political events. World Wars I and II, if they can be called the results of political events, had a drastic and lasting effect on the industry. The present land withdrawal issue combined with the regulatory aspects of the environmental movement also adversely effect the placer mining industry and tend to nullify any gains to be made by the increase in gold value. Unfortunately, these two unpredictable qualities will probably have the greatest effect on the future health of gold mining in Alaska.

Technological changes were initiated with the development of the lighter weight diesel engine, resulting in diesel-powered bulldozers, draglines and pumps. This revolutionized open-cut placer mining methods as the use of this more mobile excavating equipment made it possible to work many deposits that could not be mined by the earlier, more cumbersome machines.

In general, the advent of mechanization into the placer gold industry was dedicated to the capability of handling increasing volumes of gravel to compensate for the decreasing tenor of the deposits, and the steadily increasing costs of operation.

Improvements in gravel washing and recovery units were also noted as the somewhat fixed wooden sluice boxes were replaced by portable steel sluices, either elevated on steel trestles or used on ground level. The steel sluice plate was an influential improvement that resulted in the development of simple and flexible mining techniques.

A degree of sizing and maneuverability of tailing disposal were also innovated with the dryland dredges. Trommel screens, stacking conveyors and recovery systems mounted as a unit on crawler-type tracks were developed into successful washing plants at several locations.

In summary, this push to handle higher volumes of material was accompanied by some consideration to classifying the feed to recovery units, amalgamation and utilization of jigs, but the sluice box remained as the primary recovery system. Subjected to surging loads of solids and large volumes of water, its ability as an efficient system to recover fine gold is questionable. I do not believe anyone can quote chapter and verse on sluice box efficiency considering all the variables that exist, but I would venture to say that 25 to 40% losses are not uncommon in many operations.

The recovery of liberated gold from a placer deposit is primarily a gravity process in which the specific gravity differential between the gold particles and accompanying material is utilized with water as the transporting media. However, this is not as simple as it sounds in that the gold may be coarse, extremely fine and of varying shape factors. The accompanying gangue material also varies as to size, shape and specific gravity.

Therefore, if a sluice box is to be used as the primary recovery unit, its efficiency will be governed by the controls exercised in its operation. Any recovery unit operates more efficiently under conditions of steady feed and controlled pulp density. The intermittent and surging loads produced in direct feeding by a bulldozer or dragline do not produce optimum control of feed rate, and consequently will have their effect on recovery efficiency. Controlled solid feed rate can be obtained by a surge bin and feeder arrangement. It is not a technical impossibility, but may be an economic one.

The specific ratio between a gold particle and a quartz particle is approximately 7 to 1. On the other hand, the size ratio between a 6" boulder and a minus 60 mesh gold particle is approximately 730 to 1. The water velocity to transport the 6" boulder is dependent upon water quantity, sluice box width and grade. If the velocity is not sufficient, blockages occur, but high water velocities are also detrimental to fine gold recovery. This possibility is aggrevated and extended into coarser size ranges if the gold is flat and platey.

The obvious answer when balancing transporting power against recovery efficiency and size against recovery efficiency is the axiom, that the closer the particles are sized in a gravity process, the more efficient the process becomes. This principle, of course, has practical limitations, but any sizing operation prior to concentration will have beneficial results. Grizzlies, trommels, wobblers or practically any other screening device can be used for this purpose.

The Federal Water Pollution Control Standards state: 1) Application of best practicable control technology currently available by July 1, 1977 and 2) Application of best available control technology economically achievable by July 1, 1983. What constitutes practicable and economically achievable would probably be different for each individual operation, but indicates some measure of effort to eliminate solids discharge into a receiving stream system. Whether this effort is directed to a closed circuit water system or a direct flow to the receiving stream, some method of solid-fluid separation must be employed. Initial elimination of coarse material by sizing will benefit this procedure as well as the gold recovery aspect.

Potential losses of fine gold and regulations concerning solid and effluent discharges dictate the need to re-evaluate the sluice box as the only applicable recovery unit. Unfortunately, there seems to be no fast and practical substitute for small operations, but the conventional sluice box can be augmented by controlled feeding and sizing devices to increase its efficiency and give better control over effluent discharges.

You have noted that technology of the thirties had a marked effect on the placer mining industry. I believe that changes in or refinements on the recovery systems could be just as effective. As a parting thought, the glitter of gold may have faded over the past few years, but the lure has survived for centuries, and may yet spark another chain of history-making events.

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APPENDIX I

The following text, which forms part of "Gold Recovery in a Sluice Box" by Donald J. Cook, was distributed to some participants of the Placer Mining Conference. In its original form, it was part of the thesis presented by Donald Cook to satisfy the requirements of Engineer of Mines Professional Degree.

Whilst it was not part of the formal program, it is reproduced here as a valuable source of information for prospective as well as established miners.

PLACER GRAVEL

Placers are alluvial deposits of silt, sand, gravel, and boulders, containing some valuable mineral in workable amounts.

Composition

Though actually there are no average placer gravels, the composition representing the type of rock present in each vicinity, most sluicable gravels share at least a few features: The valuable mineral forms a small portion of the mass; the quartz sand with "black sands" make up another portion; the material larger than sand size makes up the major portion. All of this material has various shapes, weights, and specific gravities.

Native gold is the most important placer mineral; other minerals derived from placer gravels include platinum, cassiterite, monazite, columbite, ilmenite, zircon, diamond, sapphire, ruby and other gems.

Quartz is the commonest constituent of the sand, because of its hardness and chemical indestructibility. Sand is arbitrarily sized as particles between 1/16 millimeter and 2 millimeters in diameter.

Black sands usually concentrate in an alluvial deposit because they are all of high specific gravity and durable.

Placer gold is invariably accompanied by heavy minerals, which comprise the concentrate found in the sluice box at clean-up time. Some of these minerals, roughly in order of their commonness are these:

Magnetite, the most common mineral constituent of heavy sands, may seriously handicap the miner because it tends to pack in the riffles. It is almost always present and frequently weighs as much as 1 or 2 percent of the entire gravel.[1]

Titanium minerals, of which Ilmenite and Rutile are the most common, usually occur in the black sands, but do not have commercial value as gold placer products.

Garnet is a common accessory mineral of many rocks, but having a higher specific gravity than other rock-forming minerals it occurs in the concentrates.

Chromite is quite common in the concentrates, but has no value as a placer product.

Monazite is found in some districts, and is recovered commercially because of its thorium content.

Cinnabar, wolframite, scheelite, or cassiterite may be found in some vicinities, and could be of commercial value if occurring in great abundance.

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[1] E. D. Gardiner and C. H. Johnson, I.C. 6786, Placer Mining in the Western United States, p. 18

The main bulk of the placer gravel consists of coarse fragments ranging from 2 millimeters in diameter to 10 inches in diameter. Those fragments larger than 10 inches in diameter will arbitrarily be called boulders.

Characteristics

Numerous large boulders in placer gravel either prohibits or increases the cost of operations, and in the other extreme too much fine sand packs the riffles and causes excessive gold loss.

The duty of water is highest for small gravel; it is reduced, either by fine sand that sinks and moves along the bottom of the sluice in a sluggish and compact manner, or by larger boulders that require an increased volume of water to move them through the sluice. This is of interest inasmuch as in a diversified mixture the pebbles assist in disintegrating clay, whereas sand increases the carrying capacity for stones. The total transportation load is then increased and more large material is movable for a given quantity of water.

Shape

The gravel may be angular, sub-angular, or round and water worn; these features have considerable bearing on the duty of water, the action of riffles, and the grade of the sluice box.

The duty of water is greater with rounded particles that roll and gather momentum as they progress down the sluice box. The rolling and bouncing action of these particles also gives a jarring effect that is helpful in working the gold down through the riffle bed.

Sub-angular, angular, and predominantly flat pieces give succeedingly lower duties of water, for the fragments slide rather than roll down the sluice box.

Character of Fine or Cementing Material

Some gravels consist of angular or rounded stones with a little sand, others of the same material in a clay matrix.

The loose, uncemented material is easily excavated and washed and usually sluices easily.

Some cemented materials break up readily in water, whereas others may form balls that roll through sluices and pick up gold and amalgam. It is sometimes advantageous to mix this material with uncemented gravels before feeding to the sluice box, to decrease the concentration of clayey material.

GOLD

The extremely high specific gravity, and the ability to amalgamate with mercury, are properties that are utilized to recover gold in a sluicing operation.

A variety of conditions, some of which are characteristic of the gold itself, make it impossible to build gold-saving equipment that will effect 100% recovery. If these conditions are recognized, however, adjustments can be made to the recovery system to retain gold that might have otherwise been lost.

Classification

Gold may range in size from large nuggets, weighing many pounds, to minute specks, called "colors". The size of a color is usually indicated by the number of colors required to make 1¢ worth of gold; sometimes the gold particles have been so fine as to require more than 2000 colors to make this value.

The following classification of gold particles by screen sizing is quoted from Hoffman, by Boericke[2]:

"Coarse gold	-	remains on a 10 mesh screen (openings 1/16")
Fine gold	-	passes a 20 mesh but remains on a 40 mesh screen (openings 1/64")
Very fine gold	-	passes through a 40 mesh screen"

Characteristics

The gold particles have certain characteristics that either aid or are a handicap to their recovery.

Particles that are rounded and water worn indicate long stream transportation that has worn off adhering rock fragments, leaving the soft gold rounded, and almost always flattened somewhat. The lack of rolling in flat particles when washed by water in a sluice box definitely aids recovery.

Gold that is ragged and angular, with particles of adhering quartz, indicates little stream action and a consequent short distance of travel. Such "rollers" tend to roll down a sluice box, with a very good chance of being lost with the tailings.

Flat, paper thin colors, are buoyed up by water, particularly water containing much clay or talc; they may be carried long distances by a swift stream. This condition makes the recovery more difficult, for the colors are not readily separated by water action from the more compact and rounded grains that comprise the "black sands".

Some gold obtains an oxide coating which makes it lose its affinity for mercury. This coating is particularly detrimental to

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[2]William F. Boericke, Prospecting and Operating Small Gold Placers, p. 35

those miners who depend upon amalgamation to increase their recovery of fine gold.

Distribution in Sluice Box

The greatest portion of the gold is caught near the head of the sluice box. Bowie estimates that an average of 80% of total yield of large sluices is recovered in the first 200 feet of length, according to results of several early California mines.[3] This condition would prove disastrous in Alaskan operations today, for the average total length of modern sluice boxes is 60 feet. One Alaskan operator states that he recovers 82% of his total yield from the first foot of the first 12' box length.

Distribution depends on the nature of the gravel, the shape and size of gold, the grade of sluice boxes, the type of riffles, and the amount of clay.

Loss in Sluice Box

It is practically impossible to determine accurately the loss of gold during a sluicing operation. The gold content of the gravel is not accurately known, and no attempt is made for continual sampling of the tails while sluicing.

Periodic samples of the tails, and the distribution of gold in the boxes, does indicate whether losses are excessive.

Purington estimates that Alaskan shoveling-in operations recovered 80% to 90% of the total gold; other authorities place recovery with ordinary sluices and undercurrents at 60% to 85%.[4]

WATER

Probably of equal importance with the amount of gold in a placer deposit is the quantity of water available for working the deposit. Large, low-grade deposits might be worked profitably with an abundant water supply, whereas a high-grade deposit could not be worked because of a lack of water.

Few hydraulic mines can operate all year because of this lack of water. In dry climates, the operations may be forced to close down during the summer months; and in cold climates, the operations begin with the spring thaw and cease with the fall freeze-up.

Unit of Measurement

The flow of water in a sluice box may be designated in gallons per minute, cubic feet per minute, or miner's inches. These terms may be converted one into the other as follows:

1 cubic foot of water	=	7.5 gallons
1 miner's inch	=	1-1/2 cubic feet per minute
1 miner's inch	=	11-1/4 gallons per minute

[3]Robert Peele, Mining Engineers' Handbook, p. 10-571
[4]Ibid., p. 10-571

This value of a miner's inch is legally defined for Alaska, California, Montana, and the Yukon Territory.

Duty

The duty of water in a sluice box is designated by the amount of gravel that one miner's inch sends through the boxes during 24 hours.

It is important to know this duty of water when designing a sluice box, so that either the necessary water can be acquired, or the appropriate changes made in the recovery system to compensate for its lack.

The duty of water in a sluice depends on: the size and shape of the gravel, the dimensions of the sluice box, the type of riffle used, and the quantity of water available.

A low duty of water due to characteristics of the gravel could be helped by narrowing the width of the sluice, increasing the grade on the boxes, and changing the type of riffle.

Table 1, from Peele[5], illustrates the duty of water, under varying conditions, in Alaskan sluices.

Transporting Power

The movement of gravel in a sluice box, by water, results from several simultaneous actions: large particles roll or slide along the top of the riffles, depending on their shape; the remainder of the particles move by short leaps and bounds just above the top of the riffles, by "saltation"[6]; the lighter particles may leave the bed load entirely during the process of saltation, and be carried down in suspension.

If the water is carrying an underload, or small amount of gravel, the surface of the water and bed load becomes smooth, particularly with gravel containing a large amount of sands. This condition lowers the efficiency of transportation as well as the gold-saving ability of the sluice. A loaded condition, on the other hand, increases the carrying power of the water, and prevents the sands from packing by its constant agitation.

Effect on Grade of Sluice Box

Knowledge of the character of the gravel to be sluiced, the amount of available water, and the velocity of water needed to sluice this material allows the construction of a sluice box of the proper grade and dimensions.

For estimations of the velocity of water, the following table

[5] Ibid., p. 10-557
[6] G. K. Gilbert, Transportation of Debris by Running Water, p. 15

DUTY OF WATER IN ALASKAN SLUICES

Locality	Sluice Box Width In.	Sluice Box Depth In.	Sluice Box Grade In. per 12' box	Type of Riffle	Water Through Sluice, Miner's Inch	Duty	Nature of Gravel
Seward Pen:							
Big Hurrah Cr.	36	18	5	Rails	900	1.20	Unfrozen, med., much flat
Little Cr.	48	24	5-7	Angles & rails	---	1.37	Partly frozen, med.
Osborne Cr.	36	24	7	Blocks & rails	750	1.20	Partly frozen, heavy
Mt. McKinley Dist:							
Moore Cr.	24	20	6	Punched plate over matting & longit steel shod	300	1.60	Unfrozen, med., round
Fairbanks Dist:							
Pedro Cr.	36	30	11	Blocks	350	1.20	Partly frozen, heavy
Pedro Cr.	36	30	5	Rails	400	0.80	Partly frozen, med.
Yentna Dist:							
Peters Cr.	30	24	6	Rails	800	0.80	Unfrozen, med.; boulders
Kenai Dist:							
Crow Cr.	52	36	6	Rails	2600	0.50	Very coarse; many large boulders
Nizing Dist:							
Dan Cr.	48	44	5	Rails longit	---	0.32	Very coarse; many large boulders
Chititu Cr.	40	36	5-3/4	Rails longit	2200	0.42	Very coarse; many large boulders, also heavy

TABLE I

from Longridge[7] shows the action of water on different-sized particles in sluices without riffles:

Velocity	Action on Particles
16'/min.	Begins to wear away fine clay
30'/min.	Just lifts fine sand
39'/min.	Carries sand as coarse as linseed
45'/min.	Moves fine sand
120'/min.	Moves pebbles 1" in diameter
200'/min.	Moves pebbles egg size
320'/min.	Moves stones 3" to 4" in diameter
400'/min.	Moves boulders 6" to 8" in diameter
600'/min.	Moves boulders 12" to 18" in diameter

When the required velocity has been established, the grade for the sluice can be calculated by Longridge's formula[8]:

$$G = \frac{V^2 \times P}{2A} \times C$$

Where G = Fall in feet per mile, which may be reduced to inches per 12-foot box, by multiplying by 0.027

V = Velocity in feet per second

P = Wetted perimeter of sluice in feet

A = Area in sq. ft. filled by water and dirt

C = Variable co-efficient, depending on the frictional character of the gravel, varying from 6 for light gravel, to 8 for boulders and heavy clay

Although references to the above table and formula may help, actual experience guides the miner in selecting the best rate of flow and grade on his sluice boxes.

The only variable not considered in this method of calculating the appropriate grade for a sluice box is the character of the gold. Section II of this paper compares this method against actual experiments to give the most efficient gold recovery.

Distribution in Sluice Box

The proper distribution of water in a sluice box must also be considered.

To carry heavy material down a sluice the water, in depth, should cover the largest boulder to be handled. This situation, however, is

[7] C. C. Longridge, Hydraulic Mining, p. 256
[8] Ibid, p. 257

not advantageous for sluicing fine material or saving fine gold.

The most favorable condition for saving fine gold would be just enough depth of water to keep the sand from packing. With the proper grade, 2" of water could do so, but the additional gold recovery would not compensate for the resultant decrease in capacity.

Methods of Conveying to Sluice

Water is usually conveyed from its diversion point to a sluice box site by ditch, hydraulic pipe, or a combination of ditch and pipe.

After the water has reached the site of operation, there are two standard methods of utilizing it to wash the gravel through the sluice boxes:

1. Hydraulic - where no mechanical equipment is used, the gold-bearing gravel is washed directly into the sluice box by the use of a hydraulic giant (Fig. 1).

   Often even though the gravel is conveyed to the head of the boxes by mechanical means (Fig. 2), the water under pressure from the giant is used to help break up tough, clayey material before transporting it through the sluice.

2. Sluice plate - this method of charging water and gravel into a sluice box has come into popular use in Alaskan operations within the last few years. It is essentially a rectangular box attached to the head sluice box, with gravel being conveyed by mechanical means into one side or the head, and water entering either perpendicular to or parallel and opposite to the direction of the gravel feed (Fig. 3 to 5).

   This method only works with mechanical means of conveying the gravel, and best suits gravels that are loose and require little preliminary disintegration.

Either method of charging gravel and water often necessitates, during periods of water shortage, returning the sluice water for re-use. Doing so has the disadvantage of causing the pulp density to be too high, and so prevents some fine gold from settling down into the riffles.

SLUICE BOX

A sluice box is a combination conveyor system, and gravel-washing and gold-saving apparatus; hence, much of the success of a placer mine depends upon its construction and operation.

Construction

This paper does not attempt to detail the actual building of a

Fig. 1 - Hydraulicking into sluice box, F.E. Co. Operation at Engineer Creek

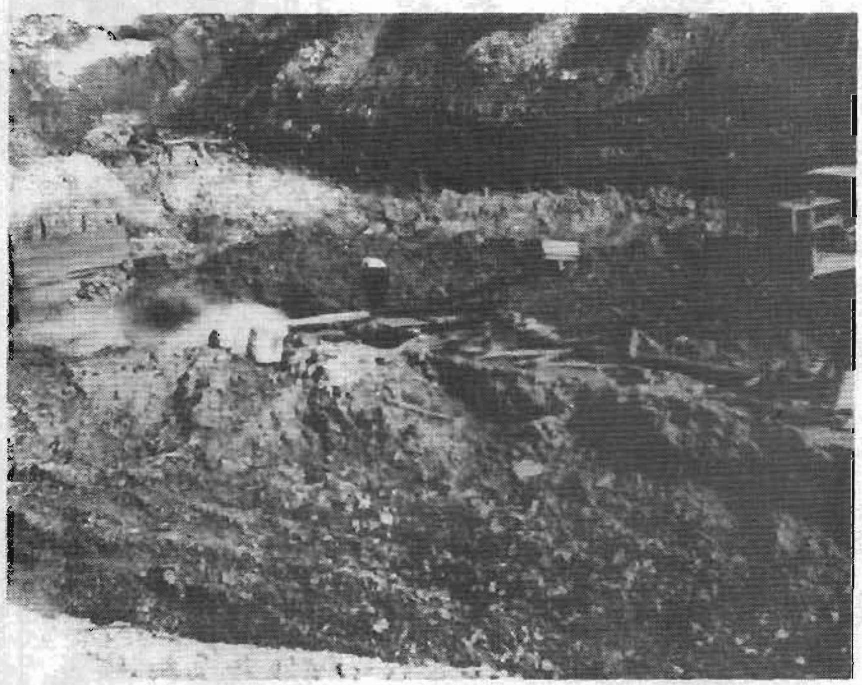

Fig. 2 - Dozer-hydraulic operation at Chatham Creek

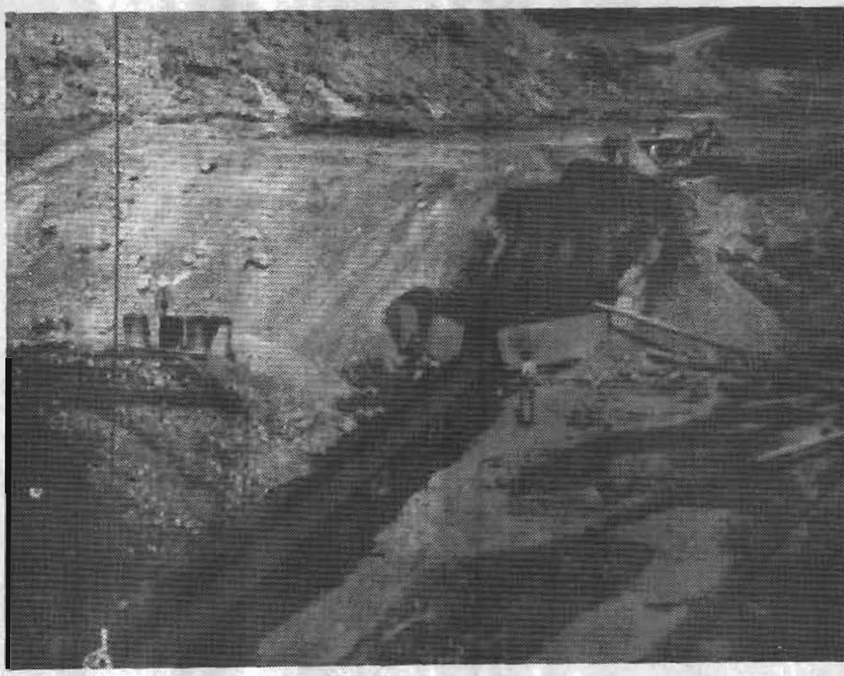

Fig. 3 - Pushing Gravel to a sluice plate at Olive Creek Mines

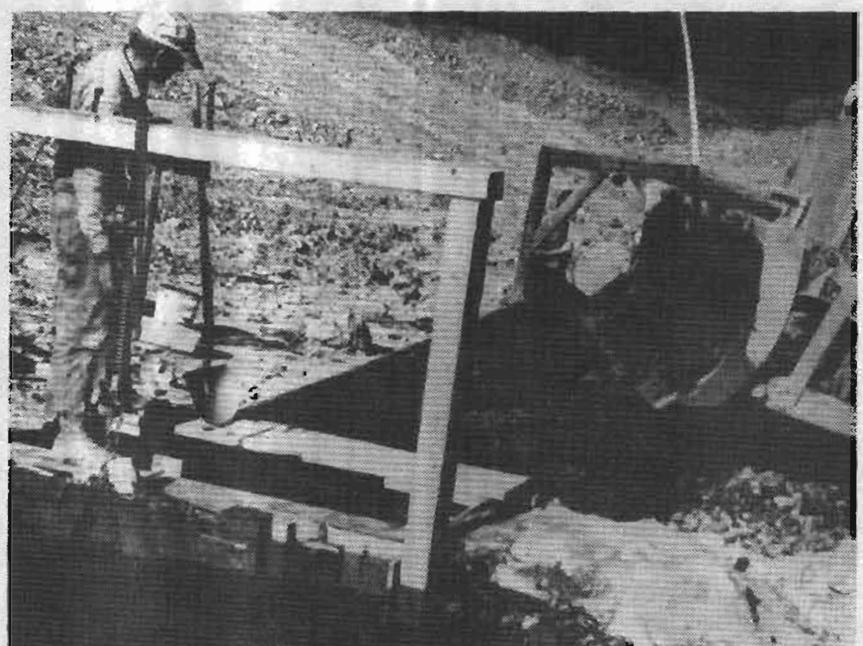

Fig. 4 - Pushing gravel to a sluice plate at Miller Creek

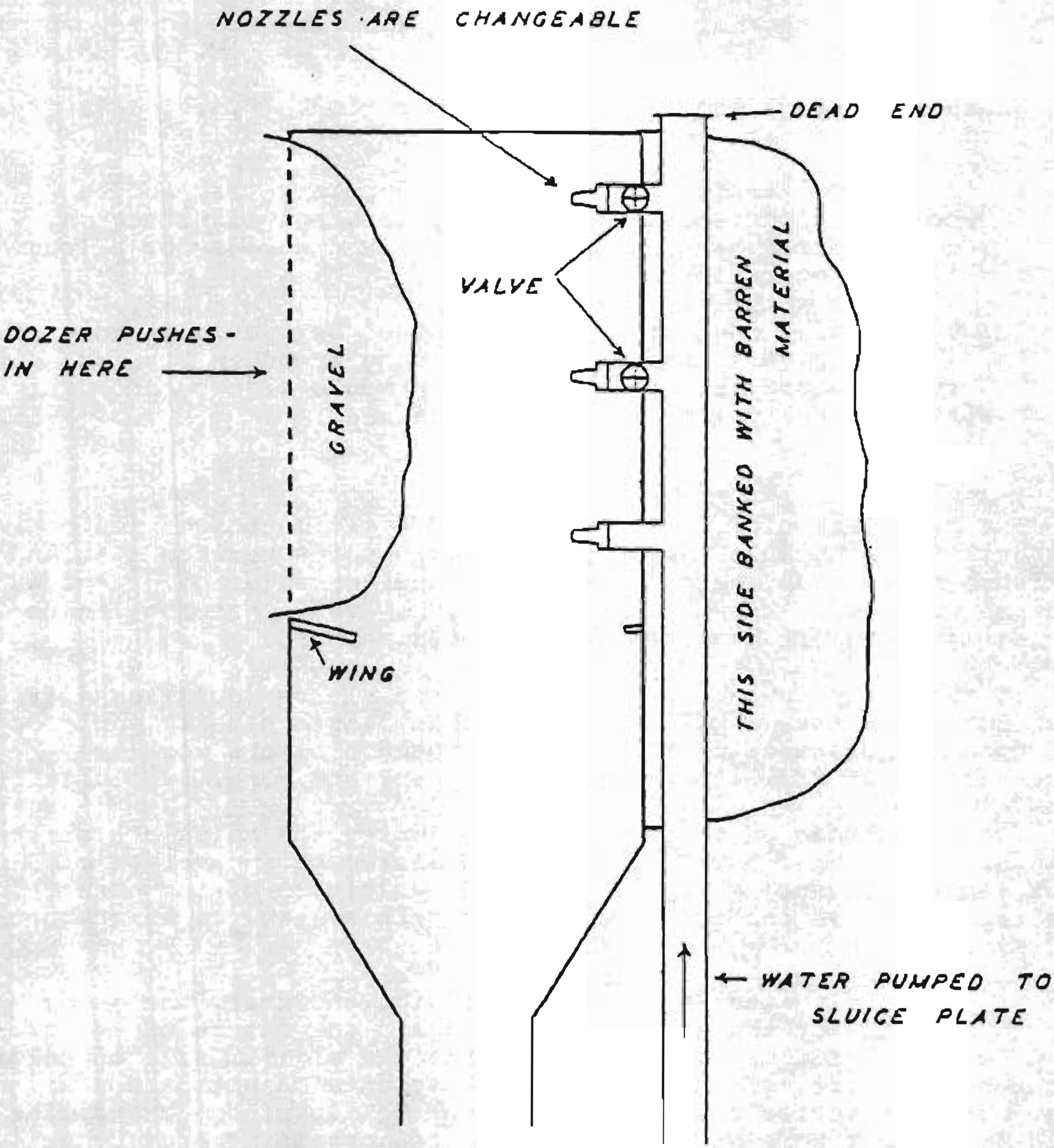

FIG. 5 - SLUICE PLATE ARRANGEMENT
COLORADO CREEK

sluice box, but studies how characteristics of gravel and gold, and the quantity of water, affect the construction and consequent recovery of gold.

Sluice boxes are usually built in 10 or 12 foot sections either bolting flush together at the ends, or telescoping the lower end of one into the upper end of the other.

Whether it is of wood or metal construction, (Fig. 6 & 7) depends mainly on two factors:

1. If the box is intended for only temporary use, wooden construction is easier and cheaper; steel construction, on the other hand, would be more advantageous for a long life of operation.

2. The initial cost of building a steel box would be considerably more than that of building a wooden box, so the financial status of the miner would also considerably affect the type of material to be used.

Length

The calculation of the dimensions of a sluice box cannot be accurately made because the complex relationships between this and the factors of grade, velocity of flow, and character of gravel and gold are not wholly known. It is known, however, that the length is not nearly so important as the cross-sectional area.

In the early days of placer mining the sluice would range from a few box lengths to a mile or more. This length usually would depend upon the distance of the dumping ground from the workings; hence, it could vary with the topography and the money available.

Modern methods of placer mining, by which the tails are stacked by mechanical means, have shortened the sluice to an average of 5 or 6 box lengths. Usually a properly designed sluice of this length, especially with an incorporated undercurrent system, is an adequate gold-saver.

In determining the length of the sluice, however, one should be guided partly by the fineness of gold and the nature of the gravel. Velocity of flow largely determines the minimum size of colors caught by the riffles; but if other adjustments cannot be conveniently made, a good practice may be to lengthen the sluice so long as the yield from lower boxes exceeds the cost of installing and operating them.

A long sluice gives tough material a better chance to disintegrate, but very clayey material has an increased tendency to "ball" and pick up gold in its passage through the box.

Cross-sectional Area

The proper width for a sluice box depends on these considerations:

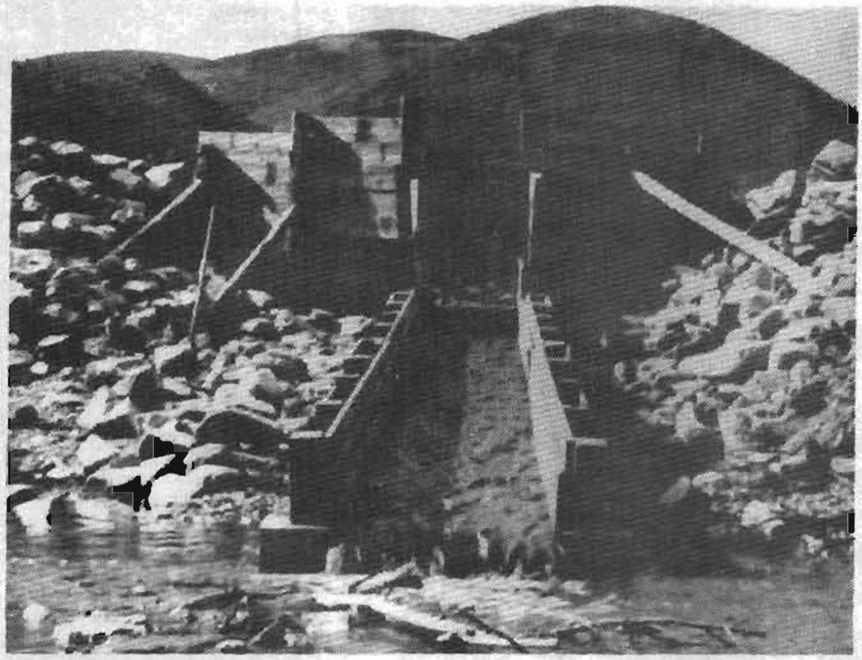

Fig. 6 - Wood constructed sluice box used on Deadwood Creek

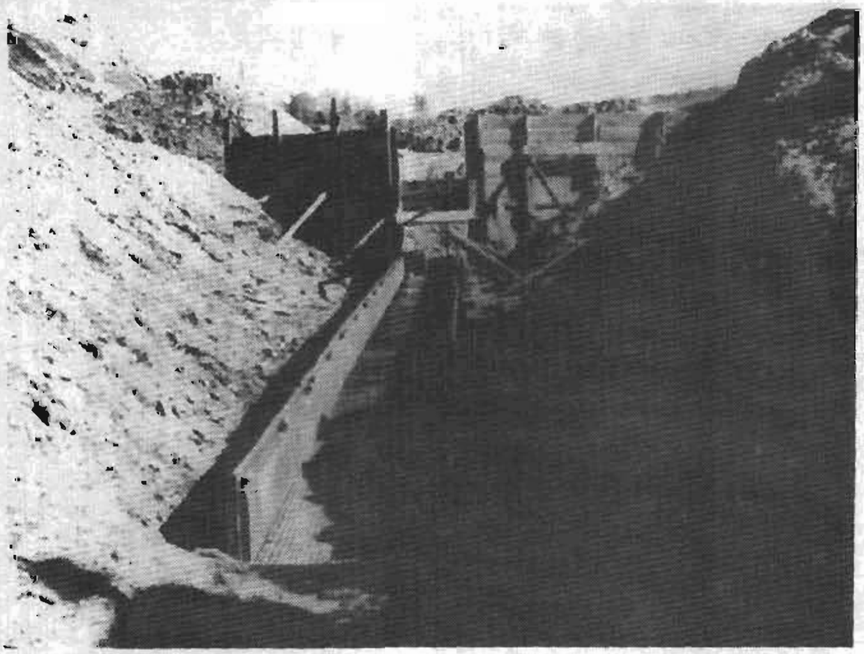

Fig. 7 - Steel sluice box used on Chatham Creek

maximum and minimum volumes of water available during the season, grade of the sluice box, character of the gold, and character of the gravel.

Two opposing conditions must be balanced in selecting the width or cross-sectional area in a sluice box:

1. For saving fine, flakey, or flour gold the material should move in a thin film over the top of the riffles, with only enough water to prevent packing of the sands. Therefore, gold would have a better chance to settle and be caught in the riffles in a wide, shallow stream than in a deep and narrow stream with the same volume of water.

2. For transporting coarse material down a sluice box, the water should be deep enough to cover the largest stones. Considering the same volume of water, the only solution seems to be narrowing the width to give a greater depth.

These antagonistic conditions always occur when sluicing material contains fine gold and coarse gravel. They could, however, be controlled by one of the following applications:

1. Separating the coarse material from the fines, either by breaking or by screening through a grizzly. This method has disadvantages in being time-consuming and costly, and, as has already been stated, the coarse material somewhat favors the disintegration and distribution of the material in the sluice, with the ultimate end of recovering the gold.

2. Adapting the width and depth of the sluice to favorable conditions for working the coarse material, then removing the fine material from the main sluice load by means of an undercurrent.

Undercurrents

In the early days of placer mining the fine material was separated from the coarse gravel by inserting a bar grizzly or punch plate somewhere in the sluice line. The fine material, falling through the screening device, would be distributed over another sluice from 4 to 10 times the width of the main sluice. This undercurrent sluice would spread the material in a broad, thin stream that would help the recovery of fine gold. Depending on the location of this undercurrent, its tailings and water would be discharged directly or led back to the main sluice.

The undercurrent, in present day Alaskan placers, consists of a punch plate, with staggered perforations to screen the material traveling over the last box length. Hungarian riffles or matting of some type is used in this undercurrent as in the earlier days. The only major difference is that the undercurrent is contained in the main sluice, and no attempt is made to increase its width.

<u>Grade</u>

Sluices are always set on an inclination, which is usually expressed either as a percentage or as a fall of so many inches in a 12 foot box length. For purposes of this paper the grade will be designated as inches of fall in a box length.

These expressions are interchangeable, as shown in the following examples:

Example 1

If a sluice has a 12" fall per box length what is the grade in percentage?

$$144 : 100 = 12 : x$$

$$144x = (100)(12)$$

$$x = \frac{1200}{144}$$

$$x = 8.33\% \text{ grade}$$

Example 2

If a sluice is set on an 8.33% grade, what is the fall per box length?

$$100 : 144 = 8.33 : x$$

$$100x = (144)(8.33)$$

$$x = \frac{1200}{100}$$

$$x = 12\text{" fall per box length}$$

The selected grade of a sluice to give the most efficient operation depends on several factors, some of which are opposing. The character of gravel; the size and shape of boulders, whether round or flat; the character of gold, whether coarse or fine; the amount of black sand; the amount of water available; the width of the sluice box; and the type of riffles used all have some bearing on the proper grade.

Light gravel containing earthy matter, and a minimum of heavy sands, can be moved with less water, and flatter grade, than can heavier, coarse gravel. Even with such material, however, a grade that is too flat increases labor in keeping the sluice clean, and so reduces capacity.

Although the theory of saving fine gold advocates a flat grade with a shallow depth of water, recovery is often improved by increasing the grade reasonably. This is especially true if the gravel contains much heavy sands, for the fine gold tends to drift over the sand that the flat grade has packed in the riffles. The increased agitation of a steeper grade loosens the sand particles and allows the gold to settle.

Plentiful water may make a flatter grade desirable, especially if conditions of sanding allow a better fine gold recovery. A scarcity of water with a flat grade reduces the duty, and limits the size of boulders that can be transported through the box. If this situation exists, fine gold recovery is often sacrificed to increased capacity by means of steeper grade.

The two opposing factors, rapidity of work and efficiency of recovery, have to be weighed one against the other in choosing the proper grade for a sluice box. The selection of proper grade then becomes a matter of experience, and testing with the amount of available water.

RIFFLES

Riffles in a sluice box that is operating efficiently accomplish three things: they retard the gold that has settled to the bottom of a flowing stream of gravel and water, and give it a chance to settle; they form a pocket to retain this settled gold; and they form eddies that classify this gold from the sand that has deposited with it.

Design

Regardless of the fact that with ideal conditions - coarse gold and easy washing gravel - almost any type of riffle works equally well, the shape of the riffle is definitely important.

To obtain the highest water duty it must offer the minimum resistance to flow, but at the same time it must be shaped to agitate the passing current just enough to produce an eddy or "boiling" action in the space behind or below it.

Economically it should be designed for cheap maintenance, ease of installation and removal, and reasonable initial expenditure.

No riffle combines all of the design specifications. Although the type of riffle should be chosen that best fits the particular sluicing conditions, the material on hand and the custom of the district do influence the decision of the operator.

Classification

Riffles may be classified in five separate catagories:

1. Block - such riffles are made of wooden blocks or stones with spacers between.

2. Longitudinal - these riffles are placed in the sluice box parallel to the flow of pulp, and may be of pole, cut lumber, iron rail or other metal construction.

3. Transverse - these riffles, loosely called "Hungarian", are perpendicular to the flow of pulp, and may be constructed of cut lumber, poles, iron rail, angle-iron, rubber or practically anything that stirs the imagination and ingenuity of the operator.

4. Blanket - corduroy, burlap, coco matting or any other fabric that presents a rough surface could comprise this type of riffle.

5. Auger hole - or mercury trap riffles are made of wood or rubber material, slotted to catch gold and hold mercury for amalgamation.

Characteristics of Individual Types

Riffles may be classified as block, longitudinal, transverse, blanket, and auger hole.

Block Riffles

As shown in Fig. 8, block riffles are of low initial cost in regions where proper material is available, but are time-consuming in installation and removal. Particular care must be taken in staggering the blocks so as not to allow a continuous current from the head to the tail of the sluice.

Stones, when available, are often used in preference to blocks; they give longer life, but their roughness necessitates greater grade to the sluice.

Such riffles were popular in the early days of placer mining, but are seldom seen in present day operations.

Longitudinal Riffles

Longitudinal riffles require a different theory of gold-saving from all other types of riffles. The coarse material, traveling down the sluice, becomes wedged between the riffles, and the downstream side of these particles then forms natural quiet zones and pockets for the deposition of gold. This type of riffle is efficient for coarse gold; however, these wedged rock particles tend to be dislodged with the consequent progression of the fine gold down the sluice box.

Poles or peeled saplings are often used for this type of riffle; they are the most economical to construct and are usually nailed to the bottom of wooden sluice boxes.

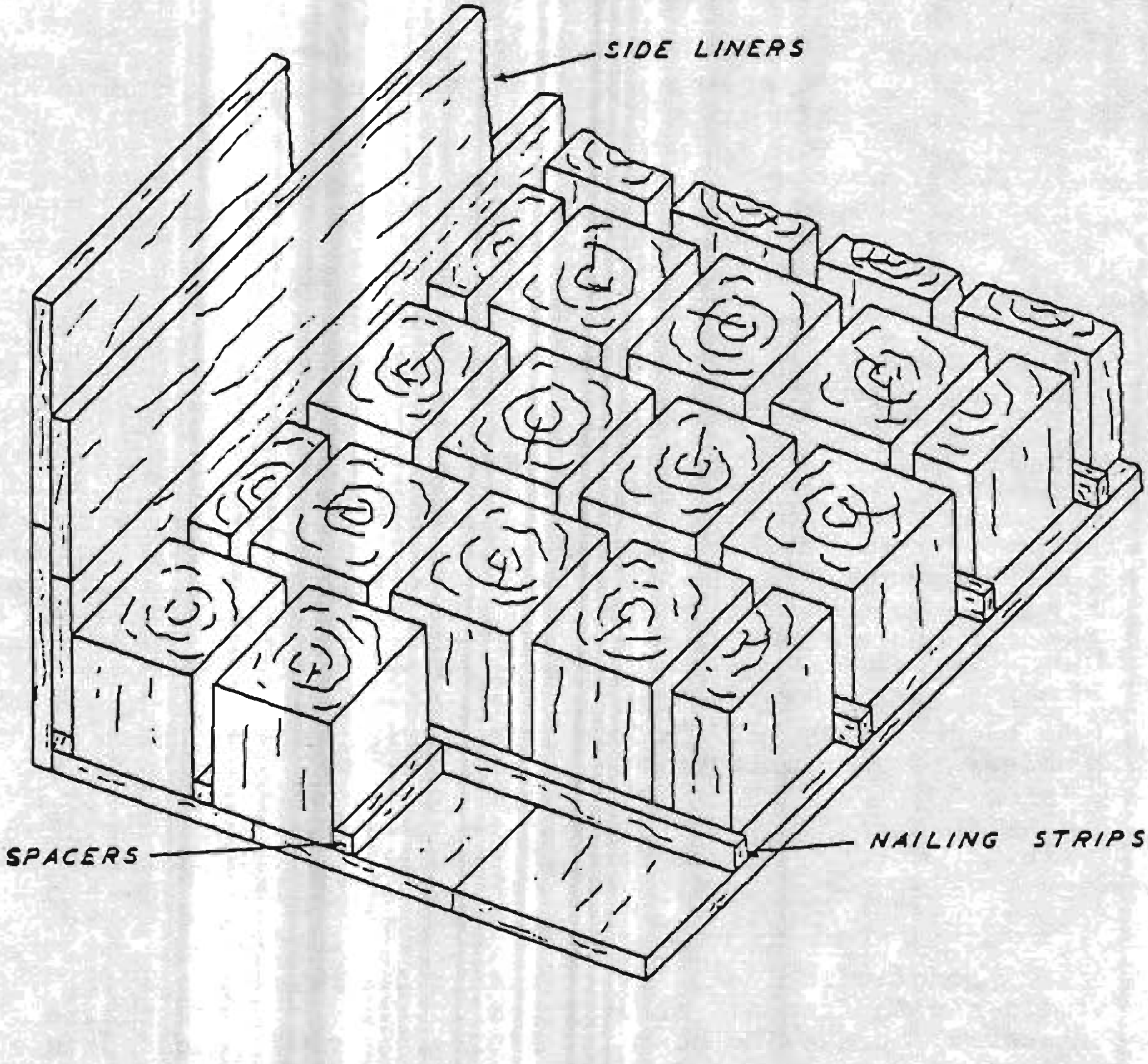

FIG. 8 - BLOCK RIFFLES

For metal sluice boxes, iron rail and T iron are common. If gold-saving is not a problem, iron rails, flange side up, provide a smooth-sliding bottom for coarse material; this decreases the resistance to flow, but at the same time offers the gold an opportunity to ride the rails down the sluice box. For this reason, iron rails are more commonly used right side up. The greatest objection to iron rails is their weight and inability to retain fine gold.

Transverse

Although transverse riffles may have a variety of modifications (Figs. 9 to 14), they all have the same basic principle: the velocity of flow is retarded to a certain degree by each bar, and so aids the deposition of gold in the depression between the riffles.

Transverse riffles with an overlap on the downstream side are commonly called "Hungarian" riffles. This type is universally used on modern gold dredges and is considered to be the most efficient gold-saving riffle[9] (Fig. 13-B). Although the area between the bars of Hungarian riffles may tend to become packed with sand, the space under the overlap is kept looser by a slight eddy action of the water which presents a protected area for the deposition of gold. This eddy action may be increased by sloping the riffle bar, as shown in Figure 13-B.

Angle iron is commonly used as Hungarian riffles, and may be set with flat upper surfaces or inclined slightly to increase the riffling action (Fig. 14-A & B).

When used as transverse riffles, iron rails are usually set right side up with the flanges almost touching (Fig. 13-A). As a general rule the flanges are parallel to the bottom of the sluice, but one Alaskan operator claims better fine gold recovery by tilting the rails at an angle, as shown in Figure 13-A.

Iron and steel are usually preferred for transverse riffle construction because durability more than compensates for higher initial cost.

This choice may not apply in a dredge sluice in which only fine material is traveling over the riffles.

Bovary's experiments[10] indicate that transverse rails are superior to longitudinal rails for wearing ability, for only the top of a transverse rail is subject to abrasive action.

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[9]Frank Redmond, Dredge Metallurgy, p. 11
[10]Peele, op. cit., p. 10-567

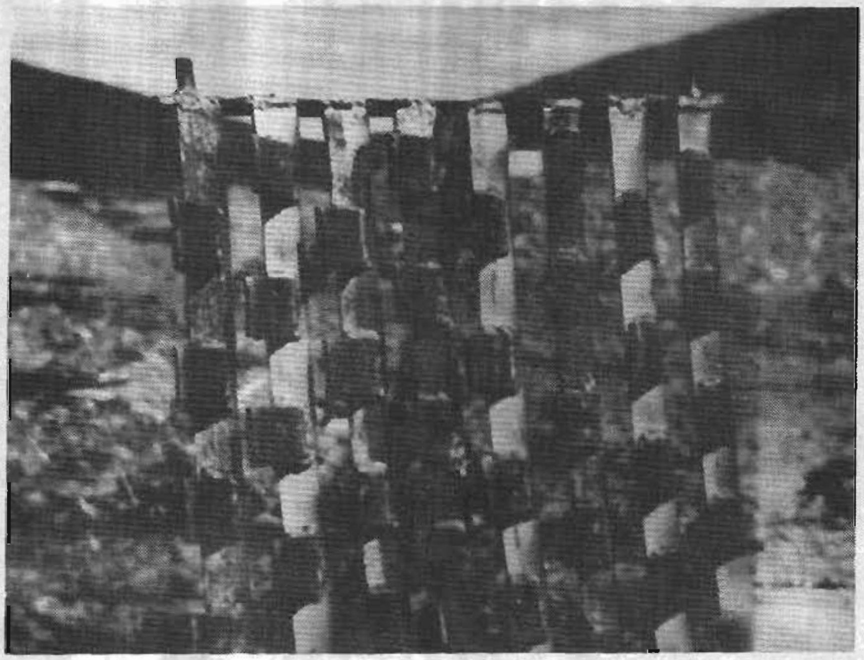


Fig. 9 - Angle-iron riffle used by Walter Roman on Mastadon Creek

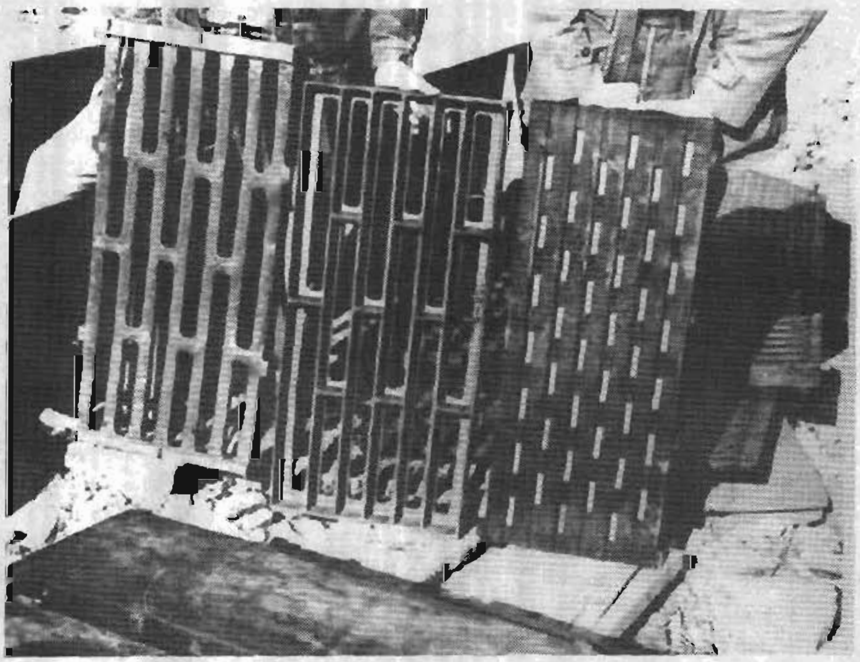


Fig. 10 - T-iron riffle and mercury trap used at Porcupine Creek

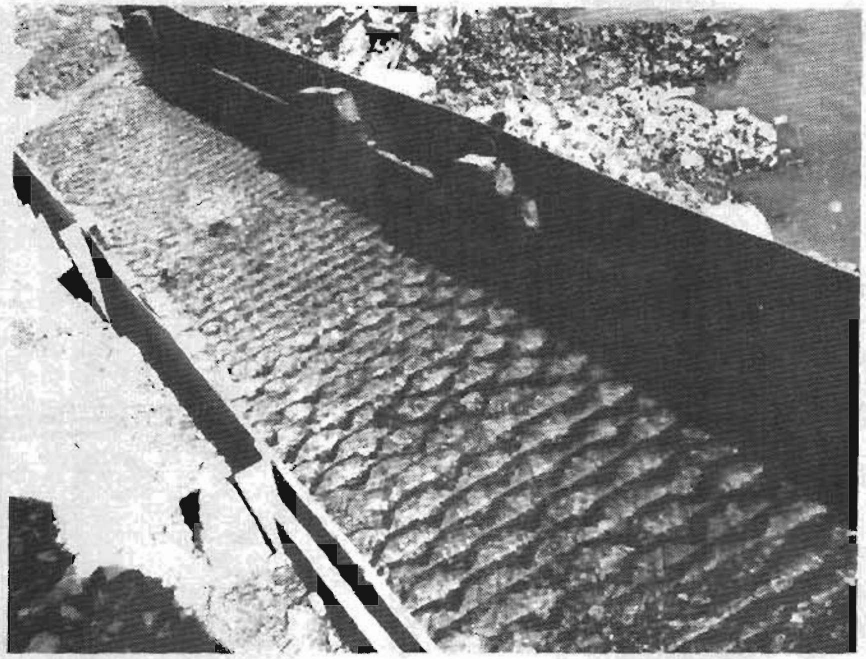


Fig. 11 - Notched angle-iron riffles used by Robert Wilkinson on Miller Creek

Fig. 12 - Variety of riffles used by Heine Carstens on Portage Creek

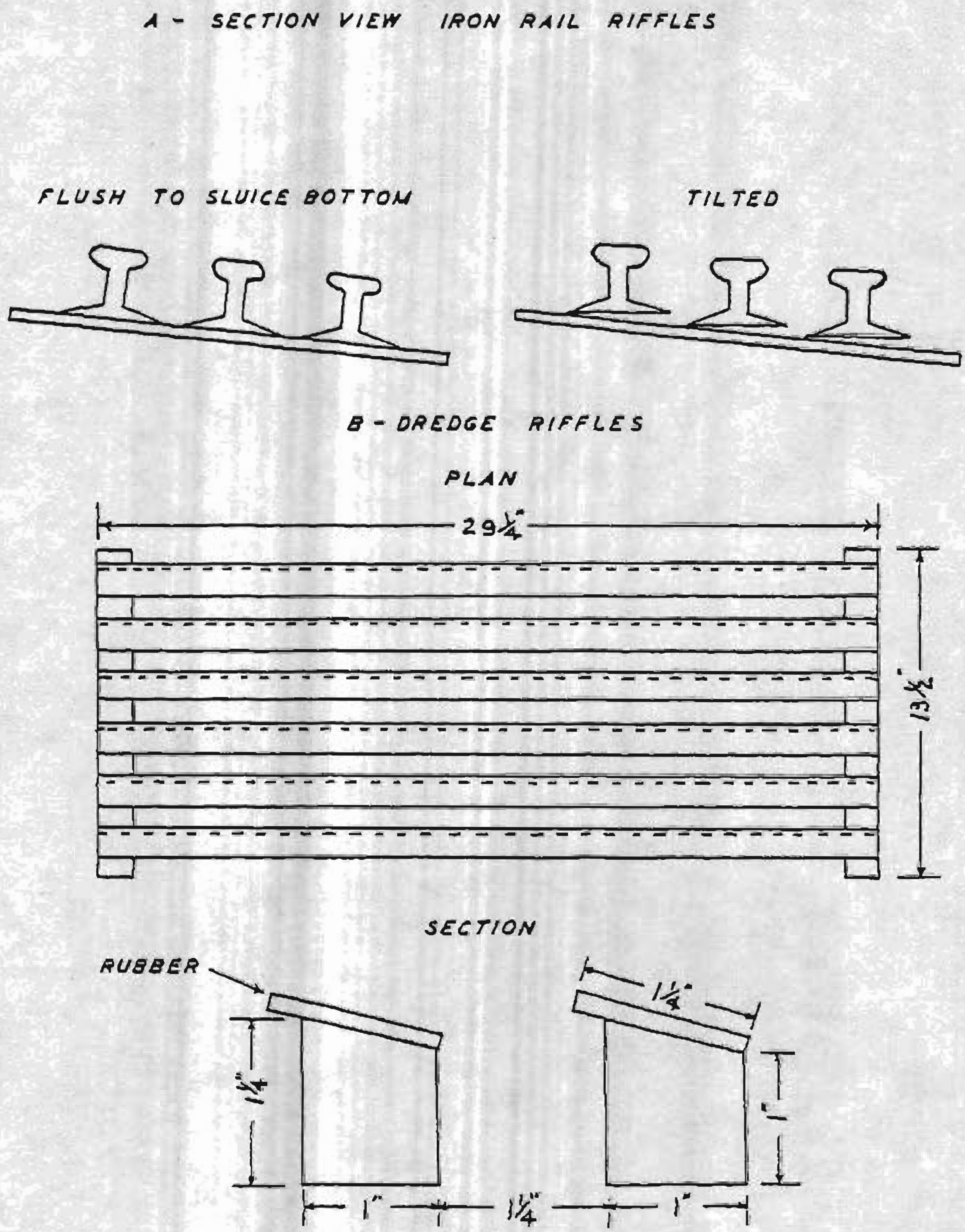
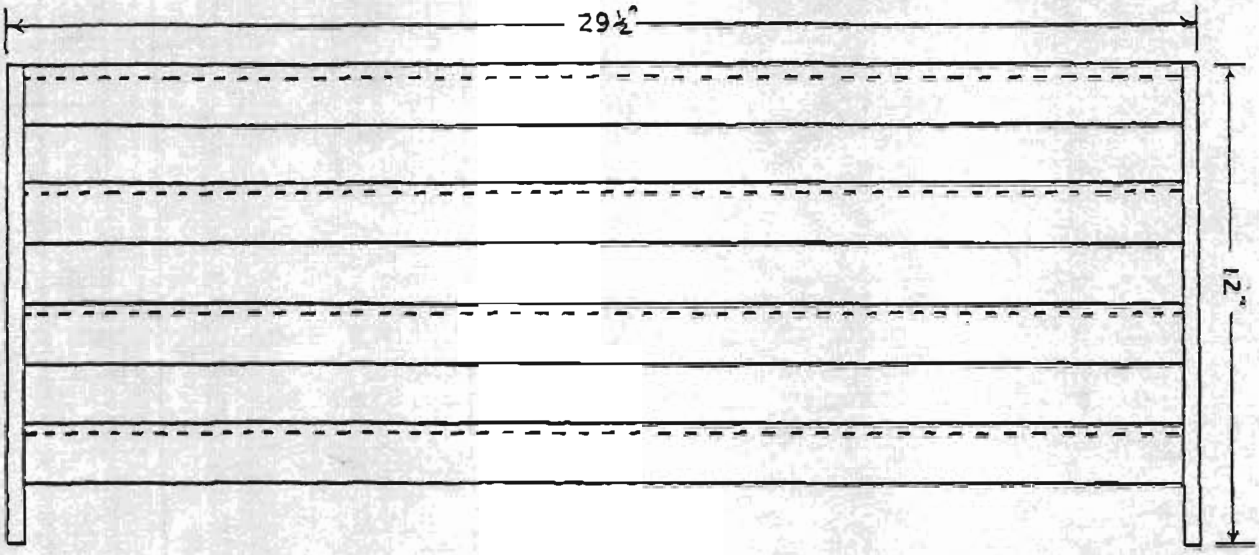
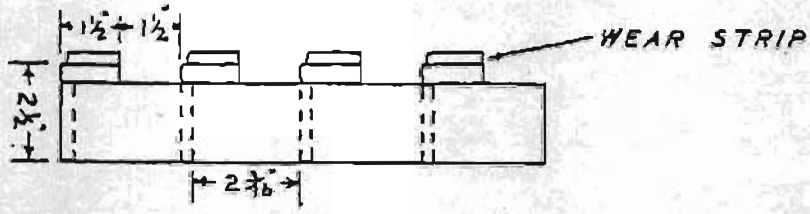

A - SECTION VIEW IRON RAIL RIFFLES
FLUSH TO SLUICE BOTTOM
TILTED
B - DREDGE RIFFLES
PLAN
29¼"
13½"
SECTION
RUBBER
1¼"
1¼"
1"
1"
1¼"
1"

FIG. 13

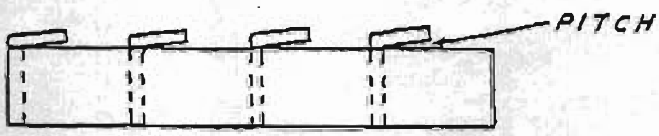
PLAN VIEW



SIDE VIEWS



A - FLAT SURFACE



B - INCLINED SURFACE

FIG. 14 - ANGLE IRON RIFFLES

Blanket

For shallow sluice streams carrying fine material, various fabrics are used to arrest the gold in its passage through the sluice box. This material, held down by cleats or wire screen, may comprise the only riffle in the sluice box; may comprise the riffle used only in the undercurrent section; or may be overlain by block, longitudinal, or transverse riffles of some type.

Auger Hole

These riffles are staggered and elongated slots in material of wood or rubber construction. They are best suited for fine gravel and are auxiliary to other types of riffles, usually as mercury traps (Fig. 10).

APPENDIX II

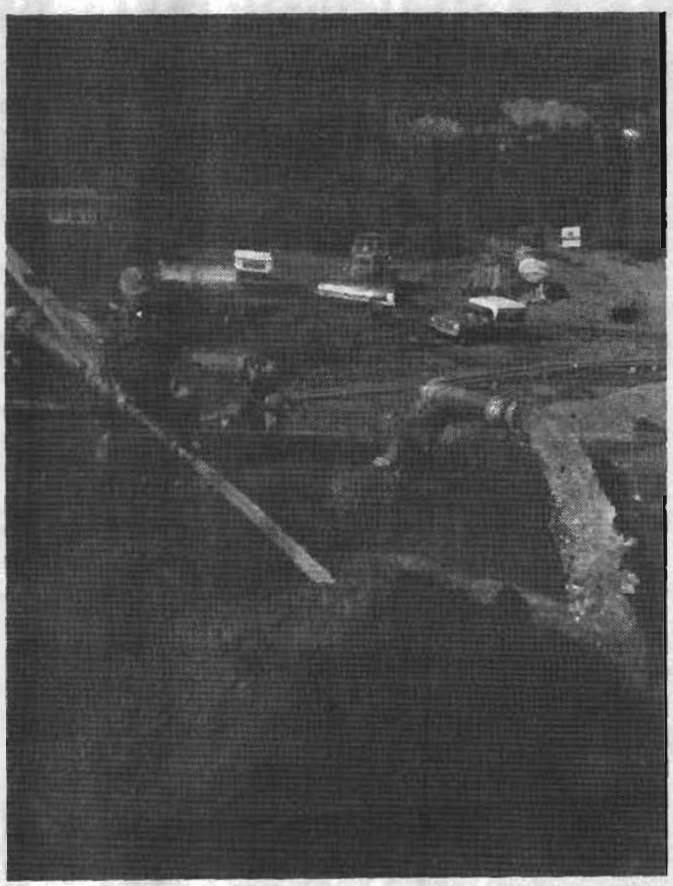
A selection of photographs illustrating various aspects of placer mining operations.

Photographic essay by Mark Robinson, Mineral Industry Research Laboratory, University of Alaska, Fairbanks, Alaska.

Tailings disposal below conventional sluice box.

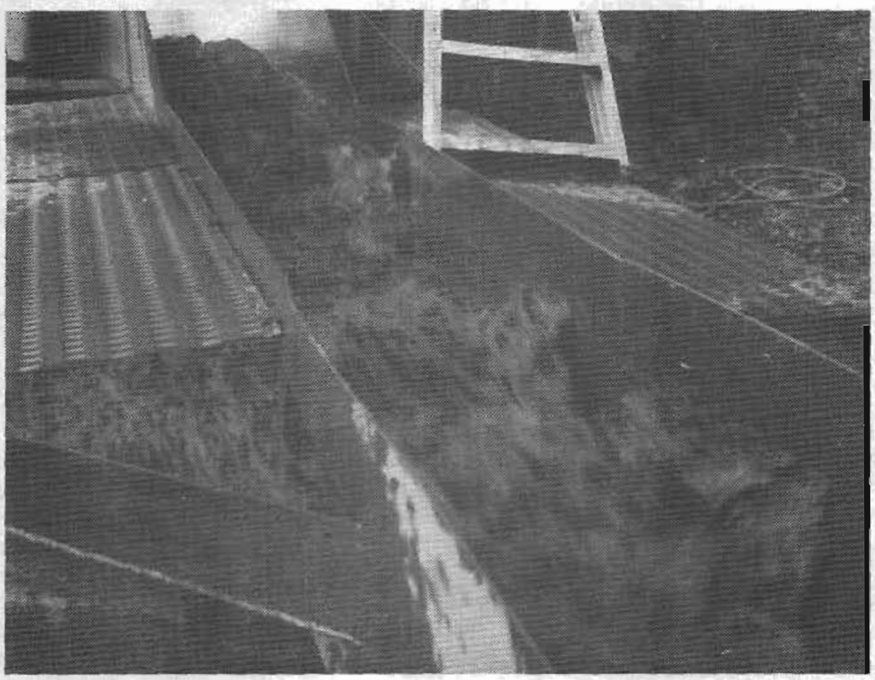
Side feed with dozer.

Frontend loader feed into conventional sluice.



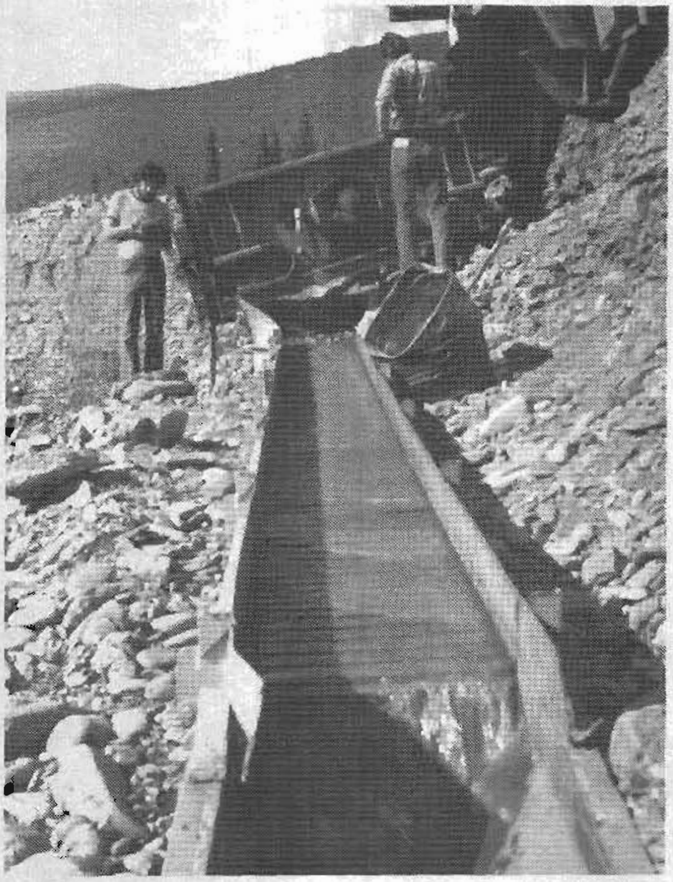
Monitoring feed into box with free water.

Tailings removal below Ross box setup.



Turbulence in main and side sluices of a Ross box.

Sloping grizzly and shaking screen.



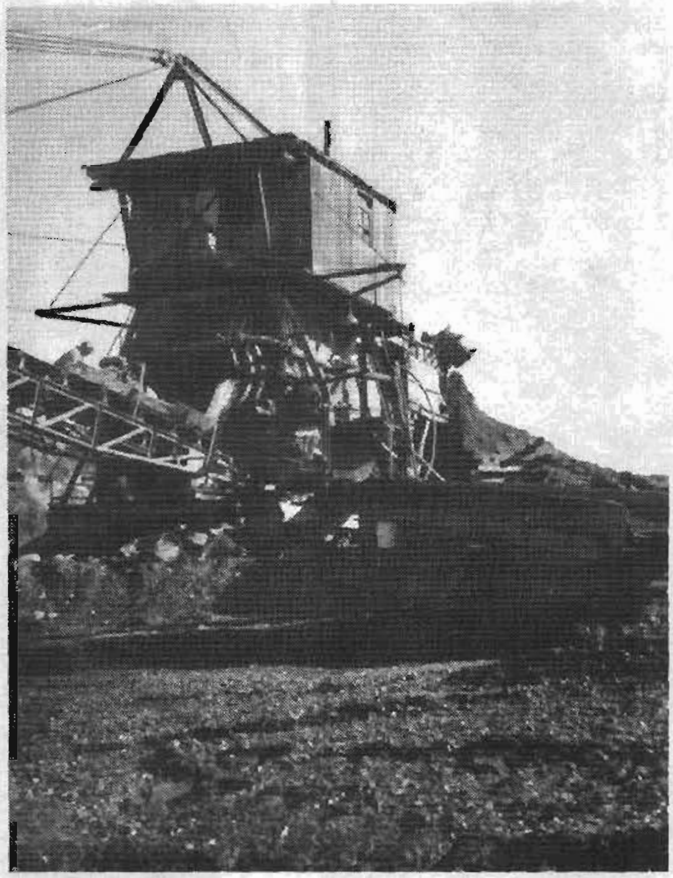
Shaking screen in combination with conventional sluice with Hungarian riffles.

Dragline setup for tailings disposal.

Side loading sluice box arrangement, with rock raker in foreground.

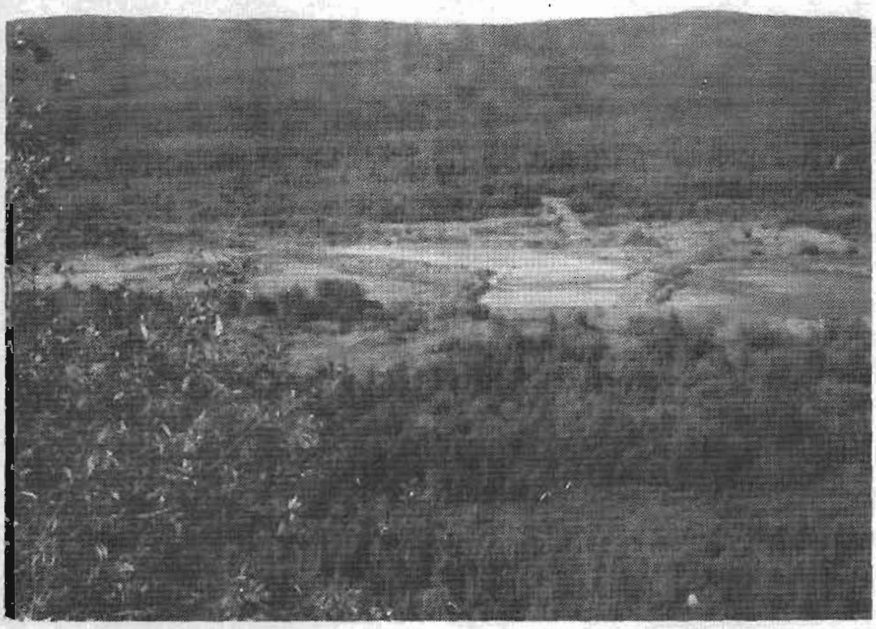
Hopper and conveyor system for elevated sluice box type of operation.

Elevated sluice box.



Dry land dredge with trommel, stacker and side sluice.

Suspended trommel screen and sluice combination.



View of a large settling pond complex (about 10 acres) below an active placer operation.

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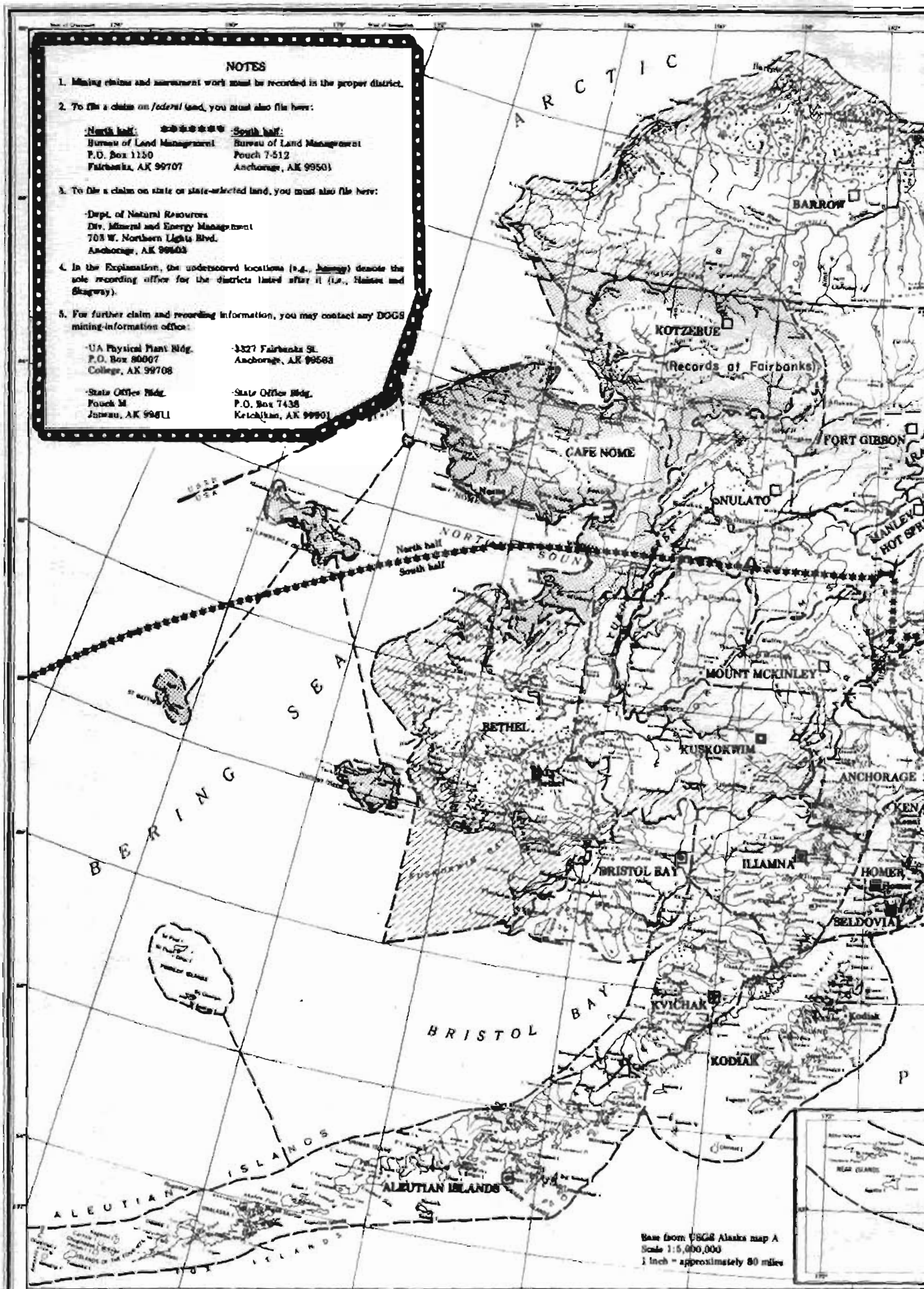

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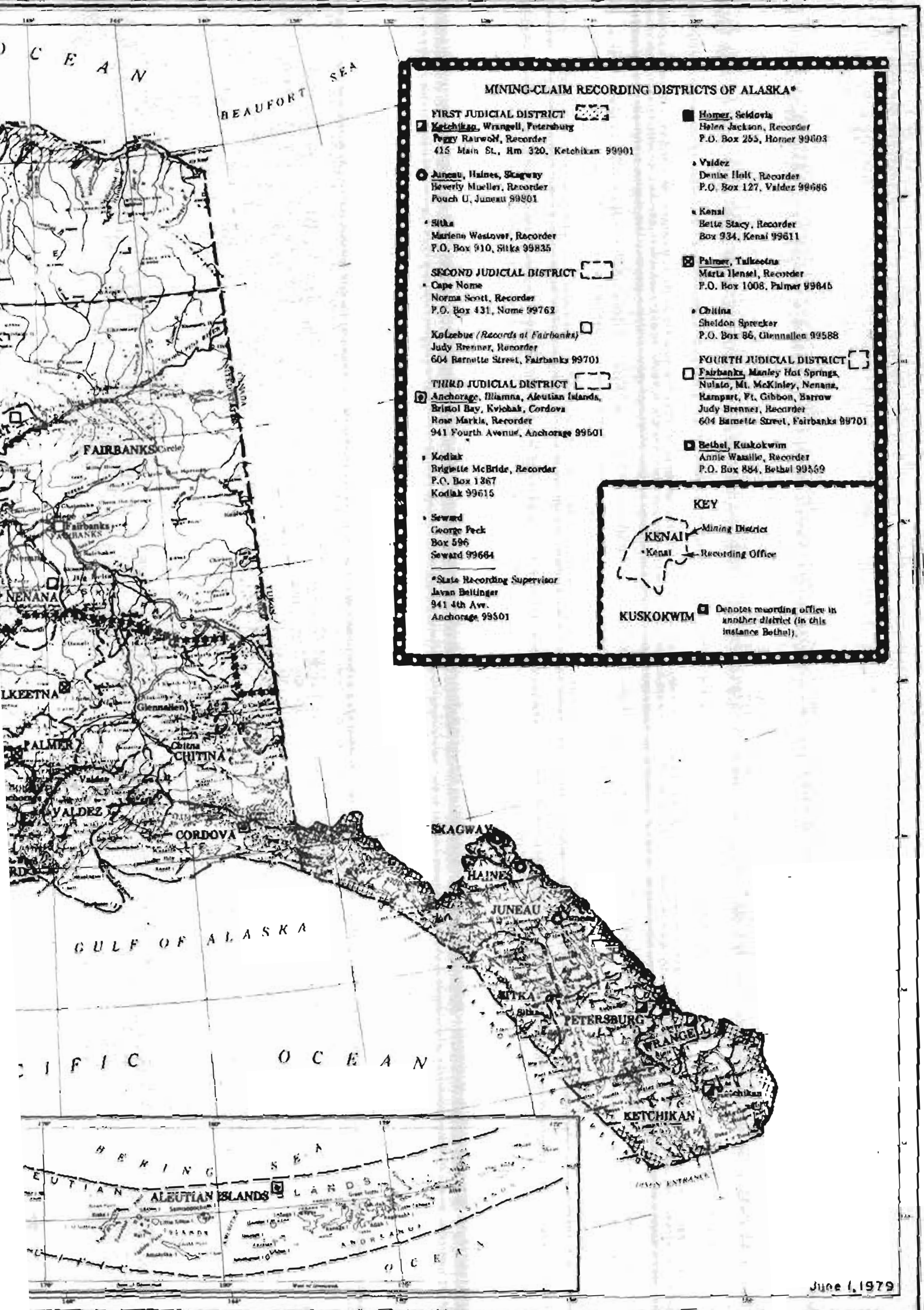

DISTRICTS OF ALASKA

Figure 1.