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Rubber Tyred Diesel Equipment in Australian Metal Mines

by

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RUBBER TYRED DIESEL EQUIPMENT IN AUSTRALIAN METAL MINES

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INTRODUCTION.

During the course of the writer's visit to the United States and Canada over the period May-July 1968 the increasing use of rubber tyred diesel equipment in underground base metal mines was one of the more significant trends that were noted. In view of the increasing use of this type of equipment in Australia, it was considered appropriate to make the review of the use of this equipment in Australia the subject of inspections and a report during the 1969 field season.

Operations in north west Tasmania, Kalgoorlie, Broken Hill, Cobar and Mt. Isa were visited. A questionnaire was used during these visits to ensure that the more important aspects were covered in discussion A copy of this is reproduced as Appendix 1.

The opportunity was taken when visiting Tasmania and Western Australia to have additional discussions with operators at Mt. Lyell and Kambalda who were about to introduce rubber tyred diesel equipment. The substance of these discussions as well as the more detailed information from established diesel operations is reflected in the text of the second part of this review.

MT. ISA - MT. ISA MINES LIMITED

(a) Background.

The use of rubber tyred diesel equipment underground at Mt. Isa has increased substantially since the introduction of the first units in mid 1964 and it is expected that in 1969/70, 35% of development and 80% of stoping production will be undertaken using this kind of equipment.

In development, rubber tyred diesel equipment may be used in any area where the footage to be mined is large enough to warrant setting up the equipment and access is available. The use of rubber tyred equipment for face operations followed by installation of permanent track a few hundred feet behind is sometimes undertaken.

Much of Mt. Isa Production comes from sub-level open stoping; where sublevels coincide with main levels on which rail tracks are installed, sublevels will usually be driven using conventional equipment. Where sublevels do not co-incide with main levels, diesel equipment, or in some cases (where ventilation is difficult) air-powered rubber tyred equipment may be used. Another factor is that where rubber tyred diesel equipment is intended to be the production equipment, e.g. from draw points, the area will usually be developed by this method also.

Where rubber tyred diesel equipment is used in sub-level stope development, leading stopes may be taken out and very early production obtained. For this reason the choice of rubber tyred diesel equipment for development, preparation and stoping may well be dictated by the relationship between development and production schedules in particular areas.

Production from Mt. Isa is expected to exceed 5 million tons of ore in 1969/70. Of this about 2 million tons will be lead ore, two thirds of which will be handled by rubber tyred diesel equipment, some from MICAF and the balance from sublevel open stopes, and pillars. More than 80% of the copper ore mined will be handled by rubber tyred diesel equipment, and most of this will come from sublevel open stopes.

The ore and rock types in which rubber tyred diesel equipment is used are described in such papers as Isokangas et al. 1968, and Davies 1967. Copper and silver lead zinc orebodies are mined and treated separately. The silver lead zinc orebodies occur as distinct concordant bands of sulphides in the Urquhart Shales. Bands grouped together sufficiently closely constitute the orebodies and these may be up to 120 feet wide. Individual orebodies persist for hundreds, even thousands of feet concordant with strike and dip of the shales. The copper orebodies consist of disseminations and vein fillings of chalcopyrite, pyrite and pyrrhotite through irregularly shaped zones of folded brecciated and recrystallised Urquhart Shale. These zones (known locally as "silica - dolomite" bodies) are transgressive to the shale bedding and confine all significant copper mineralization to the virtual exclusion of silver lead zinc mineralization. In some areas, coarse grained carbonates in the silica dolomite bodies have been leached to depths of 2000 feet, but most of the areas currently being mined are in unleached and competent ground.

Density of solid ore is accepted as 11 cu. ft. per ton in the case of lead ore; 12 cu. ft. per ton in the 650 copper orebody and 12.5 cu. ft. per ton in the 1100 copper orebody. Unmineralized material is considered to have a density of about 12.7 cu. ft. per ton. On breaking a swell of 50% is considered to take place.

(b) Equipment in Use.

Details of equipment in use are set out below:

Loaders - Wagner Scooptrams - model ST5 with Deutz A8L-714 engines, electric starters, tyres 23.5 x 25 front and 16 x 25 rear; 3 purchased 7/5/64, 5 purchased 31/7/64, 5 purchased 24/3/65, 2 purchased 23/7/65 and 3 purchased 17/2/66.

Wagner Scooptrams - model ST5A as above but with 18 x 25 front and rear tyres; 3 purchased 23/9/66.

Wagner Scooptrams - model ST5B as above; 5 purchased 18/11/68, one equipped with air operated starter.

Wagner Scooptram - model ST3 with Deutz A6L-714 diesel engine, electric starter, tyre size 16 x 25 front and rear, one purchased 27/6/68.

Wagner Mining Scoop - model MS1½ with Deutz F6L-712 diesel engines, electric starters, tyres 12 x 24 front and rear, 6 purchased 5/5/64.

Wagner Mining Scoop - model Ms1½ as above but with Deutz F6L-812 diesel engines, 2 purchased 24/11/64.

Joy TL55 Transloader, Cummins C160 diesel engine; electric starter, tyres 13 x 24 front, 16 x 25 rear; one purchased 14/10/62.

Caterpillar model 922B (1¼ cyd) with 4 cylinder Caterpillar diesel engine, electric starter, tyres 15.5 x 25 front and rear, 4 purchased 25/2/64.

Eimco model 912 (2 cyd-narrow) with Deutz F6L-812 diesel engines electric starters, tyres 12 x 24, front and rear; two purchased, 15/5/68.

Trucks - Wagner model MTPF10 with Deutz F6L-712 diesel engines, electric starters, tyres 14 x 24 front and rear, 3 purchased 4/8/64.

Wagner model MTPF 12-30 with Deutz F6L-812 diesel engines, electric starters, tyres 14 x 24 front and rear, 2 purchased 11/10/67, 3 purchased 13/10/67 and 3 purchased 20/5/68.

Jumbos - Gardner - Denver 2 boom with Deutz F4L-712 engines, electric starters, tyres 10 x 20 front and rear, 3 purchased 22/1/64, 1 purchased 1/1/66.

Gardner Denver 3 boom with Deutz F4L-712 diesel engines, electric starters, tyres 10 x 20 front and rear, 3 purchased 22/1/64

2 purchased 3/10/64 and 2 as above but with Deutz F4L-812 diesel engines purchased 24/2/69.

Utility Vehicles - Wagner model PT10 with Deutz F4L-712 diesel engines, electric starters, tyres 8.25 x 15 front and rear, 4 purchased 7/5/64, 5 purchased 15/5/64, 2 purchased 31/7/64, 2 purchased 13/11/64 as above but with Deutz F4L-812 engines.
Gardner - Denver Rockbolter with Deutz F4L-712 diesel engine; electric starter, tyres 10 x 20 front and rear - one purchased 1/6/65; also as above but fitted out as a work platform - one purchased 1/6/65.
Aveling Barford work platform (formerly grader) with Fordson Major 4 cyl. diesel engine, electric starter, tyres 7.50 x 16 front, 16.9 x 30 rear, one purchased 24/5/64.
Chamberlain Champion MKII tractor with Perkins 4/270D diesel engine, electric starter, tyres front 8.25 x 20, rear 18.4 x 28, one purchased 1/12/67.
MBU grader with Deutz F3L-912 diesel engine, electric starter, tyres 10 x 15 front, 18 x 20 rear; one purchased 1/10/68.
International tractor model 434 with International AD154 diesel engine, electric starter, tyres front 6.00 x 16, rear 13 x 24.
3 purchased 18/1/68 and 2 purchased 23/6/69.
Jeep with Deutz 3 cylinder diesel engine, electric starters, tyres 7.50 x 16 front and rear - 2 purchased 1/7/67 also 1 purchased 1/6/67 with Deutz 4 cylinder diesel.

(c) Transport of Equipment to Working Faces and Routine Servicing.

The large cage in K57 shaft makes for easy lowering of rubber tyred diesel equipment. Cage length is 22 feet 5¼ inches and width ranges from 7 feet 3½ inches to 7 feet 10½ inches. Capacity is ample in terms of weight, and disassembly for transport in the shaft is reduced to a minimum.

The larger Scooptrams must have buckets removed and in the case of models ST5 and ST5A, wheels must be changed to reduce the width sufficiently for them to fit into the cage. Model ST5B is narrow enought not to need this treatment, as are the smaller Scooptrams and Mining Scoops. The Transloader must have the bucket removed to reduce its length, but otherwise fits the cage without change.

The Wagner Mining trucks may be driven loaded into the cage and present no problems.

Jumbos must have booms removed, but otherwise fit the cage satisfactorily.

Utility vehicles are generally small enough to fit in the cage without any alteration.

Consideration is being given to connection of a number of levels in areas where rubber tyred diesel equipment is used exclusively by internal inclines.

For a description of access to MICAF stopes see Isokangas et al. 1968 pages 186 - 189.

Routine servicing carried out by machine operators is limited generally to refuelling, checking and replenishing oil levels and scrubber tanks and very occassionally changing batteries and wheels. Other servicing is carried out by the maintenance men.

Underground Rotella 10W engine oil is used in transmissions and as hydraulic oil for the Scooptrams. For engines, Rotella 20W oil is used. This reduces the variety of oils used and minimizes the adverse results of mixing the different types of oil. The one oil, 20W is used for all these applications on the surface.

(d) Operational Details.

(i) Preparation for Stoping. Where development drilling is carried out using rubber tyred jumbos, it is normal to support these with rubber tyred equipment for mucking and servicing. Rail mounted jumbos are used for much of the routine main level development which is connected to shafts, and here rail mounted mucking, hauling and servicing equipment is used.

For vertical development open inclined raises are normally used for heights less than one level interval. Beyond this the Alimak raise climber is used. The raise-boring technique has recently been introduced and will be used more extensively in future.

(ii) Drilling

Practice in the various sections is set out below.

Development On the rubber tyred 3 boom jumbo two systems are in use. In one system 13'1" integral steels with 38 mm bits are used to drill 12 foot holes; in the other 1 5/8 inch diameter holes are drilled with detachable bits, using a 10 foot feed. Holes take 6 to 8 minutes in silica-dolomites and 2 minutes in greenstone. Rockdrills used are Gardner - Denver DH123 for the centre boom to drill large holes in the cut, whilst D93 AR or DH123 machines are used on the outside. The shorter hole system with reduced cycle time is often more effective, particularly in broken ground.

Production The hole diameter of 2¾ inches used previously for some sublevel stoping is being phased out in favour of even greater use of 2¼ inch diameter holes which are thought to deviate less than the larger holes. The standard machine is the PR123 the DH123 used in more awkward spots. Another power rotation machine, the URD475, has also been used.

Hole depths range from 20 to 85 feet with an average of 63 feet. Bit life for the 2¼ inch bits averages 240 - 260 feet, with resharpening an average of every 30 feet.

Some details of long hole percussion drilling performances are given in Table I below. Footages per machine shift range from 80 - 216 feet per shift.

Air pressure is between 80 and 85 lb/in^2 on dayshift and 5 lb/in^2 higher on other shifts. Pressures have been improved recently by careful attention to reticulation.

Delays seem due to ventilation problems, loss of air pressure etc., and time available for work in the stope is 5 hrs 20 minutes per shift.

For details of drilling performance and equipment in MICAF stopes see Isokangas et al. 1968, Tables 1 and 2 on pages 195, 196. Since then, the depth of hole has been reduced from 14.4 feet to 12 feet, and the thickness of slice mined has been consequently reduced from 12 feet to 10 feet. AR93 rockdrills are replacing the original equipment of SFH123 machines. Some BBC 120F and DH123 machines are also used from time to time.

TABLE I. L.H.P.D. MACHINE PERFORMANCES

MACHINE	RODS & BIT	LOCATION	AVERAGE HOLE DEPTH	HOLE DEPTH RANGE	PENETRATION RATE (FT/MIN)	
					Upholes	Downholes
PR133	6'x1600x2¾"	R29, 1100 O/B, 14/L Cu.	Upholes = 91' Downholes = 94'	0 - 48 ft. > 48 ft.	1.22 Ft/Min. 0.81 Ft/Min.	1.23 Ft/Min. 1.00 Ft/Min.
PR133	6'x1600x2¾"	R29, 1100 O/B, 14/L Cu.	Upholes = 90'	0 - 48 ft. > 48 ft.	1.11 Ft/Min. 0.69 Ft/Min.	
PR133	4'x1600x2¾"	W74, 11/L Pb.	Downholes = 72'	0 - 48 ft. > 48 ft.		0.85 Ft/Min. 0.59 Ft/Min.
PR123	6'x1600x2¾"	R29, 1100 O/B, 13/L Cu.	Upholes = 80' Downholes = 80'	0 - 48 ft. > 48 ft.	0.90 Ft/Min. 0.66 Ft/Min.	1.35 Ft/Min. 0.57 Ft/Min.
PR123	6' & 4'x1600 x2¾"	R29, 1100 O/B, 14/L Cu.	Upholes = 80' Downholes = 80'	0 - 48 ft. > 48 ft.	0.74 Ft/Min. 0.73 Ft/Min.	0.84 Ft/Min. 0.42 Ft/Min.
PR123	4'x1600x2¾"	R29, 1100 O/B, 14/L Cu.	Upholes = 72' Downholes = 72'	0 - 48 ft. > 48 ft.	0.56 Ft/Min.	0.63 Ft/Min. 0.39 Ft/Min.
PR123	6'x1400x2¼"	Aw74, 14/L Cu.	Upholes = 78' Downholes = 78'	0 - 48 ft. > 48 ft.	1.30 Ft/Min. 0.96 Ft/Min.	1.05 Ft/Min. 0.86 Ft/Min.
PR123	4'x1400x2¼"	S32 15D Sub Cu.	Upholes = 80' Downholes = 80'	0 - 48 ft. > 48 ft.	0.68 Ft/Min. 0.76 Ft/Min.	0.53 Ft/Min.
DR123	4'x1400x2¼"	Bw82-83 11 and 12/L Y66-67, 13/L Cu.	Upholes = 54'	0 - 48 ft. > 48 ft.	0.71 Ft/Min. 0.51 Ft/Min.	
DH123	4'1400x2¼"	Q27, 1100 O/B, 14/L Cu.	Upholes = 71'	0 - 48 ft. > 48 ft.	0.73 Ft/Min. 0.61 Ft/Min.	
DH123	4'x1400x2¼"	Y73 Pillar, 9/L Pb.	Upholes = 44'	0 - 48 ft. > 48 ft.	0.98 Ft/Min. 0.68 Ft/Min.	
DH123	4'1400x2¼"	Aw74, 13/L Cu.	Downholes = 122'	0 - 48 ft. > 48 ft.		1.09 Ft/Min. 0.58 Ft/Min.
DH123	4'1400x2¼"	Aw69-72, 650 O/B, 13/L Cu.	Downholes = 78'	0 - 48 ft. > 48 ft.		0.78 Ft/Min. 0.49 Ft/Min.

MACHINE	RODS & BIT	LOCATION	AVERAGE HOLE DEPTH	HOLE DEPTH RANGE	PENETRATION RATE (FT/MIN)	
					Upholes	Downholes
DH123	4'x1600x2¾"	W74, 5 O/B, 12/L Pb.	Upholes = 80' Downholes = 46'	0 - 48 ft. > 48 ft.	0.47 Ft/Min. 0.26 Ft/Min.	0.59 Ft/Min. 0.32 Ft/Min.
DH123	4'x1600x2¾"	S32, 1100 O/B, 14/L Cu.	Downholes = 77'	0 - 48 ft. > 48 ft.		0.62 Ft/Min. 0.33 Ft/Min.
DH123	4'x1600x2¾"	R29, 1100 O/B, 14/L Cu.	Downholes = 77'	0 - 48 ft. > 48 ft.		0.52 Ft/Min. 0.33 Ft/Min.
BBC-120F	4'x1400x2¼"	276-78, 650 O/B, 10/L Cu.	Upholes = 45'	0 - 48 ft. > 48 ft.	0.95 Ft/Min. 0.72 Ft/Min.	
BBC-120F	4'x1400x2¼"	Bw77, 650 O/B, 15/L Cu.	" 64'	0 - 48 ft. > 48 ft.	0.72 Ft/Min. 0.62 Ft/Min.	
BBC-120F	4'x1400x2¼"	U31-32, 400 O/B, 11/L Cu.	" 65'	0 - 48 ft. > 48 ft.	1.35 Ft/Min. 0.81 Ft/Min.	
BBC-120F	4'x1400x2¼"	Bw77, 650 O/B, 15/L Cu.	" 65'	0 - 48 ft. > 48 ft.	0.82 Ft/Min. 0.59 Ft/Min.	
BBC-120F	4'x1400x2¼"	T24-26, 400 O/B, 13/L Cu.	" 64'	0 - 48 ft. > 48 ft.	0.79 Ft/Min. 0.61 Ft/Min.	
BBC-120F	4'x1400x2¼"	P24, 16D Sub, 15/L Cu.	" 64'	0 - 48 ft. > 48 ft.	0.86 Ft/Min. 0.70 Ft/Min.	
BBC-120F	4'x1400x2¼"	U21-23, 400 O/B, 13/L Cu.	" 82'	0 - 48 ft. > 48 ft.	0.84 Ft/Min. 0.68 Ft/Min.	
BBC-120F	4'x1400x2¼"	W68, 5 O/B, 13/L Pb.	" 65'	0 - 48 ft. > 48 ft.	0.95 Ft/Min. 0.64 Ft/Min.	
URD 475	6'x1600x2¾"	R29, 1100 O/B, 13/L Cu.	Combined 80'	0 - 48 ft. > 48 ft.	1.14 Ft/Min. 0.74 Ft/Min.	1.38 Ft/Min. 0.67 Ft/Min.

(iii) Blasting Development follows normal blasting practice. In sublevel open stoping the burden on rings is usually 8 feet, but in undercuts this may be reduced by half rings between the major rings, for scram stopes. Fans at 7ft. burden inclined 70° forward may be used in the case of leading stope undercuts. Some details are set out below:-

Typical Cu Stope

1 full ring in BW77 Stope, 15 Level, 650 Orebody (excludes 15 B sub undercut)

Ring burden	= 8'0"
Total tons	= 13,400 tons
Total ft. drilled	= 5,557'
Total ft. charged	= 4,050'

Drilling factor	= 2.4 tons/ft drilled
Charging factor	= 0.45 lbs/ton
Column factor	= 1.5 lbs/ft (yet to be proved)
i.e. Total lbs. explosive	= 6,100 lbs

Stope height about 300 ft.

Typical Pb Stope

1 full ring in W75 Stope, 13 Level, 5 Orebody (excludes undercuts)

Ring burden	= 8'0"
Total tons	= 19,700 tons
Total ft. drilled	= 7,080'
Total ft. charged	= 5,300'
Total lbs. explosives	= 8,100 lbs

Drilling factor	= 2.8 tons/ft drilled
Charging factor	= 0.41 lb/ton
Column factor	= 1.5 lbs/ft (yet to be proved)

Stope height about 360 ft.

Explosive used is ANFO except in downholes likely to contain water. Priming is usually with AN60, using millisecond delays.

Scram Stope Undercuts (vertical rings)

Main ring fans at 8ft. with half rings half way between, fired together. e.g. W75, 5 Orebody, 13 Level - Undercut ring + ½ ring.

Ft. drilled	= 2,090	(Burden 2 x 4ft = 8ft)
Ft. charged	= 1,520	
Total tons	= 2,630	
Total explosive	= 2,280 lbs ANFO	

Drilling factor	= 1.3 tons/fe drilled
Charging factor	= 0.87 lbs/ton
Column factor	= 1.5 lbs/ft

<u>Leading Stope Undercuts for Drawpoints</u> (leaning 70° forward)

Fans at 7' burden

e.g. BW77 stope

Ft. drilled	= 1,180
Ft. charged	= 885
Total tons	= 2,630
Total explosives	= 1,330 lbs ANFO

Drilling factor	= 2.2 tons/ft drilled
Charging factor	= 0.51 lbs/ton
Column factor	= 1.5 lbs/ft

Toe spacing of 8 feet in rings is increased to 12 feet where fans of holes from adjacent sublevels interlock. Loading rates can be as high as 2,500 feet/shift for two men and 2¼ inch holes, and 1750 feet in the case of 2¾ inch holes.

As a result of recent fragmentation studies, the general design of ring burdens, toe spacing and other criteria are under review. For instance in some cases ring interlock has been avoided, ring burden reduced to 6 or 7 feet and toe spacing reduced to 8 feet. Multiple firing of rings is being practised in some stopes.

Pressure type pneumatic loaders are used at pressures between 35 and 70 lb/sq in. to charge ANFO through a 1 inch bore loading hose. AN60 gelignite cartridges, 1¾ inch diameter, 3 1/8 lb weight are used to collar-prime holes, with a booster cartridge placed halfway along the column in holes longer than 50 feet. In some cases Anodets are used for centre or toe priming. Millisecond delay detonators fired in parallel from 440 volt mains are used for inutiation.

Blasting practice in MICAF is described on page 196 of Isokangas et al 1968. Firings of about 800 tons are broken with an explosives factor of 0.8 lb/ton. Modifications to the drilling pattern described by Isokangas et al have already been noted above. Burden and spacing remain 5 ft and 4 ft respectively. Anodets are used throughout. Charging rates are about 500 ft per manshift.

Limiting factors for size of boulder are the Scooptram buckets and the 6 ft and 8 ft wide chute fronts on the haulage levels in the case of MICAF stoping. Secondary breaking appeared to be carried out by plaster shots. Rockdrills for popping were available, but popping generally is not acceptable because of the difficulty of inspecting all sides of boulders to ensure they do not contain explosives.

(iv) <u>Loading and Hauling</u>

Some statistics of loading and hauling are reported for MICAF stoping by Isokangas et al 1968 on pages 197 and 198, and are set out below:-

Mucking rate including delays	503 tons/shift.
" " excluding delays	750 tons/shift.
Lead distance (one way)	Average 170 feet maximum 400 feet, new designs aim at 200 feet maximum.
Working time available	Average 5 hours 20 minutes.

The orebodies are such that selective mining is not practised. However, where mullock has to be removed for access it is left in the stope as fill.

A graph showing performance of a number of loaders over various haul distances, particularly in development, was provided by the company and is reproduced as Fig. 1. This graph does not apply specifically to MICAF.

The use of loaders in circumstances other than MICAF is not as well documented. However in development, permanent rail track is usually kept close enough to the face to limit Scooptrams leads to 500 feet.

Smaller loaders are used in pillar mining operations. Sublevel caving of pillars between sublevel open stopes makes use of Wagner Mining Scoops Model MS 1½ on sublevels where 2 crosscuts are used, while Atlas T4G compressed air machines are used where there is only one crosscut. Some crown pillars are removed by a series of narrow transverse open stopes, most of the ore being extracted by diesel loaders working on a concrete floor laid on top of the old filled stopes below. Because the loader works in the safety of a retreating drawpoint there is a certain amount of broken ore left in the stope. This is removed by a slusher with ropes strung from hanging to footwall. These stopes are later filled with cemented fill.

In development of sublevel open stopes Scooptrams may be used to commence production from a leading stope before the development of the stope as a whole is completed. When a sublevel has been driven and the slot taken out, fans of up holes are drilled and fired to the slot, as much of the broken ore as possible being recovered by Scooptram before the next fan is fired on the retreat. A scavenger drive, slightly below and to one side of the sublevel (leading stope) drive may be used in a similar way to recover most of the remainder of the broken ore.

The method is only effective where an orepass is available within a reasonable distance of the stope. It is reminiscent of that first seen by the writer at Cleveland Tin N.L. in Tasmania.

In some instances, sublevel open stopes are being brought into production where draw point loading and Scooptrams are used as an alternative to one of the conventional slusher loading systems previously employed exclusively for this purpose.

Development of drawpoint design is continuing, but some of the salient features are the use of long resin-grouted rockbolts to preserve drawpoint brows; the practice of driving drawpoints at a grade of about 1in 30 up for drainage purposes, and the use of 63 lb/yd rails at 20 inch centres in conjunction with concrete or graded mullock to provide suitable floors at the actual loading points. Designs with overcast and undercast connections to return airways have been developed to suit the location of the latter relative to the sill haulage drive.

Under very adverse conditions such as shaley development headings, tyre life can be less than 100 hours. However, average lift of new and relugged tyres in MICAF ranged from 234 - 437 hours over 12 month period. (Isokangas et al 1968 p. 198). Data for other applications was not collected.

(v) Preparation of Stopes and Filling.

Mine filling consists of roughly equal proportions of deslimed mill tailings, piped underground through 4 inch Victaulic lines and dry fill composed of granulated slag and opencut overburden from the surface, together with mullock from underground development.

Filling in MICAF is predominantly mill tailings. Provision is made to remove water by decantation and percolation, and on the haulage level, the area around the chutes is concreted to provide for easy cleanup; sumps are provided at the downgrade ends of crosscuts to collect drainage water. For further details see Isokangas et al 1968 pages 194 and 197-199.

Scooptrams are used to build fill barricades and ramps in the cut and fill stopes.

Fill preparation in a typical MICAF stope takes up to 15 shifts. Filling rates average 1800 cu.yd. per 24 hours and may be as high as 105 cu.yd/hr. Blocks of fill up to 12,500 cu.yd. may be placed at one time. A two man crew is normally employed on such a block, and filling extends through weekends whenever possible.

Cement is not normally added to fill, but is used in crown pillar recovery operations and in MICAF sills to assist in later pillar recovery.

(vi) Labour Efficiences and Requirements.

In preparing estimates of period production, the following productivities of loaders are used, assuming a 3 shift day is worked:

ST5	- 20,000	tons/4	weekly	period
ST3	- 15,000	"	"	"
MS1½	- 10,000	"	"	"

In drilling, 2-boom jumbos should produce at least 360 feet per shift.

Development using a 3-boom jumbo and Scooptram loading into 250 cu.ft. Granby trucks may produce up to 25 feet per day of 14½ ft x 12 ft heading using a four man three shift crew.

Other performance figures have been mentioned above but for comparison with rubber tyred diesel operations it is interesting to note that the average output from a 125 hp slusher for loading ore from sublevel stopes is 300 tons/shift.

Figures on maintenance from the discussion on Isokangas' paper may also be usefully included here:

In-stope maintenance amounted to 3½ hours per machine operating hour: to this must be added a further 1 hour per machine operating hour for work carried out in the shop. Material costs over an 18 month period indicated a ratio of 0.8 maintenance man hours per dollar of material used. Productivity of the MICAF stopes may be up to 8,000 tons/week per stope, but this cannot be maintained indefinitely due to cycle difficulties.

(vii) Securing Ground.

In the MICAF stopes rockbolts and mesh are used to secure stope backs and hangingwall; see Isokangas et al 1968 p 197.

Platforms on PT10 utility vehicles can be raised to 14 feet above floor level for scaling but this feature is not now used in MICAF. Scaling is usually performed from the fired ore or fill. A Chamberlain tractor has also been equipped with a scaling platform as a trial.

Rockbolts after firing are either buried in the fill or recovered on the crusher magnets.

Elsewhere throughout the mine rockbolting and meshing are used widely for ground support as required. Guniting and more recently Shotcreting in some places, is often used for permanent installations.

(viii) Roads.

The practice of spreading some ore on the fill in MICAF stopes to provide a road has already been mentioned above. The use of rails set in concrete and drawpoints and concreting under chutes has also been discussed. Some access inclines are being concreted to improve roadway conditions in new MICAF areas. Increasing quantities of raise borer cuttings are becoming available and provide excellent material for dressing roadway surfaces.

The first grader purchased was found to be of somewhat limited value, and recently a new machine, developed specially for use in underground potash mining operations in Germany, has been placed in service. This machine is proving more versatile, but unfortunately its track width is not compatible with railway track gauges underground, and it is at present restricted to one area.

Scooptrams are normally used for road maintenance purposes in areas where a grader is not available. The better results obtained from the new grader suggest that increased use of graders will be made, particularly in areas where a number of levels are connected by an incline and the length of roadway is considerable.

(ix) Dilution.

In MICAF dilution is considered to be held at a level below 10% by supervision and operator skill. Firing inclined rather than horizontal holes is thought to reduce the mixing of ore with the top layer of fill and so contributes to reduced dilution. Rockbolting and meshing of the hanging wall may also be required to maintain safe working conditions and this will help to reduce dilution. In stoping methods other than MICAF the use of rubber tyred diesel equipment is unlikely to have any effect on dilution.

(x) Other uses of machines.

The use of loaders to build fill barricades in MICAF stopes has been noted above. Isokangas et al 1968, report on page 197 that only 65% of loader hours were spent on mucking, the rest being used in charging up, grading fill and general materials handling in the stope, as well as dam building. In many materials handling applications loader buckets can be emptied by tipping, thus avoiding hand unloading. This leads to use of loaders for these purposes at the expense of production even though utility vehicles are available.

In other applications such as drawpoint loading where access for other vehicles is readily available, the proportion of working time spent by loaders on other work falls to about 14%. Two of the main tasks undertaken are removing oversize boulders for secondary breaking and materials handling. Grading of roads is normally only carried out when loading must stop for other reasons. Truck shunting may take-up some time where 250 cu.ft. Granby trucks are being loaded directly on a level.

As a utility vehicle the PT10 has some advantage over loaders where the crane can be used to spot major components during maintenance. The articulated feature is useful in narrow stopes where loaders are immobilized by breakdown.

(xi) Ventilation.

The overall system is a combined pressure-exhaust one, with downcast shafts and fans located in the footwall and exhaust shafts and fans in the hangingwall. This permits flexible arrangements in the working area to cope with heat, gas and dust control problems in the dispersed areas in which a variety of mining methods are employed.

In controlling airflow, capacities of surface fans may be changed and booster fans installed underground in high resistance circuits. A range of fans and ducting are used extensively for auxiliary ventilation of drive faces and other dead ends of various kinds.

Ventilation in the MICAF stoping areas is based on downcasting fresh air through the 10 feet x 12 feet service raise in the centre of the stope and upcasting through return air raises, 8 feet x 8 feet at either end. Auxiliary ventilation is required where for geological reasons the ends of stopes are extended beyond the return air raises. More recent layouts have 10 ft. x 8 ft. service raises and 6 ft. diameter bored raises for ventilation.

Drawpoints are up to 70 to 80 feet long and connections to return airways about 25 feet from the end provide adequate air flows for diesel equipment and dust control.

The minimum quantities of air required by Regulation 146 of the Queensland Mines Regulation Act for the operation of diesel engines are 50 c.f.m. per brake horsepower or 5000 c.f.m. whichever is the greater. It is stated company policy to aim at twice this figure. A table has been drawn up to show the flows required for various engines and machines, and the requirement of auxiliary ventilation to establish this flow in dead ends - see Appendix 2. Ventilation staff are authorized to stop jobs where these requirements are not met. Written instructions and reports are issued to cover these incidents. Copies of these forms, together with those used to record diesel gas analyses are included in Appendix 3.

As regards air quality, Regulation 146 of the Mines Regulation Act requires less than 1500 ppm of CO in diesel exhaust. In practice it has been found unusual for Deutz diesels to have more than 400 ppm CO; other engines commonly have exhaust gas analyses in the range 300-400 ppm CO. The Regulations also require that the air in which a person is required to enter or remain shall contain not less than 19% of oxygen by volume and not more than 5000 ppm of carbon dioxide, 50 ppm of CO, 5 ppm oxides of nitrogen and 20 ppm of hydrogen sulphide.

Testing of air in places where diesels are used must be carried out every four weeks under Regulation 147. All gas testing is carried out by Draeger tube instruments. The mine's Industrial Hygiene section carries out the testing every third month - the ventilation staff do testing in the other two months. Air flow measurements are carried out at the same time as the quality tests.

Regulation 6 of the Act lays down requirements for temperature and humidity of mine air, and in some cases the exhaust and heat from diesels may be sufficient, when added to air which is already hot and humid, to produce an atmosphere which either contravenes the provisions of the legislation or at least requires a reduction in working hours.

Consideration is being given to the introduction of catalytic exhaust scrubbers, both because of the adverse effect of water scrubbers on humidity as mentioned in the preceeding paragraph and because of the elimination of difficulties experienced when proper maintenance of water scrubbers is neglected. Catalytic scrubbers are much more expensive, but may require servicing as infrequently as 2000 hours.

(xii) Pillar Mining.

Some pillar mining applications of rubber tyred diesel equipment have been described above. Probably the main difficulties in using diesel equipment in pillars will rest with ventilation problems. It may be that though the flexibility of rubber tyred equipment has important advantages in pillar mining, it will be increasingly necessary to use compressed air powered machines in the more difficult situations.

In MICAF stoping fill placed on sills in new areas is now having cement added to simplify crown pillar mining later. Generally speaking however there are no special preparations made in the initial stoping for the use of rubber tyred diesel equipment in pillar mining later.

(xiii) Working Time.

The mine works a nominal three shifts/day 5 day week. However, at the time of my visit, provision was being made to work one overtime shift per week on lead ore production and three overtime shifts per week on copper production.

(xiv) Tramming speeds.

The following average speeds, which include some manoeuvring at dumping points, have been observed during studies by the company:

ST5 in MICAF	5.6 mph.
ST3	6.1 mph.
MS1½	4.7 mph.

(xv) Chutes and passes.

Normal rock passes are equipped with stop logs, curtains and flashing lights at tipping points, and are fitted with standard 6 ft wide chute fronts for loading 2 foot gauge trains and 6 ft or 8 ft wide chutes for loading 3 ft 6 in. gauge trains.

Experience with circular steel plate chutes in MICAF is described by Isokangas et al 1968 pages 202 and 203. The use of crosscut access to passes in the stope footwall is being extended in lieu of steel passes in the stope or slot passes on the wall.

Drawpoints for sub level open stopes have been mentioned above. Some designs developed in the course of introduction of rubber-tyred diesel equipment are reproduced in Figures 2 and 3. Re-inforced concrete floors have not been found satisfactory, and experience to date appears to suggest that if rails bedded in fine ore rather than concrete are to be used successfully they will not be compatible with loaders having toothed buckets.

(e) Availability and Utilization

Isokangas et al., 1968, dealt with the concepts of availability and utilization in some detail in their paper and further details came out in the discussion on it. Refer to pages 200-201 and 204 - 207 of the reference.

The practice adopted was to use scheduled time as a basis for expressing availability. In most cases this was 6 hours per shift, 3 shifts per day and 5 days per week - a total of 90 hours per week. Availability was working plus idle time (as reported by operators) expressed as a percentage of scheduled time. Utilization is working time expressed as a percentage of working plus idle time i.e. % of available time. Downtime (the difference between scheduled time and working plus idle time) in this situation does not include time spent on repair work done during overtime or in surface workshops. On this basis availability was 75% and utilization 54% for ST5 loaders in MICAF stopes over the period July 1966 to February 1967. It should be noted too that in MICAF stopes the Scooptrams are used extensively for purposes other than mucking. Refer to Section D, subsection (j) above for a more detailed discussion of this point. The effect of extensive use for other purposes on apparent productivity of Scooptrams in cut and fill stopes has been noted also in respect of the Cobar operation.

The basis of availability has been changed since the writer's visit. The new basis is 24 hours per day, 7 days per week i.e. 168 hours per week.

(f) Operator Training

The training section of Mt. Isa Mines includes three diesel instructors, and they carry out training of drivers of diesel equipment underground. Such training is carried out at the request of the mine foreman in charge of a particular area and using production equipment made available by him. Trainees with some surface plant operating experience are preferred.

Equipment Inspectors (part of the Mine Control organization described later) test the trainees who are then issued with certificates which specify the particular machines which they are competent to drive. There is no formal requirement in Regulations under the Mines Regulation Act for driver training, but provision is made to make driving without a permit a breach of the Regulations where such permits are issued by the Company.

(g) Maintenance

Isokangas et al. 1968 discuss maintenance arrangements and modifications to loaders and other equipment used in MICAF stopes on pages 199 - 202 of the reference.

The information in the following paragraphs was obtained from discussions with Mt. Isa maintenance staff and internal reports.

Major overhauls are undertaken on machines used in MICAF stopes by removing them to the surface when they reach intermediate levels (e.g. 10 level in the 11 to 9 level block). They are replaced by machines on which overhauls have been completed. Engine hour meters are used for historical records of motor operating hours, for Equipment Inspectors' tyre records, etc.

Weekly servicing and checks are supplemented by breakdown replacement of major components. The 100 and 200 hour checks have been abandoned in recent months.

Machines which can be driven in and out of the K57 shaft cage are often brought to the surface Mobile Equipment Workshop for servicing. In connection with major engine overhauls it is noteworthy that in spite of a larger number and greater range of diesel engines in the mine than at Cobar, the workshop was equipped with neither dynamometer nor fuel pump tester. Contract service for the latter was available in town, however, and a dynamometer has since been purchased.

The component make up of the Deutz A8L-714 engine allows replacement of cylinders, pistons and heads without removing the engine from the Scooptram. A high proportion of failures are due to dust ingress through damaged or faulty air cleaners. Cases of failures requiring engine replacement include the following more unusual occurrences:

(a) Sumps holed by running over large rocks or loading with rear wheels in deep ruts. Low oil pressure cut outs have been fitted to some units but this is basically an operator training problem.

(b) Broken crankshafts, one case thought to be due to a frozen crankshaft damper. Checks during maintenance and replacement of dampers have both been carried out to prevent possible recurrences.

(c) Low oil pressure is normally a result of fair wear and tear, but some cases are thought to have been caused by engines being starved for oil, and one was due to the ingress of hydraulic fill to the engine oil.

(d) Crankshaft seizure associated with holed sumps, running on low oil level, incorrect lubricant in engine and engine oil contamination.

(e) Engine knocks due to worn big ends may be caused by any of the above, or by faulty reconditioning of a previously worn crankshaft.

Re-location of oil bath air cleaners has been carried out on all units. The rear position proved vulnerable to damage by collision with walls and an alternative position amidships on either side of the engine was adopted. Other types of cleaner are being tried - the latest is the Donaldson dry air cleaner, which can be mounted in a very protected position.

Deutz pre-cleaners are being replaced by Caterpillar units which eliminate an elbow attachment.

Flexible exhaust connections from engines to scrubber tanks have been improved by the addition of extension angled elbows to scrubber tank inlets, thus reducing the amount of bend in the flexible part of the connection.

Driveline failures can be reduced by close attention to checking and re-tightening of bolts from driveline to spider and bearing assembly,

Newer units have been supplied with driveline protection (air operated directional control valves) and this had reduced damage to drivelines caused by the practice of full ahead - full astern operation by some drivers. Older machines do not have this protection.

Loading from difficult muckpiles in the jacknifed position places a heavy strain on universals at the joint where the two halves of the vehicle are articulated.

In the hydraulic system, cast iron pistons and clips in early models gave trouble by breaking under strain, destroying packings and scoring cylinder walls. Additional line filters and mild steel replacement parts were fitted and later became standard.

Damage to stabilizer cylinder external locknuts can be caused if bucket stops are not properly re-adjusted when buckets are changed.

Hoses within view of the operator present a danger in that a burst hose may spray hot oil over him. Covers have been placed over some exposed hoses; the greater use of steel tubes on the ST5A model has reduced the hazard considerably and the end of the stabilizer hose running down the boom has been secured by a loose, slip-on hose and chain.

In the electrical system a high rate of failure has been experienced in starter motors, alternators, batteries and series-parallel starting relays. Various circuit changes have been tried to reduce the failure rate.

An air starter has been on trial for some time and is understood to be proving satisfactory. Recent advice is that all ST5B and 3 and 4 boom jumbo machines will be converted and that new machines will be supplied with air starters. Some conversion to 24 volt charging has been made for trial purposes, and heavier duty batteries in steel carrying cases are also being tried out. Damage during transport is considered a significant factor in the high battery failure rate, along with abuse of terminals during changing by operators, prolonged use of starter motors and charging faults.

Axle failures have been reduced by design changes, but some of the faults are the result of operating conditions.

Axle housing flanges (to which the hub and brake drum assembly is bolted) have been thickened or strengthened by gussets between bolt holes. In addition all units have been locked into first and second gear only and the consequences of operating carelessly over undulating road surfaces are now better appreciated by operators and their supervisors.

Differential carrier assemblies have been modified by the manufacturers and the rate of failure decreased. Leaks through planetary covers have been decreased by increasing the number of bolts holding the covers on. This too is a manufacturers modification.

Travelling through drainage water, particularly that containing copper in solution, has resulted in the "freezing" of brake shoes on anchor pins and of brake cam rollers.

Loose wheel nuts are the greatest contribution to hub failure; if not re-tightened after a half hour of operation following a wheel change the loose nuts will result in damage to studs and finally to the hub itself. Over tightening of nuts in an attempt to avoid loosening can lead to stripped stud threads.

Lower swivel bearings have been the subject of considerable experiment. Case hardened steel bushes do result in wear on swivel pins; but at least the sudden collapse associated with the usual roller bearing in this position is avoided.

Shovel booms on earlier models proved insufficiently robust, and manufacturers subsequently supplied heavier booms with larger diameter stabilizer and bucket pins as a result of Mt. Isa experience. However some cracking still occurs, particularly in severe conditions, and strengthening and patching is carried out underground to keep units in service as long as possible.

Bucket lips and teeth have been under constant review. The original lip of two one inch plates welded together was superceded by a one piece lip two inches thick which was hard faced on top and bottom leading edges.

Current recommendations for the various duties are as follows:

ST5 in development - straight lip without teeth made from 2 inch mild steel, hardfaced on leading edges top and bottom.

in MICAF with up holes - straight ESCO cast lip with ESCO 45 series teeth adaptors incorporated, 7 teeth fitted.

in MICAF with horizontal holes - pointed ESCO cast lip with ESCO 45 series tooth adaptors and corners incorporated, 6 teeth fitted; or ESCO bucket with integral cast tooth adaptors and corners and shrouds. 6 ESCO series 45 teeth fitted.

in drawpoint loading - straight ESCO cast lip with ESCO 45 series tooth adaptors cast in. 7 teeth fitted.

ST5A in development - pointed lip - 2 inch mild steel hardfaced on leading edge top and bottom; no teeth.

in drawpoint loading - straight lip - 2 inch mild steel hardfaced on leading edge top and bottom; ESCO 45 series weld-on tooth adaptors, 6 ESCO 45 series teeth fitted.

Difficulties have been experienced with Scooptram buckets where pivots are set in the end of the bucket (as on the ST5A). These are sealed in grease and fitted with a grease nipple to ensure that pins remain free.

It has been found necessary to fit spill guards on buckets in line with front wheels to prevent operators being hit by flying rocks. Unfortunately the guards lend themselves to the dangerous practice of scaling the back with the bucket, which also damages the guards.

Wear patterns of buckets differ with the various applications, but a general tapering of the lip from the underside is apparent. The addition of wearing strips and hard facing by semi-automatic means has increased bucket life.

In practice it has been found that the use of the Wagner standard lip of 1 inch thick TI steel plates leads to failure due to plate separation caused by ingress of fines when the weld wears away from the leading edge.

Some of the Gardner-Denver jumbos used in MICAF have had the diesel engined carriers replaced by carriers with compressed air motors. Maintenance problems largely caused by abuse of clutches when machines were bogged in improperly drained fill have been eliminated by this change.

Maintenance crews initially had to learn by experience on the first machines delivered. Now that a body of knowledge has been build up it is possible to give more formal on the job training and also provide courses on the surface in trouble shooting etc. Most of the crews are recruited from men with a diesel fitter's background. They move into underground maintenance jobs from the Mobile Equipment Shop on the surface.

An incentive scheme operates based on the total tonnage handled by Scooptrams during the cost period. This tonnage is determined by including any double handling that may be required.

A total maintenance crew of about 90 men services all underground mechanical equipment including fixed as well as rubber tyred or rail mounted equipment. The Section Foreman has a total of 5 supervisors of whom 3 are on day shift, and one each on night and afternoon shift.

On day shift one supervisor and crew based on 13 level look after 13 level and above; one supervisor and crew stay on 15 level and look after that level only; the third supervisor and crew based on 17 level look after 14 level and all below 15 level.

On night and afternoon shifts, skeleton crews only are used. Working leading hands are in charge of the maintenance bases on 13 and 15 levels. The 15 level crew usually stays there while through the mine control system described below, the 13 level crew is directed to emergencies in the rest of the mine.

The whole crew is made up of about 42 diesel fitters, 9 boilermakers, 3 riggers, 10 greasers and 28 tradesman's assistants. Apprentices spend some time with the underground mechanical maintenance crew during the course of their training.

A new structure for underground diesel maintenance is being developed. It will call for two main sections - above and below 14 level. For each section the workshops will be manned with a crew of the same size on each of the three shifts. Additional tradesmen will be required for the new structure.

Week-end overtime is often used for bucket build up etc.

Change over times for sub-assemblies are considered to be of the order set out below:

Engines	-	3 shifts.
Transmissions	-	2 shifts.
Axles	-	2 shifts.
Wheels	-	½ shift.
Buckets	-	1 shift provided no great difficulty is experienced.

The above times may be considerably reduced when the changes are undertaken with good facilities available.

(h) Supervision and Management, Planning etc.

Because rubber tyred diesel equipment is used in such a wide range of operations at Mt. Isa, no special supervisors are appointed to particularly look after the use of this equipment. Supervision is on an area basis, rather than specialty. One exception to this rule is long hole percussion drilling which has its own shiftbosses and crews operating through the mine as a specialist group.

However, on an area basis, the MICAF operation and sublevel caving operations in pillars using rubber tyred equipment do form distinct operations. It is not considered that rubber tyred diesel operations are any more intensively supervised than other aspects of Mt. Isa operations.

Most shiftbosses have a conventional mining background - only one third would have had actual operating experience with Scooptrams etc.

The basis of production budgeting is a 5 year plan which is revised every year. Two yearly schedules in more detail are revised every quarter. Development is controlled by a separate development schedule covering a 3 month period which is revised monthly. Percussion drilling requirements and equipment requirements are both reviewed monthly. All these are agreed schedules produced by discussion between schedulers and operators. The preparation of plans, schedules, budgets and equipment requirements is carried out by specialist groups within the mining engineering branch. They work in co-operation with the production staff.

Weekly and daily production meetings are held to review performance of the mine as a whole and particularly to assist in producing a steady grade and tonnage for the mill. A certain amount of grade control is possible through the daily meeting.

A conventional telephone system exists to service the surface and underground operations of the mine. Locations of telephones used underground are reviewed at approximately six monthly intervals to ensure that changing requirements are met.

The telephone system is an essential link in the Mine Control System. This provides a central and continuously manned control room through which information and requests for services can be relayed with a minimum of delay. Supervisors going underground advise the operator of their proposed itinerary and check with him from various telephones en route to advise progress and changes of itinerary and to receive messages. Mechanical breakdowns are also reported to maintenance supervisors through this system.

Equipment Inspectors have already been mentioned in their role of testing driver trainees. They have no responsibilities to either the maintenance or production side of the operation, and can therefore report operating malpractices, equipment faults etc. in an unbiassed way. They check for such things as loose wheel nuts, empty scrubber tanks and so on. Some of these men have had surface plant operating experience; others are trained after experience as control room attendants.

No transport is provided for underground supervisors, but Deutz engined jeeps and diesel engined trucks are used where appropriate for transport of maintenance men and their equipment. The need for supervisor transport will probably become more apparent if communication between a number of levels is established by steep vertical inclines.

Labour turnover for Scooptram drivers is thought to be of the order of ½ to 2/3 the overall rate, though there are no accurate figures to support this statement. The turnover of tradesmen is of the order of 15%.

BROKEN HILL - NEW BROKEN HILL CONSOLIDATED LTD.

(a) Background

Rubber-tyred diesel equipment was introduced to the New Broken Hill Consolidated Limited mine for cut and fill mining of 'B' lode above 15 level. Details are set out in Rutter, 1968, and Mining and Construction Review, 1969. The orebody is divided into stoping panels consisting of transverse stopes separated by transverse pillars and connected by longitudinal eastern or western stopes. Panels are separated by wider pillars and consisted originally of groups of three transverse stopes; now six transverse stopes are grouped as a panel.

Since the equipment was introduced, stopes in other areas (15 level 'B' lode and 17 to 19 level 'A' lode) have been commenced, but these are "longhole" stopes in which Scopptrams are used to load from drawpoints. Current production is at the rate of 318,000 tons/year from the cut and fill panels and 210,000 tons from "longhole" stopes. Ore loaded by Scooptrams thus account for about 44% of the total mine production.

Drawpoints and access drives for the 15 level longhole stope have been cut using a Scooptram for mucking, but apart from this, no development is carried out using rubber-tyred equipment.

In site stress measurements and photoelastic studies have been carried out to determine conditions which exist when a stoping panel approaches an existing level.

Factors used to convert volumes to tonnages are 10½ cu. ft. per ton when solid and 15½ - 16 cu. ft. per ton when broken. The ore consists of zinc rich sulphide mineralisation with a granular quartz gangue and some pegmatite veins.

Composite timber/steel chutes are built up in the cut and fill stopes and the ore is drawn through undercut arc gate chutes with air cylinder operation. 250 cu. ft. Granby trucks and 9¼ ton Gemmco battery locomotives in tandem are used for haulage to the 15 level orepass on 3 ft gauge track.

21 level is also being converted to 3 ft gauge and subsequent levels will be developed with 3 ft gauge trackwork.

(b) Equipment in Use

Loaders - 3 Wagner ST5 Scooptrams - purchased March, July and September, 1966. 23.5 x 25 front tyres, 20.0 x 25 rear tyres. Deutz FA84714 engines and Clark transmissions. 2 Wagner ST5A Scooptrams - purchased July 1967 and 1968. 23.5 x 25 front tyres, 18.00 x 25 rear tyres. All with electric starters. Total operating hours range 120 - 3630.

Jumbos	- None diesel-powered - Gardner-Denver ATD3100 Air Tracs with Buffalo, DH123 and PR123 rockdrills on single booms.
Utility	- 4 Wagner PT10s purchased August 1965, two in September 1966 and one in July 1967. Deutz F4L812 engines, electric starters, tyres 8.25 x 15. Total operating hours range 1100 - 1350. Equipped with scaling platforms.

(c) Transport of Equipment to Working Faces and Routine Servicing

Equipment for the loader cut and fill stopes is lowered in the Service Shaft to 14 level and from there lowered into the stopes. See Rutter, 1968, page 275 for some details of this operation. The diesel units must have buckets and wheels removed and be broken at the articulated joint. A cradle has been constructed from steel angles and channels, and equipped with slippers to run on the Service Shaft main cage guides. The cradle can be used with or without the cage to lower equipment. Low loader trolleys are also available. The cage had a deck area 11 ft by 5 ft 4 in.

Loader drivers undertake only the straightforward tasks of re-fuelling, topping up water scrubber tanks and so on. All other maintenance is carried out by the tradesmen. Fuel and hydraulic oil is run through pipes in the access rises from portable tankers taken underground to 14 level after being filled on the surface.

(d) Operational Details

(i) Preparation for Stoping. This was carried out using conventional equipment. The first stopes were silled out on 15 level to 33 feet wide with back height 16 feet using 15 h.p. air-operated scrapers and Eimco car loaders on 2 ft gauge track. Following installation of the bottom deck gangway timber, sand fill was placed to a height of 13 feet. The next lift, to give a back height of 16 feet above the sand was mined out using 30 h.p. electric scrapers and the next lift drilled out using the Air Trac rigs. Top deck gangways were then stood, chute fronts installed and sand fill placed to a height of 21 feet, leaving an 8 ft brow beneath which the Scooptram could muck and tip. The southern stope of the panel was then backstoped around the service rise for approximately 60 feet and the equipment lowered and assembled in the space provided. The equipment then remained in the panel until mining reached 14 level. The equipment will remain in the stope until the upper stoping limit, expected to be the 12 level is reached.

(ii) Drilling. Stoping holes in the loader cut and fill stopes are drilled with single boom Ari Trac jumbos, mounting Buffalo, DH123. In the blast-hole stopes, Air Trac jumbos are used where stopes may be silled out for full top and bottom areas. Otherwise ring-drilling from bar and arm rigs, or using the Air Trac, is used.

Machine	Air Trac-Cut and Fill	Air Trac Long Holes
Hole diameter	1-5/8 in.	2½in. and 2¼ in.
Average Hole Depth	11 ft	ranges up to 100 ft average 75 ft
Tons of ore/foot uphole drilled	1.30	
Shank life	4700 ft	
Rod life	2500 ft	

Bit life - feet per sharpening	54 ft	
- feet per bit	426 ft	
Coupling life	1000 ft	
Penetration rate	2.44 ft/min average	0.63 ft/min 'A' Lode 0.83 ft/min 'B' Lode
Drilling rate, incl. delays - feet/manshift	176	
Average Air Pressure	80-90 lb/sq.in.	
Available Working Time	5¼ hours	
Drilling Dalays	Machine, Air Trac broken down, barring down, rockbolting, preparing to drill, stuck steels	

(iii) Blasting. Fragmentation in the cut and fill stopes is very good, and investigations are being undertaken to see whether a change in hole size can be profitably made. There is a limit to pattern variations that can be made because of the need to maintain a sound back.

Hole diameter	1-5/8 in.
Firing pattern and tonnage broken	7 holes across 33 ft stopes; horizontal spacing between rows approximately 4 ft 9 in. Firings approximately 60 holes at a time - 1000 tons approximately.
Explosive	ANFO. Holes filled close to collar. No stemming. Penberthy Anoloaders used for charging.
Initiation	Half second delay electric detonators in 1 in. plug AN60 gelignite placed ¼ way up hole from collar.
Charging Density	0.79 lb/ft of hole
Charging Rate	Not available - no separate contract
Average working time/shift	5¼ hours
Factor limiting size of boulder handled	6 ft x 5 ft chute front - but fragmentation generally very good
Secondary Breaking	Bore holes with rockdrill and pop.

Stoping operations in the longhole stopes where scooptrams are in use had not been operating long enough to produce meaningful figures. The method generally calls for 5 ft burden x 8 ft spacing in bench holes, hole depths 72 ft up, 78 ft down are charged with ANFO, fired electrically using millisecond delay detonators and AN60 gelignite primers, double circuits used.

(iv) Loading and Hauling. Haulage distances are generally short, as chutes are located in the eastern longitudinal stopes and eastern ends of transverse stopes, and are built up through the fill.

Mucking rate - including delays   420 tons/operating shift

- excluding delays   129 tons/hour

Lead distances (one way) range 20-300 feet; average 115 feet

Average working time/shift   5¼ hours

Control of floor height and fill dilution depends on ability of the operator under supervision to reduce the quantity of fill taken as he loads.

Experience with tyres indicates a life of 500-600 hours in stopes, running on sand fill, and 350 for re-lugs in this location. Only new tyres have been used in the longhole stoping areas where lives have ranged from 120-180 hours. A set of Erlau chains used in the cut and fill stope were only 60% worn after 12 months service. They are being installed on the Scooptram loading from 15 level longhole stope. Keeping chains tight is a maintenance problem that detracts from the other advantages resulting from their use. Hard rock lug pattern tyres are used, and premium grade rubber specified for re-lugging.

(v) Filling. Operational requirements of the stoping cycle have led to several changes from the normal filling practice in use in conventional stoping areas at New Broken Hill Consolidated Limited. Larger volumes of fill than usual have been required for the various parts of the stoping panels, and it has also been necessary to place these blocks of fill more rapidly than usual. The barricade normally constructed on pillar lines to help retain stope fill during pillar mining operations was abandoned following the introduction of consolidated fill. This also had the effect of eliminating the time taken to construct it and the resulting delay to the stoping cycle within the panel.

Because of the more rapid filling that takes place, the practice of removing some water by decanting has been introduced for the first time. Previously all water was disposed of by percolation. Initially an open-ended hose was raised and lowered by means of a rope to control the level from which water is decanted. This hose connects to a pipe which extends from the stope to a sump on the level below. Details of the drainage system are set out in Rutter, 1968. However, drainage towers are now used universally. Filling can be placed at up to 150 cu.yd. per hour using one mixing box, or 300 cu.yd. per hour when two are used. Filling rates are normally of the order of 600 cu.yd. per shift, and blocks of fill range from 1000 to 3000 cu.yd.

Cement is added to the sand fill in the ratio of 1 of cement to 30 of fill by weight. Some difficulties have been experienced with recoveries in the NBHC mill since the introduction of mechanised cut and fill stoping. The exact cause of these difficulties has not been isolated, but it could be related to such factors as the effect of cement on mill circuit chemistry, the inclusion of greater proportions of fines, with possible oxidation effects, and the spillage of diesel fuel and hydraulic oil on the stope floor, which eventually gets into the milling circuit.

(vi) Labour efficiencies and requirements. The stoping panels are regarded as producing 8000 tons per fortnight, using a crew of 4 men per shift in the breaking and filling contract, 2 men in the drilling contract, with a further 2 men in the drilling contract where the changing shape of the orebody requires the extension of the transverse stopes beyond the previous lift. Manpower requirements are estimated from factors of 50 tons/manshift for drilling, charging, mucking and ground support in the loader cut and fill stopes; with 50% additional manshifts required for stope preparation, handling supplies etc; in longhole stoping ore breaking and hauling again is based on 50 tons/manshift with only 10% additional requirement for handling supplies etc.

(vii) Securing Ground. As pointed out in the previous sub-section, two men are normally engaged in barring-down and rockbolting the back as required. They work from the muckpile, but the platform on the Pt-10 is used more often for rockbolting. Split rod and wedge bolts, 8 ft long and fitted with Brown indicator washers are used. Mesh is used in conjunction with rockbolts in securing drives on the level. Rockbolts are removed where practicable from broken ore. Further details of ground securing practice in the stopes is given in Rutter 1968.

(viii) Floor Preparation. The addition of cement to stope fill has already been mentioned.

Spillage and fines assist in providing firm floors in the stopes, but tramming distances generally are not great. In the case of longhole stopes, operating experience has not yet built up, but there is no provision for road maintenance other than by the normal accumulation of spillage and fines, maintained by the Scooptram itself. Concreting of drawpoints is under trial.

(ix) Dilution. There is little if any dilution resulting from the taking of waste with ore in the cut and fill stopes. The major source is the removal of the top layer of fill during loading. Rutter, 1968, quotes a figure of 8 in. of fill with ore embedded in it, as being taken in the final clean-up. The total quantity of sand removed will vary with operator skill and tightness or otherwise of muckpiles, plus impregnation due to blasting. This may amount to something like 8% and be a factor affecting mill recoveries.

(x) Other Uses of Scooptrams. Somewhat less than 5% of available time is taken up with a variety of jobs in the stope such as moving timber, chute joggles, etc., shifting fans used for ventilating dead ends, and breaking down and pushing up fill barricades within the stope.

(xi) Ventilation. Good conditions are maintained by the flow which is controlled by the decking over the air vents in the western ends of the transverse stopes. Fresh air is taken in on 15 level from the downcasting Service Shaft and exhausted via the service rises to 14 level, and eventually to 13 level where a 240,000 c.f.m. booster fan exhausts from the 'B' lode area. Rule 71 of Section 55 of the Mines Inspection Act (1901) as amended, sets out the requirements for operation of diesel engines underground in New South Wales. Surveys of airflow and exhaust gas quality are undertaken every four weeks, and surveys for flow only, every two weeks. These are reported on a standard sheet for each panel which incorporates a plan of the stopes. A copy of this sheet is attached as Figure 4.

"Dead end" conditions arise when the air vents are covered over with broken ore, and trolley-mounted electric fans, 24" diameter provide 16,000 c.f.m. past the loader. Short lengths of flexible tubing are used when required.

Rutter, 1968 contains a description of the ventilation system in the cut and fill panels in greater detail. Float-controlled tank type scrubbers as supplied by the manufacturers are used on scooptram engines.

(xii) Pillar Mining. It is expected that the pillars will be mined by overhand square set stoping or possibly undercut and fill stoping. Chutes and other openings in the stopes have been located adjacent to pillars to provide access for pillar recovery. One factor affecting current operations is the need to provide either finger-post barricades or consolidated fill to allow pillar mining. The side effects of this need are either disruption of the stoping cycle by the time required for barricade building or the possible effects of cement additions to fill on mill recoveries.

(xiii) Working Time. The mine operates on a 5-day week basis with two production shifts per day. Working time amounts to about 5¼ hours per shift, machine operating time (obtained from engine hour meters) is of the order of 3¼ hours per shift.

(xiv) Tramming Speeds. The longhole stoping operation has not yet operated long enough to establish likely maximum tramming speeds, which may be expected to be higher than in the stopes. The relatively short hauls and uneven floors are likely to reduce average tramming speeds. Maximum speeds may be up to 8 m.p.h., with 5-6 m.p.h. a more reliable "average maximum".

(xv) Chutes and Transfers. Details of chutes and chute fronts are given in Rutter, 1968. The chutes are 6 feet square inside and during loading operations are enclosed in the stope by "post and rail" fences to waist height. When not in use the chutes are covered by several light steel pipe frames covered with ARC mesh. No breaker bar is used. The chute front opening is 6 ft x 5 ft and the design described in Rutter, 1968 has proved satisfactory. The all-steel and all-timber chute joggles described have been augmented by the addition of a composite steel-timber joggle which is interchangeable with the other two, and consists of a 3/8 in. steel plate spiked to the top surface of a timber joggle so that the total depth remains 5 in., wear being taken by the edge of the steel plate. The variety of joggles available makes it possible to build chutes which are tailored to meet the wear patterns expected and the tonnages to be passed from various horizons. It seems certain that these chutes will meet the requirement of passing 250,000 tons of ore without major repair.

(e) Availability and Utilisation

Operating time is based on readings of the engine hour meter, and consequently includes longer or shorter periods in which the engine is idling, with no useful work being done. See updated times Rutter, 1969. Rutter, 1968 lists a number of operating statistics for Panel 2. Mechanical availability is based on hours of maintenance per fortnight affecting production, and because of the provision of night shift maintenance crews and the connection of panels to give some added flexibility, quite high figures are obtained - 84% for 1967, 92% for 1968 and 83% for 1969.

Utilisation is expressed in terms of operating hours and available hours, i.e., hours out of the 5¼ per shift when production was not lost due to maintenance delays. These figures range from 40 to 60%, usually around 57%. Actual operating hours are usually 3-3½ per shift.

Utilisation in 1969 was 63.6% of available working time.

(f) Operator Training.

In the initial stages, operators had 5 hours experience driving the Scooptram on the surface and were than issued with a "permit to drive", which was replaced by an "authorisation to drive" after a further 20 hours driving underground and further examination by Assistant Underground Manager or representative. This met the requirements of the Mines Department. Operators are from a conventional mining background.

The turnover is low and future training of drivers will be done on the job underground. The candidate will be given 5 hours practice under tuition of an "authorised driver", examined and then given a permit. After a further 20 hours driving he is again examined and given an "Authority to Drive".

(g) Maintenance.

At the time this operation was visited, the oldest Scooptrams had 2,800 hours operating time; three more had just over 2,000 hours and the fifth under 100. One engine had been replaced. Loader breakdown troubles and remedies are listed in Table I, page 282 of Rutter, 1968. Check lists of daily, weekly, three-weekly and 500-hour maintenance schedules are attached at Appendix 4.

Electric engine-hour meters are used for record purposes in determining planned maintenance requirements, in recording ventilation tests, efficiency figures and so on.

It is estimated that hydraulic failures of one kind or another are responsible for 40% of the time due to maintenance.

Buckets are built up with hardfacing, the bottoms are built up with abrasion-resisting alloy steel. The bucket lips, originally of the V-type have been modified to a straight lip type, to which Esco 40 and 45 series replaceable teeth have been added. Eight teeth are used with the outside teeth located to protect bucket corners. One original bucket has been replaced by a new bucket of Esco design and manufacture.

Maintenance crews consist of fitters with the usual mine experience. They are paid normal rates with the exception that those working on Scooptrams get a slightly higher rate and an allowance is paid to those working night and afternoon shift without supervision. The whole underground maintenance crew is supervised by 2 foremen and five assistant foremen. Two assistant foremen are based on 15 level on day shift co-ordinating servicing of vehicles with mining department requirements, arranging for the supply of parts etc. On day shift there are four men, one of whom does general work on 15 level; others service equipment in stopes. Two men on afternoon shift and night shift work on equipment in the stopes. Maintenance men have their own store on 15 level in which the more frequently required spares and other items are kept. Larger items such as the longer cylinders, engines, etc. are kept on the surface, but there is a trend toward increasing the range of spares kept in the 15 level store.

Experience with replacing major components is still being built up. The only engine change to date was made in the stope and required six shifts. Front wheels require 3-4 hours, rear wheels up to a full shift. Only two buckets have been replaced.

Repair of buckets by welding is carried out at week-ends. It takes the best part of one shift to move the welding equipment into the stope to do this work. Other maintenance is also carried out on Saturdays.

(h) Supervision, Management, Planning etc.

One foreman has charge of 13, 14 and 15 levels at NBHC. He has 13 shiftbosses to look after the operations of two loader cut and fill panels, two longhole stopes, five conventional stoping parties, as well as development being carried out by three drive parties and two rise parties.

In the loader cut and fill operation there is one shiftboss on each shift for each operating panel. All shiftbosses come from a background of conventional mining.

A long-range plan in narrative form is maintained as a framework within which a five-yearly plan is kept. This plan is updated annually and from it a detailed annual plan is made. A computer programme had been written to assist in the calculations required in working out the expected total tonnage and grade from a detailed tabulation of planned tonnage and grade from individual working places.

Communication is somewhat complicated by the fact that the loader cut and fill stopes are serviced from 15 level. When the stopes are well advanced there can be over 100 feet of ladderways to be climbed from level to working face. To meet this situation, a portable telephone is installed at the top of one ladderway in each panel. This connects to 15 level store where there is a man on duty who can relay messages elsewhere in the mine or to the surface through the normal automatic telephone system. This type of operation does not lend itself to, nor does it require, any special provision of transport for the supervisors.

Labour turnover is very low - any changes are due to changes of job within the operation, rather than to losses to the industry altogether.

COBAR - COBAR MINES PTY. LTD.

(a) Background.

All development and stoping operations at Cobar Mines Pty. Ltd. are carried out by rubber tyred diesel equipment with the exception of vertical connections (raises, shafts etc). These are made by conventional methods, including Alimak raise climbers for raises beyond 80 feet or more recently Robins 61R raise borer. Broken rock from these operations is loaded and hauled by diesel equipment, along with that from all other operations in the mine.

A description of operations was prepared recently by Brady et al. 1969. The parallel lenticular orebodies are mined by mechanized cut and fill over the whole strike length. Each stope lift is connected to access inclines adjacent to the orebody. Ore widths range from 20 to 70 feet and average 35 feet. The two main lenses are 600 feet apart, the Western Copper Orebody being 1200 feet long, while the Eastern Copper Orebody is 600 feet long and the No. 2 Copper-Zinc Orebody, 400 feet long. No. 1 Copper-Zinc orebody is rather shorter still.

The lodes trend north-south and dip east at approximately 70°. The Eastern Orebody has no well defined walls and consists essentially of chalcopyrite - pyrrhotite bearing chloritic slates within an overall weakly mineralized zone. The Western Orebody mineralization is massive with relatively sharp boundaries. The copper zinc lodes are also massive sulphides with sharp boundaries.

The high pyrite and pyrrhotite content of the ore makes shrinkage stoping unattractive because of oxidation and re-cementing of broken ore. Well developed shearing and the relatively narrow orebodies make sub level open stoping unattractive because of relatively high development costs and high dilution. Cut and fill provides a satisfactory answer to most of these problems.

To avoid tramming in the inclines stope passes have been introduced into which rubber tyred diesel powered load and carry machines discharge ore from the stopes. This is picked up from drawpoints on the main haulage levels and transferred to the main orepass system. Production of 625,000 tons per year at present comes one third from 1800 level and two thirds from 1200 level, the only two levels developed so far. They are 600 feet apart.

Borehole stress field measurements have been carried out on both these levels and core testing carried out at a number of sites on 12 level. Stephenson, 1968, in reporting results of these tests concluded that uniaxial compressive strength (16,860 lb/sq. in) and Young's modulus (11.4×10^6 lb/sq. in) were both higher than expected. Variations in mechanical properties of the rock throughout the mine were detected but were small enough to be neglected for the purposes of photo-elastic studies when compared with the overall small scale heterogeneity of the rocks.

The density of the ore varies over the range 10.3 to 12.7 cubic feet per ton solid, with a swell factor of 1.4 giving a range of 14.4 to 17.7 cubic feet of broken ore per ton.

Some details are set out in tabular form below.

Stoping Area	Density Cubic feet/ton. (Solid)	Mineralogy
12 C.W. (North)	12.66	Chalcopyrite in siliceous shale.
" " " (South)	10.64	massive sulphides.
12 C-Z 2	11.13	" "
12 C-Z 1	10.24	" "
12 C E	12.40	Sheared slate gangue.
18 C A	12.57	" " "
18 C B	10.30	massive sulphides.
18 C C	11.87	combination of 18 C A and 18 C B type ore.

(b) Equipment in Use.

Equipment in use in July 1969 was as follows:

Loaders - 2 Joy TL55 Transloaders purchased June 1963.
2 " " purchased April 1964.
All with Deutz F6L714 engines, electric starters.
16.00 x 25 rear tyres, 13.00 x 24 front tyres.

2 Wagner ST5 Scooptrams purchased July 1965.
2 " " " " March 1966.
All with A8L714 Deutz diesel engines, electric starter, 16.00 x 25 rear tyres, 23.5 x 25 front tyres.

3 Eimco 916 LHD machines purchased June 1967.
1 " " " machine " September 1968.
1 " 915 " " " November 1968.
All with A8L714 Deutz diesel engines, air starters.
18.00 x 25 front and rear tyres.

1 Wagner MS1¾ Mining scoop purchased June 1963.
1 Wagner MS2 " " " September 1967.
Both with electric starters and Deutz F6L714 engines.

Trucks - 2 Wagner MT416D-35 end dump trucks purchased June 1963; also with electric starters and Deutz F6L714 engines.

Jumbos - 1-3 boom Gardner Denver development jumbo on Getman carrier purchased June 1963.
1-3 boom Gardner Denver development jumbo on Getman carrier purchased September 1964.
1-2 boom Gardner Denver development/stope jumbo on Getman carrier purchased June 1968. Since converted to 3 boom.
2-2 boom Gardner Denver stope jumbos, on Getman carriers purchased March 1965.
1-2 boom Gardner Denver stope jumbo on Getman carrier purchased September 1965.
1-2 boom Gardner Denver stope jumbo on Getman carrier purchased February 1966.
Two of the stope jumbos have been connected to compressed air drive, the others are powered by Deutz F4L812 engines with electric starters.
2 Gardner Denver Air Tracs purchased December 1967 Air powered.

Utility - 2 Wagner PT10 utility vehicles with baskets for back scaling, reach 19 feet. Powered by Deutz F4L812 engines with electric starters.
2 Wagner UT42 with basket for back scaling, boom HIAB type crane.
1 Wagner VT42 personnel carrier.
3 Conquip graders powered by Perkins 4-270 water cooled diesels with electric starters. (Based on Chamberlain MkII Industrial Tractor).
1 Back hoe mounted on Chamberlain Industrial MkII Tractor, powered by Perkins 4-270 water colled diesel with electric starter.
5 Mercedes Benz Unimog trucks, powered by Mercedes model OM636 water cooled diesel engines and electric starters.
3 Liner Roughriders (for handling small stores) with 2 cylinder Lister water-colled diesel engines, hand started.

(c) Transport of Equipment to Working Faces and Routine Servicing.

The larger pieces of equipment must be dis-assembled for lowering underground, but once removed from the shaft and assembled, equipment can be driven to all working places on a level. Standard drive dimensions are 14 feet wide by 12 feet high. The cage has a capacity of 10 tons and is approximately 11 feet long, 11 feet high and 6 feet wide.

For lowering, loaders are broken at the articulation joint and buckets and wheels removed. The heaviest piece is the rear section of the Eimco 916, which weighs about 8 tons. Some shortening at the engine end is necessary to fit the machine in the cage. A roller platform low loader (total height about 6 inches) is used to move sections in and out of the cage; some large sections must be laid on their sides. Graders are lowered in the cage as are all other machines. Unimogs are lowered without breaking down into smaller sections. Jumbos are lowered with booms and console removed.

Routine servicing of equipment is carried out by both operating and maintenance crews. However, the operating crews rarely do work other than refuelling and attending to scrubber tanks. Sometimes they will top up with hydraulic oil and more rarely inflate tyres. The maintenance crews normally hand a machine over with all maintenance completed and refuelling only remaining to be done before it is ready for work. Lubricants are piped to spring loaded hose reel dispensers in the lubrication and workshop bays from central storage areas on each level.

(d) Operational Details.

(i) Preparation for Stoping. All horizontal development is carried out using rubber tyred diesel equipment. The vertical connections are made either by rising 8ft by 8ft in size or by raise boring. One of the Wagner end dump trucks has been modified to carry and erect the raise boring machine. Broken muck from raising operations is loaded and hauled by rubber tyred equipment.

Raises beyond 80 feet are driven using an Alimak STH3K raise climber. Longer raises use the curved rail arrangement, shorter raises use the hinged rail arrangement for moving the climber from the raise at firing time.

(ii) Drilling. All holes are drilled with Gardner Denver DH123 4½ inch drifters.

	Stoping	Development.
Hole diameter.	2 in.	$1^7/8$ in with 3 x 3 in holes for cut.
Average hole depth.	17 ft.	10 ft.
Tons ore/foot drilled	1.43	
Shank Life	1000 ft (1400 series)	2600 (1600 series)
Bit Life feet/sharpening	average 21.5 ft, range 6ft-80ft.	
total	stoping and development 144 ft.	
Penetration rate	varies over a wide range - usually about 2 ft/min.	
Drilling rate	165 ft/manshift (2 per jumbo) delays about 30%.	
Air pressure	Averages 90, ranges 85-95 lb/sq. in. Little variation between shifts.	
Available working time	6¼ hours. Decreases as stopes move further from the level and travelling time increases.	
Drilling delays	Lack of drilling sites can cause major delays during which the crew will be placed on other work. Delays during drilling include ground control, moving, ventilation breakdown, collecting hoses and bits.	

(iii) Blasting. In stoping, all holes are 2 inches in diameter with a few exceptions where 1 7/8 inch bits must be used to attain full hole depth. Firings range from 1000 to 3000 tons. Because of the possibility of pyritic dust explosions, holes are stemmed with limestone dust, the size of firings is limited and firing is only carried out when men are out of the mine.

Drilling pattern	5ft x 5ft at right angles to holes which are inclined at 65°.
Type of explosive	Ammonium nitrate fuel oil loaded by NVE pressure loader, 500 lb capacity.
Type of initiation	Bottom priming with L series protected millisecond delay detonators in one plug of AN 60 gelignite.
Explosives factor	0.75 lb per ton.
Charging density	1.05 lb/ft of hole.
Charging rate	1000 feet per manshift. 490 tons/ manshift excluding delays.
Available working time	6¼ hours per shift.
Factors limiting size of boulder.	Transloader bucket opening 58in x 40in. Many pieces fallen from the brow already have holes in them - otherwise plaster shots are fired.

(iv) Loading and Hauling.

Mucking rate including delays	435 tons per machine shift.
Mucking rate delays	Amount to 35-40% and include ground control, breakdown, orepass full and ventilation.
Lead distance (One way)	ranges from 200-1000 feet.
Available Working Time	6¼ hours less ½ hour for refuelling and servicing.

A white line is painted on stope walls on which a small spotlight from the vehicle shines to assist drivers in maintaining a level floor during mucking and reducing dilution by fill.

Selective mining is practised in that copper and copper-zinc ore is mucked separately and placed in separate orepass systems for treating in distinct sections of the mill. In addition some areas of waste included in wider parts of the Western Orebody are left in the stope after breaking. This waste is either left in place or, after moving by Scooptram, used as part of fill barricades. Areas to be left in this fashion are determined by the geologist from stope control drilling assays and inspection of the back and muckpile. The area to be left is then marked by painting a white line on the back above it. This is easily done from the top of the muckpile.

A graph showing tons loaded and hauled per operating hour against tramming distance has been prepared for a range of equipment and combinations. A copy is attached, Figure 5.

Data provided on tyre life is set out below:

Machine	Life Hours New	Life Hours Relug.	Av. No. Relugs	Cost/ton handled, cents
ST-5 Front	192	137	2.87	
Rear	173	151	2.76	10.54
Eimco F)) R)	335	331	2.03	8.34
Transloader F	320	250	1.37	9.54
R	223	219	2.5	

(v) Preparation of stopes and filling. Hydraulic fill using classified mill tailings is used. As only minus 14 micron material is removed before use provision is made for decantation as well as drainage of surplus water. Fill preparation consists of extension of the Armco ventilation pipes at the ends of stopes, extension of decantation pipes, installation of concrete brick bulkheads in access crosscuts from inclines and building fill barricades.

Waste from within a stope and development mullock is used for fill barricade construction. Because of their higher discharge, Wagner Scooptrams and Eimco 915 LHD units are preferred to Eimco 916 LHD machines for this purpose. A tractor with backhoe is used to speed up the operation of digging out and extending the Armco ventilation pipes in 1200 level stopes.

Decant pipes are connected directly to major sumps in the drainage system via access crosscuts and the inclines. Percolation pipes in the floor of stopes are similarly connected.

Manpower required for fill preparation is about 1 manshift for every 100-150 tons of fill placed. Filling is run into stopes at 100 tons per hour, and 5 operating hours filling per shift is normally obtained. The size of pour ranges from 300-400 up to 15,000 tons. Filling is run from the mill and no special operators are required. No additions, such as cement, are made at present.

(vi) Labour efficiencies and requirements. Lateral development - A crew of 14 who drill and muck produce 700 to 800 feet per month and an average of about 2.7 feet per manshift was obtained in 1967/68.

Vertical development - of a total crew of 6, 2 are engaged in conventional raising, and produce 50 to 60 feet per month; an average of about 1.6 feet per manshift was obtained in 1967/68.

Miscellaneous mining - a crew of 5 is engaged in minor development and construction.

Stope drilling - a crew of 16 produced 414,000 feet in 12 periods but actual rates are as high as 320 feet per jumbo shift (2 men, 2 machines).

Ore handling - a crew of 15 for mucking and barring down, wetting down the muckpile etc produce 625,000 tons per year.

Stope mining - a crew of 6 carry out rockbolting and other ground control activities.

Preparation for filling - a crew of 14 are required.

Servicing - a crew of 7 extends pipelines, ventilation piping and carries out other miscellaneous jobs in this field.

Roads - a crew of two is required - one each on day and afternoon shifts. Each spends half a shift grading roads on each level.

(vii) Securing ground. Two of the utility vehicles are fitted with HIAB cranes and baskets giving a maximum floor height of 19 feet, while a third has a maximum height of 22 feet. Theoretical maximum back height is 25 feet. 8 foot expansion shell rockbolts are used, where necessary with chain wire mesh. Rockbolts are placed from the pile of broken rock wherever possible. Rockbolts are not normally removed until broken ore reaches the crusher station, where an electro-magnet is situated over the impact conveyor after the crusher.

(viii) Roads. No additions are made to stope fill to improve the floor as a roadway. In inclines and other travelling ways roads are initially formed using development mullock, and more recently raise borer cuttings are proving very useful top dressing for roads. Graders work not only on main level roads and inclines but also within stopes where this is necessary,

(ix) Dilution. Dilution from picking up fill during loading operations is considered to be of the order of 5%. Dilution due to overbreak is not accurately known but is considered to be very small - of the order of 2%. The use of paint guidelines on stope walls and flat beam spotlights on loaders is intended to assist in reducing dilution by taking too much fill in loading.

(x) Other uses of machines. The provision of two Mining Scoops for utility purposes reduces the calls on Scooptrams and LHD machines for use other than as load and haul vehicles. The principal uses to which the big machines are put are the lifting of fans for installation during development work the building of fill barricades in stoping, and the clean up of development faces.

(xi) Ventilation. The general ventilation system is described by Brady et al 1969. Access inclines serve as intake airways. Connections to the upcast ventilation shaft are made through level development, 8ft by 8ft ventilation raises and finally 5ft diameter Armco corrugated galvanised iron pipes through the sand fill in the stopes.

Rule 71 of Section 55 of the Mines Inspection Act 1901, as amended, sets out the requirements for operation of diesel engines underground in New South Wales. A minimum airflow of 50 c.f.m. per brake horsepower or 5000 c.f.m., whichever is the greater, is required. In addition maximum allowable concentrations of 1000 parts per million of oxides of nitrogen and 1500 parts per million of carbon monoxide in the undiluted engine exhaust must be observed.

Routine surveys of temperature, gas concentrations and flow at established stations are carried out weekly. These measurements are also made in working places. Standard forms including a small isometric plan are provided for reporting observations. Copies of some of these are attached as Appendix 5. One of the forms sets out the number of vehicles that may operate in stope ends under the flow conditions measured in the survey.

Draeger tubes are used for measuring gas concentrations. A nickel-plated brass manifold is used to obtain vehicle exhaust gas samples. It is considered that the use of this manifold permits a more accurate gas concentration reading, as the practice of placing the Draeger inlet directly in the exhaust results in errors in the sampling volume.

All vehicles are tested once a month for oxides of nitrogen and carbon monoxide under full throttle, no load conditions. The test is carried out by the Ventilation Officer, and vehicles are taken out of service on his direction if the exhaust gas is above or near the limit. Several readings are taken when conditions are doubtful.

Vehicles put out of service in this way must be retested and found satisfactory before going back into service. The most usual causes of vehicles failing to pass the test are:-

(a) injectors in need of servicing.

(b) fuel pump setting - this must always be a compromise as the maximum power setting is not the optimum setting from the point of view of gas production.

Balance between nitrogen oxides production and carbon monoxide production for a given fuel-air ratio depends on temperature. At higher temperatures the proportion of nitrogen oxides increases. The Deutz (air-cooled) engines therefore usually have high nitrogen oxide concentration and lower carbon monoxide concentration in the exhaust than for the other (water-cooled) engines.

Water bath scrubbers have negligible effect on engine performance, and negligible absorption once water is warm. Hence they do not affect the exhaust gas composition. Catalytic conditioners, if operated at the correct temperature, remove all carbon monoxide by oxidation, with negligible effect on nitrogen oxides. When operated at too low a temperature they not only cease to operate but also tend to choke up and increase engine back pressure. This leads to an increase in carbon monoxide content and reduction in nitrogen oxides because of the reduced combustion efficiency. Power output is also reduced. This effect is most noticeable on water-cooled engines, and also on engines of service vehicles.

The mine at present exhausts 280,000 c.f.m. up No. 1 shaft for an annual production of 625,000 tons.

(xii) Pillar Mining. The cut and fill method used reduces the quantity of ore tied up in pillars. Only crown pillars below operating levels will be formed. No provision has yet been made for mining these pillars, but in view of the wide spacing of major levels, the ore involved will be only a small proportion of the total.

(xiii) Working time. The mine operates five days a week on a three shift basis for drilling and mucking in both stoping and development. Eight hour shifts are worked, from 8am to 4pm on the day shift.

(xiv) Tramming speeds. It is estimated that maximum tramming speeds reach 8 to 10 miles per hour.

(xv) Transfer Points. Because of the machine's bottom dumping characteristic, special provision must be made at passes where the Transloaders are to be used. In such cases slots are cut in the floor which permit the Transloader wheels to go to the edge of the pass but provide an opening with an inclined bottom to receive the discharge from the Transloader and direct it into the pass.

In practice, Transloaders have been used only on transfer operations from stope passes to main orepasses. This eliminates the need for any special provision for them at stope orepass dumping points. Stope passes are now constructed so that they are reached from stope access crosscuts and access inclines, rather than directly from the stope. Breakback toward the stope along crosscuts direct to stope passes (as described in Brady et al 1969) and difficulty of maintaining the pass barricades, led to this new development.

At drawpoints at the bottom of stope passes, floor wear is apparent and it seems as though some installation of concrete or other re-inforcement may be required. Pre-splitting might be used to give a floor free of cracks and less likely to wear away.

(e) Availability and Utilization

Rowe and Maher, 1969, review the concepts and definitions used in expressing availability at the C.S.A. mine. As the mine operates 3 shifts per day, 5 days per week, 120 hours per week is taken as the maximum availability. Available time is taken as the difference between 120 hours, and the time which elapses from when a vehicle is first reported broken down, or servicing commences to when the vehicle is once more ready for use. Availability percentage for the week is the relationship between available hours and 120.

These figures, taken out on a weekly basis, are compounded for each four weekly period. Available and total hours and percentage availability are taken out for each machine and group of machines.

Availability necessarily varies with the size of the fleet in relation to the extent to which vehicles are used and are essential to production.

It is interesting to consider the cumulative effect of operational delays on availability in reducing the hours per shift that a vehicle actually mucks. Appendix 6 attached sets out some figures based on Cobar experience in this field.

Some typical availabilities for 1968/69 are as follows:-

Scooptrams and Eimco LHD machines - 50-55%.

Transloaders (only used by operators when above not available) - 70-80%.

Mining Scoops - 65-80%.

Wagner PT-10 - 70-90%.

Stope Jumbos - 60-75%.

Wagner Trucks - (Rarely used now for regular haulage) - 75-88%.

(f) Operator Training.

The Mines Inspection Act requires that drivers of underground rubber tyred diesel equipment shall be authorized to drive by the Mine Manager. They receive training from the foreman in charge of their particular section of the mine. Some have plant operating experience in surface construction jobs, while others have a background of conventional mining. They are described as mechanical miners and come under the A.W.U. award.

(g) Maintenance.

Rowe and Maher, 1969 discuss the maintenance of load-haul-dump equipment in detail.

Transloaders have been modified by enlarging the size of the dump door opening and by changing the driving position from "straight - ahead" to "side-on".

Modifications to Scooptrams have been concerned with axle loadings resulting from use in heavy ore on rough and inclined roadways. Axle capacities have been increased, bucket sizes decreased and chassis members strengthened.

In the case of the Eimco machines strengthening of chassis and axle has also been found necessary under Cobar operating conditions.

The buckets have been modified with Esco 3 piece replaceable lips with integral tooth sockets, and ribbing and hard facing of the undersite is carried out. Eimco buckets have been fitted with cast steel shrouds to protect the rear corners where wear can be excessive. Bucket modification and rebuilding is carried out on the surface - buckets are changed over underground.

Electric engine hour meters are used to indicate service intervals. Daily servicing requires from 1 to 3 hours of maintenance work, 100 hour servicing 8 to 16 hours of maintenance work. In total, daily and 100 hour servicing require 14 to 40 hours for every 100 operating hours. Major overhauls are planned between 2000 and 2500 hours. Components found by experience to fail before 4000 hours are replaced (usually) or rebuilt at this time. Replaced components are rebuilt in the surface workshop.

Maintenance crews usually have a traditional fitter or electrician's background. They are trained on the job to work on the various machines, usually by putting a new man with several experienced tradesman through a variety of jobs under the close supervision of a foreman. The situation is easier now that the operation has been running long enough for supervisors to be drawn from tradesmen who have had significant experience in actually working on the machines. Some supervisors have been sent away for training courses run by manufacturers' agents in Australia.

Maintenance crews participate in a bonus scheme based on percentage availability. This is calculated along the lines indicated in section (f) above, but in cases where repair of a machine is held up for lack of spare parts, after 4 days machines are counted as having the same availability as the group average. Availability is calculated each fortnight for bonus payment purposes.

The fitters are equally distributed on day and afternoon shift: each shift has six fitters, one boilermaker and 4 tradesmen's assistants on 1800 level, supervised by a shift foreman and on 1200 level, 5 fitters, 1 boilermaker and 3 tradesmen's assistants, again with a shift foreman in charge. On night shift there is 1 fitter and 1 assistant on both levels, rostered out of the normal crew.

There is 1 electrician and assistant on both levels on day shift, while the 1 electrician and assistant on afternoon shift move from one level to another as required by priorities.

On 1200 level there is one tyre fitter who alternates between day and afternoon shift.

The usual pattern of work will call for a fitter with or without assistant to be engaged on each of the following:

daily maintenance of load and carry machines.
100 hour maintenance of load and carry machines.
major overhaul and 1000 hour maintenance of load and carry machines.
rock drilling jumbos.
breakdowns.

Times required to change over the main sub assemblies have been estimated as follows:

engines - 2 shifts.
transmissions - 1 shift.
axles - full assembly - 1 shift.
wheels - 1 - 1½ hours depending on size etc.
buckets - about 3 hours for conditions of normal difficulty.

Some thought is being given to the problem of how to make engines truly interchangeable. At present the location of auxiliaries etc. is not always consistent and some changing round may be necessary to suit different machines which use the same basic engine.

(h) Supervision, Management, Planning, etc.

There is a General Mine Foreman and a Foreman for each of the two levels who work all day shift.

On 1200 level there is a production shiftboss on each of 3 shifts and a services shiftboss on each of day and afternoon shifts only. On 1800 level a similar arrangement prevails, except that there is only one services shiftboss who works all day shift.

In addition there is a project foreman who provides close supervision of particular projects such as the introduction of the Raise Borer. The Stope Control Officer has foreman status. He designs the rows of holes required to bring out ore to limits set by geologists, physically makes spot checks of drilled holes for depth and angle and in conjunction with the Production Engineer, designs stope firings.

All of the above officers have a conventional mining background. It is usual for shiftbosses to be paid overtime for whole shifts worked at weekends. Pay scales seem comparable with first line supervisors elsewhere.

At a higher level there is a Scheduling Engineer who works with the Foreman to do daily and weekly schedules of cycles. He is also in charge of the Stope Control Officer and Ventilation Officer. The Mine Planning Engineer provides detailed plans for mining as agreed upon with other engineers. He also produces an eight year plan which is updated annually. In addition there is a Senior Project Engineer who is in charge of investigations and projects, the Mine Clerk etc. He is responsible to the Production Engineer, as is the Scheduling Engineer and General Mine Foreman. There is also a Senior Mining Engineer who examines alternatives for increasing production, considers broad planning of new developments etc.

For communication there is a telephone system which is an integral part of the main mine and plant system. Telephone locations are listed in Appendix 7 and include workshops, crushing and loading stations, supervisors' offices underground, stores etc, as well as in the access inclines close to the stope entry cross cuts in current use. These latter telephones are re-located as required.

No special transport is provided for supervisors - they walk, or ride on maintenance and supply vehicles if these are travelling in the same direction at convenient times. As stopes move further up, particularly in the case of 1200 level at present the loss of time in travelling by both supervisors and miners and others working in stopes becomes greater. A completely satisfactory answer is not yet in sight.

Labour turnover data does not distinguish between miners and maintenance men. On the basis that annual turnover equals number of losses expressed as a percentage of average employment level, the average for the whole mine is 23% and the trend is downward.

LUINA - CLEVELAND TIN N.L.

(a) Background to the various operations.

Rubber tyred diesel equipment is used throughout the mine. At the time of my visit, a small quantity of equipment for conventional open stoping with a scraper was being obtained in order to mine the extremities of lodes which, being less then 8 feet wide, are too narrow to mine using the rubber tyred equipment. Most of these areas are in the upper sections of the mine. Some narrow sections are being mined by widening the sill to 8 feet for the rubber tyred loaders, and carrying a narrower stope above this by shringage methods using airleg drills.

Production to date has been entirely from development stripping and stoping using rubber tyred equipment and has reached 280,000 tons per year, 70,000 tons of which has been from development.

For a description of rock types and the orebodies in general, refer to Cox, 1968. Orebodies consist of finely banded "lode bed" containing up to 35% sulphides which is stratigraphically conformable with the enclosing rocks, a series of interbedded shales and cherts. The interbanded chert horizons constitute approximately 30% by volume of a single orebody and contain negligible tin-copper mineralization.

Density factors have been determined by bulk sampling. Chert is 13.2 cubic feet per ton, sulphide bands 10.2 cubic feet per ton, and lode material (ore as mined containing 69.5% sulphide bands 30.5% interbedded chert) 11.0 cubic feet per ton. This figure becomes 11.1 cubic feet per ton if an allowance for 10% overbreak of chert is made. A figure of 16 cubic feet per ton has been used for broken ore.

Mining up to the present has taken place in that portion of the orebed which lies above creek level in Crescent Spur. (Access is from adits driven into the spur from roads on the eastern slope. Overhead open stoping is carried out from drives at 60 ft vertical interval, which are driven 12 ft by 12 ft minimum section to the limits of the lode and stripped to the full width. Ore outlines are determined by drilling a pattern of XRT diamond drill holes at 60 ft intervals in the level drives). Ore limits derived from stope preparation - see below are marked on 10 scale plans by geologists. These limits are used by surveyors to design vertical fans of holes, for the 2 boom jumbo. For setting angle holes a clinometer is clamped to the drill steel while the boom is adjusted by the controls to position the rockdrill correctly. Drilling and blasting of fans cannot commence until about 50 feet of drive has been stripped from the end of the orebody. As much of the broken ore as possible is loaded out by the Scooptrams before the next lots of holes are fired, retreating toward the access adit. A pad of broken ore amounting to about half the tonnage in one lift is not recovered and is carried down to the lower levels as subsequent lifts are worked out. This will utimately be recovered through drawpoints to be installed at some lower level.

Mining below creek level will require a 1 in 9 decline, 18 feet by 12 feet, to take the place of the access roads on the eastern slope. A shaft for ore haulage may be added later.

Rock mechanics studies have been undertaken with a view to monitoring the stability of the eastern slope of Crescent Spur. A consultant is retained for this work, and borehole extensometers are to be installed.

Ore from stopes above the lowest adit level is tipped into the orepass on the level on which it is picked up by the Scooptram. The orepass, of nominal 10 ft x 10 ft section is fitted with a modified Mt. Isa type chute, 8 feet wide, and trucks are loaded from this chute to transfer ore to the mill stockpile. Trucks are also used to handle rock from development and waste from selective mining to dumps.

(b) Equipment in use.

Cleveland Tin N.L.

Trucks	-	2 Wagner MTT 423-38	18 ton capacity.
		1 Euclid RF 16	18 ton capacity.
Scooptrams	-	4 Wagner ST5A	6 ton capacity.
Jumbos	-	2 Gardner - Denver 3 boom with DH123 drifters	
		1 Gardner - Denver 2 boom with DH123 drifters	
		1 Atlas - Copco Tunmec 2 boom with Panther Rockdrills (Air motor driven or towed into position by ST5A).	
Utility	-	2 Wagner PT-10 trucks, 1 with scaling basket.	
		1 Grader	
		1 Land Rover (shift supervisor)	

(c) Transport to working place and routine servicing.

Cleveland Tin N.L.

All working places are accessible from outside access roads which lead to mill stockpile and workshops. Minimum size of adit is 12 feet by 12 feet and no dismantling is required.

Operators check units before start of shift and refuel, replenish oil etc. at this time. They also check for any previous shift reports of faults.

Samples of report sheets used are included in Appendix.

(d) Operating Details.

Cleveland Tin N.L.

(i) Preparation for Stoping. Access is by adits at 60 foot vertical intervals driven into the spur from roads on the eastern slope. Drives 12 ft by 12 ft minimum section are advanced to the limits of the lode, stripped to the full width and ore outlines determined by drilling a pattern of XRT diamond drill holes at 60 ft intervals in the level drives. Overhead open stoping is then carried out as outlined above.

(ii) Drilling. In the figures quoted below, stope drill holes are 2¼ inches in diameter. This has now been reduced to 2 inches.

Machine	G-D 2 boom (stoping)	G-D 3 boom (development)	Atlas Capco Tunmec (development)
Hole Diameter	2 in.	1 7/8 in.	1 7/8 in. plus one 4 in. cut hole per end.
Av Hole Depth	50 ft.	10 ft.	10 ft.
Tons Ore per Foot Drilled	1.33		
Shank Life		1600 ft.	
Bit Life	15 sharpenings at 20 ft = 300 feet.		
Penetration Rate	About 1 foot per minute.		
Drilling Rate	300 ft/manshift	400 ft/manshift	40 ft/manshift.
Average Air Pressure	90-100 lb/sq in. on all shifts		
Available Working Time	6 hours.		
Drilling Delays	Primarily due to bits not following in a hole.		

(iii) Blasting.

	Stoping	Development
Hole Diameters	2 in. previously 2 in. currently	1 7/8 in.
Firing Pattern and Tonnage Broken	250	9 ft end of 12 ft x 12 ft 100 - 150 tons.
Explosive	A.N. 60 & Anfo	AN60 & Anfo
Initation	Electric Detonators.	Fuse and detonator.
Charging Density	1 lb/ft of hole 1.33 tons/lb	
Charging Rate	3 hours for 2 stoping rings.	
Secondary Breaking	Drill and pop with airleg. Rocks over 3 ft x 3 ft put aside are paid for in contract. Chute opening at orepass limits size.	

(iv) Loading and Hauling. Trucks are used to haul ore from orepass to mill stockpile and to haul mullock from development ends and selective mining in stopes to disposal areas, usually associated with road widening. The Scooptrams handle ore from stopes to the orepass on each level over average lead distances (one way) of 700 feet, generally within the range of 500-1000 feet. An average rate of 9 loads per hour is maintained. See Figure 1 for details of performance. Machines seem to be actually in use for between 3 and 4 hours per shift.

Ore and waste are distinguished visually and waste is disposed of separately where possible.

Tyres are recapped as often as carcase condition warrants; the number of recaps ranges up to 9. The front wheels of two of the Scooptrams have been equipped with protective chains of German manufacture and their use was considered beneficial, though it was too soon for positive figures supporting this to be available. Rear wheels cannot be fitted with chains without some modification. Tyre life was stated to average 220-260 hours before chains fitted, average tyre life is now 550-650 hours. From time to time survey offsiders are used to monitor wheelspin, and this and similar action by other supervisors is regarded as essential in keeping tyre costs within bounds.

(v) Filling. No stope filling is undertaken at this stage of the mine's development.

(vi) Labour requirements and efficiencies. Little basic information was collected as the mine has been operating on a relatively small scale. The mine will change to a more complex operation as stoping extends below the lowest adit level, and ore will have to be loaded into trucks and hauled up the decline, pending the introduction of a haulage shaft. Present equipment seems quite adequate for the existing production rate.

(vii) Securing ground. An hydraulic basket on one of the Wagner PT-10 utility vehicles is used for barring down and for charging rings in stoping operations. Ground generally stands well without support and rockbolting to a pattern is not required.

(viii) Roads and floors. Haulage roads are dressed with fine tailings from the heavy medium plant, or with finely crushed ore and graded frequently.

(ix) Dilution. Dilution of something under 10% is due to overbreak from stope ring firings, and the necessary simplification of outline that must be made.

(x) Other uses of equipment. As a general rule, Scooptrams are not used for purposes other than mucking, but may sometimes be pressed into service for barring down, or towing the Tunmec jumbo to and from the face. MTT trucks are occasionally used for other purposes such as ventilation system extensions at weekends.

(xi) Ventilation. The mine in its present state of development presents some difficulties in ventilation, due to the large number of points where there is direct access to the surface.

In development ends, a pressure system using 20,000 cfm fans is used. In stoping areas, ventilation currents are directed toward one or other of two ventilation rises, located at each end of the mining area.

Each rise is equipped with a 60,000 cfm fan operating at about 2½ inches w.g. The object is to meet a requirement for 75-100 c.f.m. per h.p. of diesel engine operating in a given area. Ventilation stoppings are being constructed in worked out areas to concentrate air flows in working areas and discourage the tendency for currents to reverse.

General requirements of the Tasmanian Mines Department for diesel engines underground are set out in the Renison Ltd section of this report.

(xii) Pillar Mining. At present a surface crown pillar has been left, together with a central pillar to provide access to each lode at each adit level. The present intention is to recover the crown pillar by benching from the surface and the central pillar by ring drilling, recovering the broken ore from both pillars at the bottom of the area being considered with drawpoints, using the rubber tyred equipment or by some other suitable method. No particular provision for pillar mining has had to be made during the initial operation.

(xiii) Working Periods. In particular, working time available for each shift is 7-7½ hours. 3 shifts are worked for 5 days, with a further shift on night shift Saturday. Additional shifts are required at the weekend for the particular job of moving ore from stockpile to crusher at the mill (Scooptrams only).

(xiv) Tramming Speeds. No information on tramming speeds was obtained.

(xv) Chutes and Passes. At tips on levels, Scooptrams discharge over stop logs into the nominal 10 ft x 10 ft pass. At the bottom of the orepass, ore is loaded into MTT trucks from a modified 8 ft wide Mt. Isa type air operated undercut arc gate chute. The cylinder is protected by a steel plate, chains and weights have been balanced and the chain control cylinder disconnected. In loading, the MTT trucks cannot be filled completely without spotting the front and rear sections of the body in turn under the chute.

(e) Availability and Utilization.

In the case of Scooptrams, with operations above lowest adit level, and on the basis of 7½ hour shifts, 2 machines are scheduled for each shift - a total of 45 machine hours per day. On this basis availability ranges from 45% to 65%.

In the case of trucks, on a 45 machine hour per day basis, availability is 55% for the Wagners and 65% for the Euclid. While most production continues to come from above creek level no difficulties are expected with trucks, as probably one only could maintain production from the orepass chute to mill and adjacent stockpile. As it becomes necessary to haul ore up the decline, trucks will be more fully employed.

(f) Operator Training.

For Scooptram and truck drivers, the most useful background is considered to be that of driving heavy trucks, preferably with power steering, and preferably on articulated vehicles. Training consists of one week with an experienced operator followed by a test by the engineering foreman.

(g) Maintenance.

A major source of difficulty has been an unusually high frequency of MTT axle failures. This was associated with an increase in loading resulting from placing side boards on the trucks. Poor roads and the fact that the axle is rigid are also contributory factors.

Engine hour meters have not been found successful in Cleveland's conditions and estimates by supervisors are used to determine the hours run for servicing purposes. A number of forms are used covering inspection and servicing at regular intervals and examples are collected in Appendix.

For mucking from stopes, Scooptram buckets have been built up by hardfacing, and drill steel reinforcement and teeth added.

Maintenance tradesman usually have no experience of the mining environment, nor have they any experience with Wagner equipment. Diesel fitters are preferred, and next fitters with heavy equipment experience covering hydraulic equipment, airbrakes etc. On the job training is usual and supplemented by booklets covering trouble shooting procedures. One fitter has been sent away to the Deutz diesel engine agents for further training. Maintenance men are paid the appropriate hourly rate plus overtime.

There is one foreman, one leading hand and a number of tradesman. There is one man on each of afternoon and night shifts but the remainder of the crew (about 8 men) is on day shift. They are split into two working groups which normally specialize in Scooptrams or Trucks, but this distinction is not rigidly maintained if operational circumstances require variation.

(h) Supervision, Management and Planning.

Supervisors on the mining operation include a foreman and three shiftbosses. Their experience ranges from 30 years of hard rock mining including Western Australia goldfields to two years at Cleveland, driving all types of rubber tyred diesel equipment. Pay rates for shift bosses are of the order of $80 per week.

Given the tons and grade or ore to be produced over a given period the planning engineer prepares schedules for work on three and six month bases. Operating staff then prepare schedules for day to day work from the three months schedule. Development of each new level follows the pattern of driving the adit in mullock, driving north and south in ore followed by a minimum of 50 feet of stripping to orebody widths retreating from the extremities, before stoping can commence.

There is no special provision for communication from the surface. The shiftboss is provided with a diesel Landrover for his on-shift transport. The ore vehicle is driven by at least three different drivers. Rough roads and underground conditions are hard on chassis, batteries etc, and something more robust would be desirable in the opinion of operating staff.

Appendices, Cleveland Tin N.L.

1. Graph showing productivity of Scooptrams against tramming distance.
2. Range of forms used for reporting maintenance.
   - (a) 150, 600 and 1200 hour check list - Scooptram.
   - (b) Weekly check list - Scooptram.
   - (c) Daily check list - Scooptram.
   - (d) Repair sheet describing work carried out.
   - (e) 150, 600 and 1200 hour check list - MTT truck.
   - (f) 75 hour checklist - MTT truck.
   - (g) Daily check list - MTT truck.
   - (h) Operator's report - MTT truck.
   - (i) Operator's report - Scooptram.

RENISON BELL - RENISON LTD.

(a) Background to the various operations.

The Mine depends entirely on rubber tyred diesel equipment for all underground development (except rising); for stoping, for ore haulage and mullock disposal and for servicing. Shafts provide ventilation but not access.

Annual production is of the order of 400,000 tons of ore per year.

A general description of the geological background to the deposits is contained in a brief paper by Gilfillan, 1965.

There are two types of orebody - the Federal lode type which is not conformable with the bedding and follows structural rather than stratigraphic features and the conformable lodes such as the North Stebbins which are flat lying in a bed named the No. 2 Horizon and show complete structural conformity with the overlying and underlying sediments. The Federal lode contains more tourmaline and quartz and less sulphides than the conformable lodes which have a carbonate gangue.

Both lode types however contain large amounts of sulphides (35-50% in the Federal and 50-70% in the No. 2 Horizon orebodies, assays averaging 16% and 25% S respectively). The accepted conversion factors are 10 cubic feet per ton in the solid for the Federal and 9 cu.ft./ton for the Sill lodes. Pyrrhotite is the main sulphide. The presence of pyrrhotite is not always indicative of cassiterite.

The recently discovered Basset lode is related to the Federal lode type. It is still being tested.

The orebodies lie in a series of sedimentary rocks. The Federal lode is in an argillite which gives trouble on the hanging wall of the stope and is unsuitable for road material as it breaks up under the combined effect of water and traffic. Rocks enclosing the No. 2 Horizon orebodies are described as bedded dolomites, red oolitic sandstones, purple mudstones, cherts, greywackes and conglomerates in the Red Rock member and bedded dolomite, shales, siltstones and fine sandstones in the Renison Bell Shales. None of these rocks provide suitable road material.

The mining method is cut and fill stoping in both the Federal lode and the No. 2 Horizon orebodies.

(b) Equipment in Use.

Trucks	- Wagner MTT 423, Deutz A12L714 engine Tyres - 16.00 x 25 24 ply front. 18.00 x 33 32 ply rear. Rated capacity 23 short tons. 2 purchased October 1965-electric starters. 2 purchased October 1966-electric starters. 1 purchased March 1967 - electric starter. 2 purchased April 1967 - air operated starters.
Scooptrams	- Wagner ST 5, Deutz A8L714 engine. Tyres 23.50 x 25 front. 16.00 x 25 rear. Rated capacity 4½ cu.yd. struck. 2 purchased October 1965 - electric starters. Wagner ST5A, Deutz A8L714 engine. Tyres 18.00 x 25 front and rear. Rated capacity - 4½ cu.yd. struck, bucket changed at 5,500 hours to Esco 3½ cu.yd. capacity struck. 1 purchased October 1966 - electric starter. 1 purchased April 1967 - air starter, bucket not modified.
Jumbos	- Gardner Denver 3 boom with DH 123 drifters on Getman carrier, Deutz F4L 812 engine. 1 Purchased August 1965 (since modified by removal of one boom) - electric starter. Gardner Denver 2 boom with DH 123 drifters on Getman carrier, Deutz F4L812 engine. 1 purchased December 1966 - electric starter. 1 purchased September 1969 - electric starter. Also Gardner Denver and Atlas Copco single boom crawler type machines, compressed air powered.
Utility Vehicles	- 2 Wagner PT-10 utility trucks 1 ton capacity, Deutz A4L812 engines. Purchased October 1965 - electric starter. One unit scrapped November 1969. 1 HIAB scaling platform on Fordson County Super 4 tractor. Electric starter. Purchased August 1967. 1 Caterpillar D6 Bulldozer. Purchased July 1967. 1 Massey-Ferguson Model 135 tractor with 2 wheel Ferguson trailer. Purchased November 1968. 1 low loader trailer to carry crawler tracked drill rigs between stopes and surface. 1 Caterpillar 950 front end loader with 2½ cu.yd. bucket for loading from surface stockpile and carrying to crusher bin. Purchased October 1968 - electric starter. Recently fitted with tyre chains. 1 Caterpillar D5 Bulldozer. Purchased September 1968. 1 Deutz Model D4006A 4 wheel drive tractor with trailer purchased August 1969.

(c) Transport of Equipment and Routine Servicing.

All working places are accessible through the decline which is 14 feet by 14 feet in section and has an average gradient of 1 in 9. However, pipes are located overhead and there is a practical limit of about 9 feet of headroom. With the establishment of ventilation connections it is possible to remove the large diameter ventilation pipe used before the establishment of through ventilation.

Headroom of 10 feet will be established when the ventilation pipe is removed and other pipes relocated.

Routine maintenance of vehicles is done on the surface before the start of each shift by maintenance crews. The afternoon shift maintenance men prepare vehicles for night shift. Refuelling is also done on the surface.

A low loader trailer is used for the transfer of tracked vehicles such as the crawler drill jumbos.

(d) Operational Details.

(i) Preparation for Stoping. Information about the orebodies is obtained from diamond drill holes laid out in horizontal fans from suitable places on the decline. Ventilation and fill rises are provided by Alimak rising and the initial silling out and stoping is by crawler-mounted, air operated drills and rubber-tyred diesel loaders and transporters.

(ii) Drilling. The basic hole size is 1¾ inch, with 1 5/8 inch bits to follow where this is necessary.

Machine.	G-D Air trac DH 123 (Federal Stope)
Hole Dia.	1¾ in. (all areas)
Av. Hole Depth.	10 ft (all areas)
Tons Ore/Ft Drilled.	1.05 (Federal Stope)
Shank Life - Feet.	2800
Rod Life - Feet.	1900
Coupling Life - Feet.	2400
Bit Life - Feet/Sharpening.	10
- Total - Feet.	440
Penetration Rate.	0.489 min/ft (Test Period).
Drilling Rate (Incl. Delays).	332 ft/shift
Air Pressure.	95-100 lb/sq.in.
Working Time.	8 hour shift less 60 min travel and crib.

(iii) Blasting.

Hole Diameter.	1¾ in.
Hole Depth.	10 ft (last 12 months - previously 20 ft).
Average Firing.	56 holes, pattern 5 ft x 5 ft, inclined at 50 degrees.
Explosive.	ANFO
Initiation.	1¼ in. dia. AN60 primers, electric millisecond delay detonators.
Explosives Factor.	0.8 lb/ton.
Charging Density & Rate.	Not Available (Calculated about 1.4 lb/ft).
Size of Boulder.	Limited by tailgate on MTT 423 - about 3ft x 4ft. Little secondary breaking required but when needed holes are bored with airleg and fired with AN 60 gelignite, fuse and detonators.

(iv) Loading and Hauling. Scooptrams are used to load the MTT trucks, which drive into the cut and fill stope, so lead distances for the loaders are often quite short in stoping, possibly averaging as little as 50 feet. In development, distances are greater and the overall average is possibly 300 feet, with a maximum of 500 feet. Loading rates, including delays, vary with distance. Difficulty in filling the bucket is a very important factor. Loading rates varied from as low as 80 to over 250 tons per hour in the study carried out in January 1969 (Appendix 11).

Delays varied from as little as 15% of the total time available when mucking out the Renison decline to as much as 58% in the Stebbins area which was currently being opened up and where the quantity of air circulated placed a limitation on the number of vehicles that could operate in a given area at any one time. At present ST5A machines are regularly used in ore with ST5 machines providing additional capacity on this job when required.

MTT trucks operated over one way distances ranging from 3,000 to 5,500 feet. The Federal stope haul was about 4,000 feet at the time the operation was inspected. An average of 133 tons per manshift was obtained from the whole transport operation using Scooptrams and MTT trucks. For Scooptrams approximately 0.7 maintenance manhours were required per Scooptram operating hour in the first 8 periods of 1968/69.

A satisfactory solution for control of floor height and fill dilution has not yet been reached in the cut and fill operation in the Federal Lode. The practice of painting a line 1 foot above fill level has been superceded by painting a line 5 feet above the fill level. This has the advantage of being easier to paint up and closer to the operators' eye level.

Waste is left in the cut and fill stope whenever possible. The principal source is overbreak of the hanging wall. The presence of sulphides is only a poor guide to the presence of tin, and panning of stope samples is sometimes undertaken to determine ore from waste. The foot and hanging walls are marked up by paint lines on the back of each lift in the Federal lode. These marks are placed by the geologists on the basis of their examination of the back, adjacent drilling data, mapping on previous lifts, etc.

Due to wheel spin when filling buckets and the poorer road conditions under which they operate for most of the time, the Scooptrams have much higher tyre costs than MTT trucks which have higher fuel costs. Tyre lives appear to average about 116 hours on loaders (86 changes in 10,051 hours) and about 274 hours on trucks (54 changes in 14,842 hours). Chains, having a life of about 1000 hours, are used on the front wheels only of the Scooptrams. Chains have also been fitted to the Caterpillar front end loader. Hard rock lug non-directional pattern tyres are used on Scooptrams and trucks, with the extra deep tread type used where clearances permit. Poor driving technique in arduous conditions can give lives as low as 40 hours for Scooptram tyres. Recapping is practiced as often as carcase condition permits.

(v) <u>Preparation of Stopes and Filling</u>. In the cut and fill stopes two access ways are established to each stope floor from the decline. This divides the stope into three blocks for filling purposes. Waste broken in development is used for filling at the rate of 0.48 cu.yd. (broken) per ton of ore. Spreading only is accomplished at the rate of 313 cu.yd. per manshift. Fill dropped from the surface through a 7ft x 7ft pass has been distributed by Scooptrams or by bulldozer in the areas close to the foot of the pass. However, in the last twelve months, underground development waste has provided sufficient fill - none has been required from the surface.

(vi) <u>Labour Requirement</u>. In cut and fill stoping in the Federal Lode, the requirement per ton produced used for budgeting purposes is 0.016 hours of Scooptram, 0.032 hours of MTT truck and 0.95 feet of Air-Trac drilling. The requirement is then related to machine availability to give the number of machines required for a given level of production. At the present level of production the underground crew is about 68.

(vii) <u>Securing Ground</u>. The HIAB scaling platform is normally used for barring down in the cut and fill stope.

(viii) <u>Roads and Stope Floors</u>. As previously mentioned, the argillites and other sediments in which the orebodies are located are not particularly suitable for road construction. At present crushed rock fines from an old open cut are used as a dressing on haul roads. No surfacing is placed on the mullock fill in stopes, but the possibility of doing this with advantage is being explored. Another possibility receiving attention is the opening of a quarry away from the immediate mine area to produce concrete aggregate and road metal of better quality than that currently available.

(ix) Dilution. Although no actual measurements have been made it is considered that dilution might amount to 7% in the cut and fill operation. This is made up of overbreak not left in the stope and top layer of fill removed with ore during loading.

(x) Alternative Uses of Scooptrams. Apart from loading MTT trucks Scooptrams are also used for spreading fill from fill rises in the cut and fill stopes, and to provide working platforms for pipefitting. Possibly 15% of Scooptram time at present goes into these auxiliary operations. There is scope for the development of suitable utility vehicle for use in overhead pipefitting.

(xi) Ventilation. The main ventilating air current is provided by exhaust rises located at each end of the mine and fitted with exhaust fans, capacity 150,000 c.f.m. each at 5½ in. w.g. Intake air comes through the access decline and through ventilation rises as well.

The ventilation requirements are laid down as Statutory Rules, 1969 No. 52 under the Tasmanian Mines Inspection Regulations 1969. A permit in writing from the Chief Inspector is required before a diesel engined machine may be used underground and this permit specifies the ventilation requirement. This is usually based on data set out in the United States Bureau of Mines Schedule 24 and is of the order of 100 c.f.m. per engine horsepower. Draeger tubes are used for the measurement of gases present. Limits for ventilation quality generally are those prescribed in the Schedule of Recommended Maximum Concentrations of Atmospheric Contaminants for Occupational Exposures, issued by the National Health and Medical Research Council of Australia. The main limits quoted in Regulation 89(2) are as follows: not less than 20% oxygen; not more than, 5,000 p.p.m. carbon dioxide, 50 p.p.m. carbon monoxide, 25 p.p.m. total oxides of nitrogen expressed as NO_2, 20 p.p.m. hydrogen sulphide, 5 p.p.m. sulphur dioxide, 5 p.p.m. aldehydes and 5 p.p.m. NO_2.

In blind headings at Renison the exhause system of ventilation is used, so that air containing diesel exhaust gases is drawn away through the ventilation piping.

(xii) Pillar Mining. The question of removing the crown pillar from the Federal lode is being considered but no firm conclusion has yet been reached.

(xiii) Working Time. Shifts are worked 8am - 4 pm - midnight and midnight to 8 am on a five day week. The midnight to 8am shift is primarily for development, but after meeting development requirements the transport crew proceeds to the stopes and hauls ore. The normal procedure is to operate two loaders and five trucks per shift, with additional loaders if fill spreading etc. has to be done.

(xiv) Tramming Speeds. Because of prevailing road and other conditions underground, only first and second gears are available to drivers, the others being locked out by the maintenance crew. Under these conditions Scooptrams have a maximum speed of 7.2 m.p.h. and MTT trucks 5.5 m.p.h. Block signals, operated by the vehicle lights, also serve to limit vehicle speeds to about 6 m.p.h.

(xv) Transfer Points. At the surface, MTT trucks and Scooptrams or the front end loader discharge over stop logs either into the crusher feed chute or onto the stockpile. Because of the high pyrrhotite content, ore is susceptible to spontaneous combustion and to consolidation due to oxidation if left on the stockpile too long.

(c) Availability and Utilization.

Availability is assessed in terms of the number of hours all machines were available out of the 24 hour five day week for which they may be theoretically required. Over the eight periods of 1968/69 financial year up to the time of my visit, Scooptrams had been available for 10,163 hours and used for 6,168 hours - an availability of 66% and utilization of 40%. Similar figures for MTT truck availability were not available, but utilization amounted to 8,007 hours - about 31%.

(f) Operator Training.

As in other States, the Tasmanian Mines Inspection Act requires that operators of diesel engined vehicles shall be competent and authorized to drive by the Mine Manager. Some of the operators were previously miners using conventional equipment in the old Renison Bell mine. Most of the more recent recruits claim to have had some experience in operating construction plant.

New operators initially drive on the surface only and spend a total of one week in the maintenance shop under instruction by the mine foreman. A recent concentration of operations has permitted the appointment of shiftbosses to supervise transport operations and it is expected that they will take over the training of new loader and truck operators.

(g) Maintenance.

Engine hour meters are used to measure operating times. Major overhaul of Scooptrams seems to be requred at 2-3,000 hours, while one machine has reached 5,700 hours and is showing signs that a complete rebuild is required at about this time.

All rubber tyred jumbos are brought to the surface on Friday night and at least 2 shifts worked over the weekend in stripping and rebuilding rockdrills, building up pins, bushes, guide shells etc. Crawler jumbos and machines are serviced underground as required.

The three boom jumbo has been modified by increasing the size of the counterweight and improving the braking system. Recently the centre boom has been removed.

Axles on loaders and trucks do not appear to be a problem, the original size housings and rated axles being still in use.

Buckets on the ST5A Scooptrams originally had a lip. As this wore away it was fitted with a set of Esco replaceable point digging teeth. Elsewhere the bucket is built up by beads of hard facing. The Scooptram that has been operating longest was re-equipped at 5,000 hours with an Esco bucket of 3½ cu.yd. capacity. Probably there will be no overall drop on performance, as with the larger bucket, the density of ore is such as to lift the back wheels off the ground if its full capacity is used.

Most of the maintenance crew have an automotive background, and because of the extent of electrical equipment on the Wagner machines this is considered rather more appropriate for these machines than the background of a conventional fitter. Training on the particular machines is given on the job, and it takes about 3 months before an adequate background of experience is built up by a new man. Some advantage is taken of schools run on the mainland by suppliers of major components - engines, transmissions etc.

The whole crew numbers 14 of whom ten are tradesmen. Three men are rostered to afternoon shift, and one of these acts as leading hand in charge on afternoon shift only. There is a regular leading hand on dayshift as well as the foreman.

The maintenance men are paid normal rates plus overtime - an average figure is $1.90 per man hour.

Estimates of the time taken to change major sub assemblies are set out below:-

(a) Engines - 18 hours.
(b) Transmissions - 4 hours.
(c) Axles - no trouble experienced with these - time may amount to 6 hours, with over 8 hours for the front axle of an MTT truck.
(d) Tyres - around half an hour depending on the availability of equipment and tyres on the job.
(e) Buckets - changing rarely required as all equipment is driven directly to the working place.

The general question of major rebuilding of machines is becoming important to this company. There would be some advantages in carrying out this work by the company in view of the experience built up within the maintenance section. Probably some additional space and staff would be required if the rebuilding were carried out on the mine, rather than by the major component suppliers.

Another point of interest is the desirability of de-rating rebuilt equipment, or even converting some of the older production vehicles to provide service vehicles tailored to particular requirements. See King, 1968, for some details of practice in the United States and Canada in this connection.

(h) Supervision Management Planning etc.

With the recent closing down of outside operations (Battery mine and Open Cuts) and concentration of operations on the Renison decline mine itself, five shiftbosses are available to supervise the 3 shift operation. The usual distribution is to have one man on trucks and loaders i.e. ore transport, and one on development and services on each of day and afternoon shifts, with one shiftboss only on night shift which is, as previously stated, essentially a development shift only.

All these men have a background of conventional mining. They are paid approximately $80 per week and report to a Mine Foreman who normally works all day shift.

Planning over a 5 year period is carried out by the Mine Superintendent, and updated each year. Operating staff work on a yearly plan, and generally speaking, the staff involved is so small that frequent discussions for co-ordination are not difficult to arrange. However, increasing complexity of operation suggests the need for additional technical staff for planning purposes.

At the present time there are six telephones underground.

Supervisors use diesel Landrovers for transport, and each supervisor is provided with a vehicle during shift. Landrovers are used for supervisor transport only. Even so there is the feeling that a more robust vehicle, particularly as regards springs and chassis, would be more suitable for this particular purpose.

Labour turnover in the mine crew of 68 is affected by odd circumstances, such as the fact that 13 out of the last 26 terminations were survey chainmen! Probably a figure of around 40% per annum would give a reasonable estimate of the situation.

In the case of the maintenance crew, numbers are smaller still and over the last eight periods this group has gained seven and lost four to reach the present total of 14. Here again a figure of 40% per annum might not be unreasonable.

KALGOORLIE - MT. CHARLOTTE MINE OF GOLD MINES OF KALGOORLIE (AUST.) PTY. LTD.

(a) Background

Block A (surface to 500 feet) of the Mt. Charlotte orebody was mined by the cut and fill method using rubber tyred diesel equipment in the stope. Ore chutes were connected directly to a crushing station from which ore was elevated to the 5 level by conveyor belt to a storage bin above the 650 level skip loading pocket.

For Block B (500 feet to 900 Feet) another crusher has been installed just above No. 10 level, with provision to crush ore and mullock separately. Ore is broken in three open stopes, 100-120 feet long separated by rib pillars 80 feet long and with an 80 foot crown pillar left below the cut and fill stope of Block A. Two drives are used on each sublevel at 800 feet, 700 feet and 580 feet. These drives are circular in shape, 10 ft in diameter and located on either side of the orebody. Rings are blasted longitudinally, starting from a 12 ft wide cut off slot.

Broken ore is drawn through "mill holes" which are 14 ft wide and 45 ft long. 16 ft pillars are left between mill holes, resulting in a spacing of 30 feet. Most of these mill holes are located on 9 level, but because of the shape of the orebody some have been located on sublevels at 860 feet and 800 feet, reached by ramp. Rubber tyred diesel powered machines are used to transfer ore from mill holes to the orepass leading to the crusher. The term "mill hole" has been retained for local use at Mt. Charlotte because of extensive use at the Fimiston operation. In the Mt. Charlotte context however they would more correctly be called draw points.

Sub level development and ring drilling use conventional compressed air-powered equipment with haulage by electric loco on rail tracks. Development of the haulage level is by rubber tyred diesel equipment as is the decline which is being driven at 1 in 7 to provide access to Block C (900 feet to 1150 feet). Quarry type trucks with capacities up to 35 tons will be used to haul ore from mill holes (drawpoints) at the bottom of Block C to the existing haulage level ore tip. At the time of my visit finality had not been reached in the choice of truck for this duty.

A general description of the Mt. Charlotte orebody and cut and fill operations is given by Simpson, 1964. Appendix 8 contains a description of more recent operations and is an extract from a comprehensive description of all operations provided by the company. The orebody consists of narrow quartz veins containing pyrite, ilmenite and gold, in a massive medium grain dolerite. The veins are associated with altered ("bleached") rock, also containing gold. The whole mass is bounded by the Charlotte and Reward faults. Average economic dimensions of the orebody have proved to be of the order of 600 feet long by 150 feet wide.

At the time of my visit a start had been made on the removal by sub level caving of two rib pillars in the centre of the cut and fill block. Conventional equipment is used, the ore being passed into the open stope in Block B below. The openings thus provided are intended to allow the passing of fill from the surface into Block B.

Production in May 1969 was at the rate of 45,000 tons per period from Block B stopes, 3,000 tons per period from sub level caving of Block A pillars, and 2,000 tons per period from development. Of this total, all the stoping and about 60% of the development tonnage was loaded and hauled by diesel equipment.

No rock mechanics investigations have taken place since the early work on design of the cut and fill stope reported by Simpson, 1964.

For practical purposes Mt. Charlotte ore is regarded as occupying 12.5 cubic feet per ton in the solid and 21 cubic feet per ton when broken.

(b) Equipment in Use

Loaders - 2 Eimco 916 LHD machines (purchased December 1967 - air starter)
2 Joy Transloader TL55 machines (purchased latter half 1964 - electric starter)

Jumbos - 3 Gardner-Denver rubber tyred ring drilling jumbos with 1 DH123 rockdrill; 2 in use in sub level caving of Block A pillars, 1 in use in Block B slots
6 Atlas Copco Simba Junior skid mounted ring drilling rigs equipped with 1 Buffalo rockdrill; all used in Block B stoping.
1 Ingersoll-Rand Crawl - IR single boom jumbo with D475 rockdrill; used for development on haulage level.
1 Ingersoll-Rand 3 boom rubber tyred jumbo model MJM/D475A self propelled by diesel engine, mounting D475 rockdrills (purchased end 1968 - air starter); used for development on haulage level and in decline.
1 Gardner-Denver 2 boom jumbo - in workship being remodelled.

Utility - 1 Caterpillar 950 2¼ cu.yd. bucket front end loader (purchased early 1968 - electric start).
1 Allis Chalmers model D grader (purchased mid 1968 - electric start)
1 Chamberlain tractor model D470 Industrial Mark II fitted with fork lift attachment capable of lifting 5ft x 4ft platform to 15 feet.

(c) Transport of Equipment to Working Faces and Routine Servicing.

Units were lowered directly into the cut and fill stope from the floor of the open cut. With the completion of Block A, a shaft for servicing purposes has been sunk adjacent to the Reward Shaft which is normally used exclusively for hoisting on a 3 shift 5 day basis. The service shaft has a single cage and counterweight, the cage compartment being 10 feet by 10 feet.

There are large doors in the floor of the cage and the larger items of equipment are broken down, usually into two or three pieces and slung from the winder rope attachment through the bottom of the cage. In order to handle the heavier items of equipment the winder rope must be reeved to a three part line, and this takes up the best part of a shift. The cage acts as a traveller to keep the machinery being lowered in the centre of the compartment. The degree of breakdown required is along the following lines:

Grader	1 piece.
Transloader	2 pieces.
3 boom Jumbo	booms separated from body.
Eimco LHD	bucket plus two halves of body.
Caterpillar 950	bucket, and arms too usually, removed from body.

One of the loaders is usually employed to pull lowered equipment from the shaft; an air hoist is available to assist in assembly of the units underground.

An underground repair centre has been established on 9 level. At the end of each shift the maintenance crew work later than the operators and undertake refuelling, exhaust scrubber servicing and checking of vehicles to be used for the next shift. Drivers do not take part in this operation at all.

(d) Operational Details.

(i) Preparation for Stoping. Sublevel development is carried out using conventional methods of air leg drilling with tungsten carbide tipped bits. Broken material is loaded using Eimco rocker shovels into 1¼ ton capacity side tipped trucks hauled by storage battery locomotives.

(ii) Drilling. Holes in the Block A pillar stopes are being drilled 2¼ inches in diameter, in stoping in Block B 2 inch holes are used, and in development with the 3 boom jumbo 1¾ inch holes are drilled except in the cut which is formed by 4 holes 3 inches in diameter (not charged) and a central 1¾ inch diameter hole which is charged and fired.

Machine	G-D single boom	Simba	I-R 3 boom
Hole Diameter	2 in.	2 in.	1¾ in.
Av Hole Depth	40 ft	60ft-80ft max.	12ft (now replaced by 14ft for which performance figures are not yet available)
Tons Ore/Foot Drilled		3.2	
Shank Life		couplings 380ft rods 600 ft	Seco rods 1365 ft Coromant rods range 14-674 ft I-R spiral 1380 ft (first break). Couplings 1065 ft
Bit Life		per sharpening 28ft total 692 ft	per sharpening 24-36 ft total 386 ft
Penetration Rate		4 ft in 3-4 min	
Drilling Rate	100ft/manshift includes some shifting	Averages 140ft/ manshift, includes some shifting.	
Av Air Press	Up to 100 lb/sq.in.; never below 90 lb/sq.in. Little variation between shifts.		
Available Working Time	6 to 6½ hours		
Drilling Delay	Rockdrills are maintained on a breakdown basis. Stuck steels are the other principal source of lost time.		

(iii) Blasting.

	Stoping	Development (Jumbo)
Hole Diameter	2in.	1¾ in.
Firing Pattern and Tonnage Broken	6½ft burden 15ft toe spacing, fans interlocked. Up to 3 rings-45,000 tons	40 holes/end 12ft deep 4 holes 3 in. diameter in cut.
Explosive	ANFO except for up holes above 35 ft-Anzite in those	ANFO except for Decline lifters-gelignite in those.
Initiation	1½in Anzite primers at collar and half depth. Full range millisecond delay detonators.	Half second delays primer placed in centre of hole.
Charging Density	1.5 lb/foot of hole (including spillage) 0.35 lb/ton.	
Charging Rate	6 men take 6 shifts to charge 1 ring -15,000 tons	ie. 2 crews of 3 men take 3 days.
Secondary Breaking	Holes drilled with airlegs semigel explosive.	

Note: 1. In the 1 in 7 decline 8 lifters and 14 back holes are used for the 17ft wide x 14ft high opening. The miner operating the jumbo is paid per foot of hole drilled, not per foot advance. Exactex is to be used to obtain a smooth back and much attention given so that each end is taken out on the 1 in 7 grade.

2. Poor charging density in the upper portion of up holes is thought to have been the cause of poor fragmentation in some blasts, and holes beyond 35 feet vertical height are now charged with Anzite plugs, the rest with ANFO placed by NVE Anoloader. A charging density of 1.5 lb ANFO per foot of 2 in. hole is regarded as satisfactory.

(iv) Loading and Hauling. Mucking rates from mill holes vary but 200 loads/shift with the Eimco and 80 loads with the Transloader seem to be the maximum normally attained. An average figure covering variations in drivers and equipment, delays etc is 500 tons per manshift.

The average haulage distance is 500 feet (one way) ranging upwards from a minimum of 400 feet. Of an average working time of 6½ hours, machines are usually available for 80% of this time. Production requirement of 50,000 tons over 40 shifts per period is obtained by scheduling 2 Eimcos on one shift per day and 2 Eimcos and 1 Transloader on the other. One Transloader is scheduled for development ore. Because of tight shaft schedules mullock is handled at a fixed time twice a week (Tuesday and Thursday) and all haulage units concentrate on mullock at these times until the mullock pass is full. Pass capacity, originally 500 tons, has since been increased to 1000 tons. About 3-4,000 tons of mullock is hauled per period at the present time.

A figure for maintenance in terms of tons mined per maintenance manshift can be deduced from the size of the maintenance crew, and is approximately 150 tons per manshift. This would exclude rockdrill maintenance, carried out by special crews at G.M.K.'s main plant area. Another relevant figure for loaders is 1½-2 maintenance manshifts per operating shift.

It is not practical to selectively mine ore in the open stoping method used for Block B. Some limited selective mining was practiced in the cut and fill stoping of Block A.

There is some information available on the relationship between performance and tramming distance and this information, collected by the Planning Department of Gold Mines of Kalgoorlie, is set out in Appendix 9. The results of this study indicate that personal factors and manoeuvring complexities in the tipping area tend to have a greater effect on performance than the actual distance travelled.

Non directional hard rock lug pattern tyres are used on production machines. Front tyres on transloaders, not being driven, have a long life. Rear tyres last about 450 hours. Tyres on the Eimco loaders last an average of 250-300 hours. Up to three relugs are possible. Water is used in Transloader rear tyres to act as ballast, but otherwise air is used for tyre inflation.

Tyre chains were tried in the past, but conditions being severe, considerable maintenance was required to keep the chains operational. The trial set were taken out of service after about 600 hours and were regarded as 75% worn at that stage.

Further trials are to be undertaken using a closer pattern chain, as a review of figures suggested that some potential for cost savings was indicated by the earlier tests, even allowing for the additional maintenance required.

Substantially higher tyre lift was obtained in the cut and fill stope - Transloader tyres running to 1300 hours.

(v) Filling. No filling is taking place at present. Sub level caving of the two Block A rib pillars is designed to provide passage for fill from the surface to Block B. Stopes and pillars in Block B have been so proportioned that swelling of pillars on firing will just occupy the available space. Controlled drawing from the 30 ft spaced mill holes below Block B should then permit maximum recovery of pillar ore before fill dilution becomes excessive. As fill subsides more can be added at the surface through spaces made by pillar removal in Block A.

(vi) Labour Requirement. For stope drilling nine operators and two labourers (for machine shifting) are required. The mucking crew consists of two operators on one shift, three on the other, together with one operator on each shift who is full time on development mucking. One driller operates the three boom jumbo one shift per day for major development headings.

(vii) Securing Ground. The platform on the Chamberlain Tractor is sufficiently stable to allow rockbolt installation from it. Ground conditions generally are good. In Block B, only the backs in the crusher station and garage area have required support. This has been done with ARC mesh and rockbolts 6 ft long, with expansion shell type anchors.

(viii) Roads. Small quantities of special material are taken underground loose in the Service Shaft cage for road improvement purposes. A suitable mixture that has been used in the past consists of:

½ Paringa tailings sand
1 dust (quarry dust, loam etc)
2 ¾in. crushed stone
2 ½in. crushed stone

All mill holes seen on my visit appeared to slope down into the stope to a greater or lesser degree and were wet. A certain amount of this water was picked up in loader buckets and drained out along the roads.

Design of mill holes calls for a step up above the drive floor and for the mill holes themselves to be driven up at a grade of 1 in 50 to 1 in 70. Although such a design may be drier than those that I saw being used, the roads themselves at mill hole entrances may be wetter as a consequence.

A limited experiment in the production of material of suitable size for roads has been carried out by increasing the number of holes and quantity of explosives used in excavation of a development end. Results were not conclusive, but the technique might prove useful in solving a temporary difficulty where shaft time to lower road material was not available.

Development dirt is generally stowed until mullock is crushed. During stowing, suitable loads are often bypassed to be used on roads.

The normal haulage crew includes an operator for the grader on the opposite shift to the production Transloader, both being used normally on only one shift per day.

The siliceous nature of the ore provides a particularly abrasive road surface and this is reflected in the difficulties experienced in maintaining tyre chains and in the marked contrast in tyre wear between cut and fill mining in Block A and the mill hole operations in Block B.

(ix) Dilution. There is some overbreak in the sublevel stope due to breaking back along heads. Some dilution from fill must be expected in the pulling of broken pillar ore from the mill holes. However neither of these can be related to the use of rubber tyred diesel equipment.

(x) Other Uses of Equipment. Provision of the Caterpillar 950 front end loader as a utility vehicle means that the Eimco LHD machines and the Transloaders are rarely used for purposes other than loading and hauling ore and mullock, at any rate during the scheduled 40 production shifts per period.

(xi) Ventilation. Block B is ventilated by a 100 inch diameter fan on the surface which exhausts air from the Block via an 11 ft diameter ventilation shaft raised from 9 level. The capacity of the fan can be increased over a wide range by changes in number and pitch of the blades to a maximum of 200,000 cubic feet per minute at 12 inches water gauge.

Ventilation of development ends where rubber tyred diesel equipment is used is carried out by electric fans having a capacity of about 15,000 c.f.m. at 5 ins. w.g. blowing fresh air to the face through collapsible plastic film tubing.

The Regulations under the Mines Regulations Act are being revised. Those currently in force are the subsections of Reg. 246 in Section xiii. The requirement is for a minimum flow of 5,000 c.f.m. in any place where a diesel is used, and for minimum air quality standards of oxygen not less than 20% and not more than 0.25% CO_2, 0.01% CO and 0.0025% oxides of nitrogen. The exhaust gas must be cooled to 170°F. Draeger tube type instruments are used for gas analysis.

(xii) Pillar Mining. This has been described in previous sections. The rubber tyred diesel equipment will be used to draw pillar ore in the same way as open stope ore. Possibly the method proposed has resulted in slower development in the provision of a large number of mill holes under pillars as well as stopes, but there has been little other effect on stoping operations.

(xiii) Working Time. The mine operates on a 5 day week basis, with production on 2 shifts per day. Each shift is of a normal 7½ hour duration, (including half an hour for crib) but actual working time is probably about 6½ hours.

(xiv) Tramming Speeds. The data collected in the course of the study which forms Appendix B shows that tramming speeds averaged as high as 10.8 m.p.h. for the Eimco LHD machines. They rarely operate in top gear and normally load in first and tram in second. Overall travel speed of the Transloaders is affected by the face forward driving position restricting reverse direction travel.

(xv) Transfer Points. The orepass at the haulage level must provide for both Eimcos and Transloaders to discharge. The latter require a drive - over facility and this is provided by a grizzly set in the floor over the top of the pass. The main elements are 15 in. x 6 in. R.S.J. sections set at the Transloader wheel track centres (about 4 ft 5 in) with an 18 inch wide wearing plate on top supported and braced to the bottom flange by 4 inch bars to give a tapered opening. A transverse R.S.J. brace divides the grizzly into two large holes, flanked by a total of 4 holes each about 40 inches square. The whole unit weighs about 12 tons.

(e) Availability and Utilization.

Availability is expressed by those in charge of maintenance as the percentage of hours out of the potential seven per shift over which equipment is available for use. Normal production schedule requirements are then considered in arriving at a figure for the average over a long period. Requirements are listed above, but briefly both the Eimco LHD machines are called for on two shifts per day, five days per week; one Transloader on one shift and two on the other, each day for five days per week. The Caterpillar 950 is required two shifts per day five days per week.

Under this definition Eimco LHD availability is 68%, Transloader 60% and Caterpillar 950 75%.

Utilization is defined as engine hours recorded divided by number of shifts worked multiplied by seven hours per shift.

Using this definition in the first four periods of this year the following figures were obtained:

Cat 950	- 75%.
Transloader	- 37.5%.
Eimco LHD	- 56%.

(f) Operator Training.

Loader drivers are usually recruited from the ranks of machine miners. They are given one week's training with a regular driver and then tested by the Fitter Foreman. Initially new drivers work on Transloaders or the Caterpillar 950 and graduate to the Eimco LHD machines only as vacancies occur.

The Mines Regulation Act Regulation 246D requires that the Mine Manager authorize in writing the drivers of diesel engined machinery. Such authorization is issued to those passing the Fitter Foreman's test. Shiftbosses are also authorized to cover the rare occasions when they are required to move a machine.

(g) Maintenance.

Major sources of trouble encountered to date with the Eimco machines have been axles. A total of 13 front and 2 rear have been broken. Modifications have been made, including increased axle size and a change in the type of bearings used in the planetary reduction system in the wheel hubs. Any further increase in axle capacity will not be easily achieved as the axle housings themselves are now the factor limiting increase in component size. Hydraulic ram and pump failures have also been a significant source of lost time.

The first Eimco buckets gave short life, apparently due to incorrect material being used in their fabrication.

Major overhauls are carried out when indicated by the regular inspections, including compression tests, which are carried out at 120 hour intervals. In general, engine efficiency falls off to such an extent that overhaul is required for this reason rather than because of poor exhaust conditions. Spare engines are carried for the Eimcos and the Transloader. Transloaders have been completely rebuilt three times in a life of 14,000 hours. Eimcos had been operated for about 3,000 hours of the time of the writer's visit. Much damage is said to be caused by the practice of not letting the machine stop and engine speed drop before changing direction.

Engine hour meters are used to record operating hours. Electric units are described as proving more positive than the hydraulic ones. Separate records of work done are kept for each machine.

All machines are being progressively changed to an air spray type of exhaust scrubber in which water is supplied to 40 thousandths of an inch diameter orifice sprays from a pressure tank, kept at 12-15 lb/sq.in. by a reducing valve from the machine's compressed air system. This method eliminates the requirement for a water pump which has proved to be a source of trouble in the machines equipped with this method of providing water under pressure for the sprays.

Buckets have been fitted with Esco teeth nine being used on the partly worn lip in the case of the Eimco machines. Series 32 teeth are used on the Eimco buckets and series 25 on the Caterpillar and Transloader buckets. It is felt that the use of larger teeth on the Eimcos would contribute toward early failure of the backs of the buckets, which have a clamshell action.

As an experiment a number of alloy steel wearing strips in a V shaped pattern have been welded to the bottom of one Eimco bucket.

Maintenance crews are drawn from fitters or automotive mechanics with a diesel engine background and receive "on the job" training on particular machines. The crews participate in the general underground bonus and overtime. They usually work one extra shift (Saturday) plus an extra hour each shift for some men on refuelling and checking machines for the oncoming shift.

The crew consists of a Fitter Foreman and Assistant Fitter Foreman, both on day shift and six tradesmen, four of whom would be on day shift and two on afternoon shift at any given time. In addition there is a lubrication serviceman on day shift. The maintenance crew does not handle rockdrills - these are serviced at the Golden Mile section of G.M.K.'s operations.

Change times required for the major items of equipment as set out below:

(i) engines - 2 shifts
(ii) transmissions - 1½ shifts
(iii) axles - 1 shift
(iv) wheels - range 20 minutes to half an hour
(v) buckets - half a shift.

(h) Supervision, Management, Planning.

The Fitter Foreman is responsible to the Mine Manager Mt. Charlotte, for mechanical operations and to the Assistant Mechanical Engineer (G.M.K.) for technical aspects. On the mining side, supervision of day to day operations is carried out by a total of three foreman and seven shiftbosses. All these supervisors hold Underground Supervisor's Certificates of Competency issued by the Western Australian Mines Department, and are authorized diesel machine drivers as well.

The Drilling Foreman looks after conventional development of sublevels etc and ring drilling and blasting. The Development Foreman is concerned with cutting mill holes and development of the haulage level, as well as driving the decline for Block C. The Production Foreman is concerned with ore haulage and hoisting. Each foreman has two shiftbosses, one on each shift, and the seventh shiftboss is available on dayshift and works largely in the field of drilling and conventional development. Pay rates for shiftbosses are about $70 per five day week - but overtime is paid for beyond this.

Planning the physical layout of the Mt. Charlotte operation is the responsibility of the G.M.K. group Planning Department. The general arrangement for the whole block is considered and agreed upon between the operating staff and the Planning Department. Details of the overall plan are prepared by the operating staff. Similarly the basic scheduling is carried out at a joint meeting of operating and planning groups, but in this case it is the operators who take the principal part and also go into further detail as required from time to time. Production is limited to 50,000 tons of ore per period by shaft capacity. Production targets for the Mt. Charlotte mine are set by G.M.K. management.

Communication is maintained between the Winder House and every underground plat by telephone. No transport is provided for supervisors, nor is it necessary in a mine the size of Mt. Charlotte. However, the question of transport will become more important as development proceeds in Block C, to which access for service and haulage will be by the decline only. This question was receiving attention at the time of my visit. A diesel engined Landrover was subsequently purchased.

Labour turnover is very low. In the maintenance group it amounted to only 16%. However, with turnover at a low level and a small crew, the loss of one very experienced man can affect efficiency of the group to a greater extent than the bare figures indicate.

COMMENT ON ASPECTS OF PRACTICE

APPLICATION OF EQUIPMENT.

In some cases, new mines have been opened in which the whole operation is carried out with rubber tyred or caterpillar tracked equipment. There are no railway tracks at all. Cobar Mines Pty. Ltd., Renison Ltd, and Cleveland Tin N.L. are examples of this situation. At Cleveland however, conventional equipment is being introduced for stoping areas less than 8 feet wide. Located at the extremities of the orebody, ore is picked up by rubber tyred equipment after scraping to the wider section.

Elsewhere, as at New Broken Hill Consolidated and Mt. Isa Mines Limited, rubber tyred diesel equipment has been introduced for a particular section of the mine to meet a particular problem. From this beginning, the equipment has become more widely used, particularly at Mt. Isa, because it has permitted much quicker production from normal stoping operations by eliminating the extensive preparatory work required for slusher installations.

At the Mt. Charlotte Mine of Gold Mines of Kalgoorlie (Aust.) Pty. Ltd, which is a smaller operation, some use of conventional railway tracks and equipment has been made in development of stopes for ring drilling and supplying the ring drilling operation as well as in pillar mining.

Where shaft haulage is employed it seems usual to use the Wagner Scooptram and Eimco LHD machine as transporters as well as loaders of ore. Where shaft haulage is not used as at Renison and Cleveland the rubber tyred diesel powered ore transporters travel into stopes and the Scooptrams are used primarily as loaders with noticably reduced maintenance on axles.

In development, the use of diesel equipment is usually limited to areas in which it will be used for haulage later. However, there are some advantages in development of what will ultimately be rail tracked haulages by diesel equipment. This is particularly the case where broad gauges and large and heavy locomotives and trucks are to be used. The laying of temporary tracks can be avoided by the use of rubber tyred equipment.

In other cases, best use of scarce development miners can be made by providing them with high capacity rubber tyred equipment, easily moved from one face to another so that several may be advanced at the same time.

EQUIPMENT IN USE.

The Wagner Scooptram and Eimco LHD machines between them seem to have superceded the Joy Transloader for load and carry applications. Most underground profile trucks appear to be Wagners, though a Euclid was on trial at Cleveland Tin N.L. The possibility of using ordinary quarry pattern diesel trucks was under consideration in Western Australia.

In drilling, Gardner-Denver two and three boom jumbos on diesel powered carriers predominated in development and two boom jumbos were also important in stoping though to a lesser extent. Ingersoll Rand and Atlas Copco supplied the other units used in development. In stoping the use of air rather than diesel powered equipment of a less elaborate nature was particularly noticeable in the established mines such as Mt. Isa and New Broken Hill Consolidated.

For utility purposes the Wagner PT-10 and UT-42 appeared to be fairly generally used, often modified to provide a platform for scaling and rockbolting. A variety of alternative utility vehicles adopted from standard industrial or agricultural tractors was found including such makes as Fordson, Chamberlain and Massey-Ferguson. The Mercedes-Benz Unimog, converted jeeps and standard diesel powered Landrovers were used by maintenance and supervisory personnel.

The question of a suitable vehicle for supervisors seems still unresolved. The Landrover does not seem robust enough, particularly when driven by a number of different people on a multi shift operation. Possibly the answer to this problem, as to some other ones, lies in greater attention to road surfaces.

In a few operations old production vehicles have been modified for use as maintenance transport or for special purposes such as Raise Borer Machine transport. Other operations will probably follow this course as the first production vehicles are retired from service in their original roles.

At Cobar Mines small stores are carried underground from the surface by a small building contractor's site vehicle, powered by a 2 cylinder diesel engine, and fitted with an exhaust scrubber. Other stores are handled in small rubber tyred trailers coupled together to form a train and towed on the surface by a utility truck.

More specialized vehicles such as conventional front end loaders, with bucket capacities 2¼ cu.yd. or less and industrial tractors with backhoes are used for special auxilliary purposes so that the Scooptrams or their equivalents can be available always for production and not side tracked to help with pipe fitting, transport of stores and equipment and stope preparation where the cut and fill method is in use. The facility with which bulk stores and robust equipment can be unloaded from front end loader or load and carry machine buckets is a significant factor in operator preference for their use for this kind of auxilliary purpose.

The buckets of load and carry vehieles can be used for road construction and maintenance, but, where the length of road requiring maintenance is sufficiently large, small graders are profitably employed. These are usually of the kind normally used on the surface, but Mt. Isa Mines has tried with some success a machine of German origin specially designed for underground work in potash mining.

TRANSPORT OF EQUIPMENT.

Mines such as Renison and Cleveland which are served by a decline from the surface have few problems as regards transport of vehicles to and from their working places. At Renison, a low-loader trailer is used to move tracked vehicles such as stope drills, bulldozers, etc., to avoid damage to main roads.

Where access to the underground workings is by shaft, transport of equipment, fuelling and maintenance all become more complicated. In the very largest mines, such as Mt. Isa, the scale of operations often permits the use of winders and cages big enough to transport equipment underground without disassembly. In other cases, with the knowledge that rubber tyred diesel equipment is to be used, a larger than usual cage can be provided for servicing purposes.

In smaller operations such as the Mt. Charlotte Mine, the scale and depth of operations makes it necessary to use a relatively small shaft and winder for servicing. Machines must be broken down into their main component parts and the winder rope reeved to a 3 part line. The latter operation takes the best part of a whole shift to complete. The cage remains in the shaft as a "traveller", the heavy items being slung from the winder rope attachment through doors in the floor.

At Cobar, a special very low profile trolley is used to load machines into the cage on their side, while at Mt. Isa, the fitting of special narrow wheels to some types allows all load and carry vehicles to be driven into the cage under their own power. At New Broken Hill Consolidated Ltd., a special cradle has been constructed of steel channel and angle sections complete with slippers for the shaft guides. This may be used with or without the cage for lowering heavy equipment. Special low flat top trolleys are also available for lowering sub-assemblies in the cage and transporting them along levels.

Where machines are to be used captive in stopes as in cut and fill operations the drives and rises or winzes giving access to the stopes are frequently a greater bottleneck than the main shaft.

ROUTINE SERVICING.

In this context routine servicing means checking pressures and inflating tyres, checking and topping up oil levels, refuelling, servicing scrubber tanks etc.

At Renison and Mt. Charlotte maintenance men do this work on overtime before or after the normal shift. At Mt. Isa, operators carry out the above tasks and also change batteries and wheels on rare occasions. In Broken Hill, drivers refuel and top up scrubber and other tanks but otherwise not carry out any servicing. The same applies at Cleveland.

Practice appears to vary from mine to mine depending on factors such as local industrial practice and whether vehicles are driven to the surface or major underground service shops at change of shift or are captive in stopes or other working places.

OPERATIONAL DETAILS

(a) Preparation for Stoping. At mines such as Cobar, Renison and Cleveland where equipment is all rubber tyred, vertical connections for ventilation, servicing, ore passes, etc. are the only portions of stope preparation carried out by conventional methods. Even here Raise Boring, Alimak Raise Climbers and cage rising are replacing the conventional methods, particularly for the longer raises where set up time for mechanical equipment can be justified.

At other mines where conventional rail mounted equipment is in use, sublevels in blast hole stopes and similar preparatory work may often be carried out with conventional equipment. The smaller size of opening needed and the lesser ventilation requirement are factors favouring the use of conventional equipment in these circumstances.

It is unusual for conventional equipment to be used for preparation for mechanized cut and fill stoping as was the case at New Broken Hill Consolidated Ltd., but this was a new installation in a special situation, and the conventional method adopted was very familiar to the workmen.

(b) Drilling. Hole depths in cut and fill stoping and development mostly lie at the lower end of the range 10-14 feet. At Mt. Isa, hole depths in blast hole stoping run as high as 110-120 feet, but the average is probably much lower - say 80 feet. The upper limit seems to be about 80 feet at most other places. Hole diameters range down from 2¼ inches for the longer holes to 1 5/8 or 1¾ inches for cut and fill stoping and development. There is a trend toward the use of smaller diameter holes. A few larger diameter holes (3-4 inch diameter) are frequently used in development cuts.

Tonnage factors in stoping range from 1.05-1.4 tons per foot drilled for the cut and fill method, ranging up to over 3 tons per foot drilled for blast hole stopes at Mt. Charlotte. Penetration rates range from less than 0.5 feet per minute at depth in some of the larger Mt. Isa holes to over 2 feet per minute in the short and small diameter holes used in development and cut and fill. Performance per shift varies with industrial conditions and time actually worked at the face as well as rock type, equipment, etc. Figures range from a low of 100 feet per manshift at Mt. Charlotte with a single boom jumbo to over 300 feet per shift at Renison and 400 feet per shift with a 3 boom jumbo in development at Cleveland. More usual figures seem to lie between 150 and 200 feet.

(c) Blasting. ANFO seems to be the universal explosive. Exceptions to its use include the upper portion of up holes at Mt. Charlotte where poor ANFO charging density is thought to have been the cause of poor fragmentation in some blasts. At Mt. Isa, ANFO is not used in downholes likely to contain water; nor is it used in stoping at Cleveland. ANFO charging densities of 1.5 lb per foot of 2 inch hole are regarded as satisfactory at Mt. Charlotte.

Electric millisecond delay detonators and rarely half-second delay detonators are used with AN60 or Anzite plugs as primers and boosters. Primers may be placed at the bottom and/or part way down the hole. Collar priming is used in stoping holes at Mt. Isa, and in conjunction with primers part way down the hole at Mt. Charlotte. Quantities of explosive charged range upward from around 0.4 lb per ton for open stoping operations to 0.75 lb per ton and more for cut and fill stoping, undercutting, etc.

Charging rates vary. At Mt. Charlotte 18 manshifts are required for 15,000 tons; at Cobar 1000 feet (the equivalent of 490 tons) is charged per manshift, while at Cleveland 2 stoping rings are charged in 2 shifts.

Secondary breaking is by drilled holes with fractional plugs of gelignite, except at Mt. Isa where plaster shots are more popular.

The size of boulder that can be handled at Renison and Cleveland is limited by tailgate openings of 3 feet by 4 feet on the MTT ore transporters. At Mt. Isa Scooptram buckets and the 6 feet and 8 feet chute front openings on the haulage levels are the only limits on boulder size. In stope firings at Cobar, large pieces sometimes fall from the brow without breaking. Holes already drilled are used for secondary breaking in this case or plaster shots are fired. Such loose pieces should be broken before the next firing takes place and they are buried.

(d) Loading and Hauling. Experience at several mines indicates that 500 feet is probably the practical upper limit for hauling with load and carry machines in development. In cut and fill stoping, haulage distances vary from averages of 100-200 feet at Broken Hill and Mt. Isa up to 400-1000 feet at Cobar. Mucking rates generally lie in the range 400-500 tons per machine shift in this sort of operation. At Renison, diesel trucks are used to haul ore from stopes to the surface over distances averaging 4000 feet. The load and carry machines are used primarily as loaders with haulage to trucks usually under 100 feet. Overall productivity of 133 tons per machine shift is obtained from this combined operation.

In loading from blast hole stopes as at Mt. Isa and Mt. Charlotte, production rates of 300 to 500 tons per machine shift, comparable with cut and fill mining, are obtained.

Results of studies at Mt. Charlotte indicate that personal factors and manoeuvering complexities in the orepass dumping area have a greater effect on performance than the actual distance travelled.

In cut and fill mining control of floor height and dilution (by taking excessive quantities of fill) is aided by white lines painted on walls, flat-beamed spotlights, etc., but basically it depends on supervision and operator skill.

Selective mining is practiced in the cut and fill stopes at Cobar where copper and copper-zinc ore are loaded separately and tipped into different ore pass systems. Elsewhere the flexibility of the rubber tyred equipment allows waste overbreak and inclusions to be handled separately from ore, and dilution reduced. This selectivity is usually only in cut and fill operations, but it also carried out to a more limited extent in the blast hole open stoping method used at Cleveland.

Load and carry machine tyre lives vary with the duty for which the machines are used. They range from as low as 40 hours in rough development ends with poor driving technique to as high as 500-600 hours in cut and fill stopes. The more usual range for average conditions appears to be 180-380 hours. Relugging is carried out as often as carcase conditions permit, usually two or three and rarely up to nine times.

Tyre chains have been tried at most operations. The advantages in increased tyre life are universally recognized. However, the maintenance problem of keeping chains tight is a major difficulty which inhibits their more widespread use. On some machines tyre clearances or the use of wheelspin restricting devices prevent the use of tyre chains on all four wheels.

(e) Preparation of Stopes and Filling. At Cleveland and Mt. Charlotte, filling was not part of the current operations at the time of the writer's visit. At Renison waste from development within the mine was providing adequate fill for cut and fill stoping. In the case of the other three mines, hydraulic fill was used for mechanized cut and fill operations, augmented by granulated slag, open cut overburden and development waste for the blast hole stopes at Mt. Isa.

At New Broken Hill Consolidated the construction of the traditional finger post barricade on pillar lines has been abandoned. Cement in the proportion of one to thirty of sand is now added to the fill instead. No cement additions are made at Mt. Isa and Cobar.

Even though construction of the finger post barricade is not required, stope preparation can be a frequent cause of cycle delays in cut and fill mining at Cobar and Mt. Isa. At Cobar, a diesel powered backhoe mounted on an industrial tractor was to be tried out soon after the writer's visit to speed up the digging out and extension of the Armco ventilation pipes.

Some changes have been made at New Broken Hill Consolidated to meet the requirement of more repid filling of larger blocks than was previously usual. Decantation as well as percolation is now used to remove water. Both methods are in use at Cobar and Mt. Isa also.

(f) Labour Efficiencies and Requirements. These are expressed by the various companies in different ways, but some generalizations are made below. Lateral development using rubber tyred equipment at Cobar and Mt. Isa is carried out at efficiencies of the order of 2.5-2.7 feet per manshift. Production at Mt. Isa and Renison is of the order of 330 tons per shift for the 5 cu.yd. bucket size load and carry machine. In cut and fill stoping at Broken Hill and Cobar, productivity of men engaged in drilling, charging,mucking and ground support is in the range 50-70 tons per manshift.

(g) Securing Ground. Provision to reach high backs is made through hydraulic platforms on either PT10 utility vehicles or Chamberlain tractors. Rockbolts can be placed from the platforms, but in cut and fill operations the broken muckpile is used for barring down and placing rockbolts whenever possible. Rockbolts from cut and fill muckpiles are either buried in the fill or recovered on crusher station magnets. In drawpoint brows at Mt. Isa long resin-grouted rockbolts have been found the best method of preserving the designed shape as originally excavated.

(h) Roads. Raise borer cuttings are becoming available in increasing quantities at more and more operations as this method of making vertical development openings is more widely adopted. Cuttings provide excellent dressing material for roads. Other materials used at various operations include selected bucket loads of fine rock from development, proportioned mixtures of tailings sand, dust and sized crushed rock, fine tailings (from the Cleveland heavy media plant) and fine crushed ore. In cut and fill operations, selected buckets of broken ore are spread on the sand fill to form temporary roads.

At special areas such as drawpoints, under chutes and in access inclines where traffic will be heavy and water damage is likely, some mines have favoured the placement of concrete in an effort to improve road conditions.

Load and carry machine buckets are used for road maintenance in isolated areas but for best results, graders, preferably equipped with provision to vary blade angle during operation, are universally used. Most of these are light construction machines, suitably modified for underground use, but Mt. Isa Mines have been pleased with the performance of a machine of German origin designed for underground work in the potash mines of that country.

At drawpoints, the use of concrete has already been mentioned. An alternative of rails embedded in fine ore is also being tried out at Mt. Isa but this design is not compatible with toothed buckets. Designs call for grades of about 1 in 30 up in order to obtain proper drainage.

A particular problem is encountered at Renison where none of the rock in the mine is suitable for road construction. A quarry, located in suitable material close as possible to the mine will probably be necessary to provide road material, concrete aggregate etc. of suitable quality.

(i) Dilution. In cut and fill mining dilution is usually held to a level of about 10% by careful supervision and skilful operators. The main sources of dilution are the picking up of fill with the bottom layers of broken ore and hangingwall spalling. Rockbolts and wire mesh may be required on the hangingwall for safe operating conditions, and dilution will be reduced also under these circumstances. The practice of firing inclined rather than horizontal holes is considered to result in less penetration of broken ore into the fill surface at Mt. Isa.

In methods other than cut and fill, the increased flexibility of layout of rubber-tyred diesel equipment over slushers and rail haulage may sometimes lead to a reduction in the quantities of waste included in mining outlines.

(j) Other Uses of Load and Carry Machines. In the cut and fill stopes at New Broken Hill Consolidated Ltd. and Mt. Isa where machines are captive in stopes, load and carry machines spend varying proportions of time on jobs such as charging up, barring down, grading fill, materials handling and breaking down and pushing up fill barricades. Wagner Scooptrams are preferred to Eimcos for fill barricade building because of their bucket tipping at a higher point. Time spent on these various activities is estimated to range from 5-35% of available time. In other mining applications where vehicles are not captive, the larger areas are served by Wagner Mining Scoops or construction type front end loaders so that the specialized load and carry machines can be reserved for that duty only.

(k) Ventilation. Ventilation practice varies in detail from mine to mine and State to State. Broadly speaking however, in major development ends and ends of stopes beyond the effective through ventilation, auxiliary ventilation by fan systems providing at least 15,000 c.f.m. is universally adopted.

Draeger tube type instruments are used for measuring exhaust gas concentrations, and this is normally carried out under no load full throttle conditions at four weekly intervals. Flow measurements are carried out at the same or more frequent intervals.

At both Cobar and Mount Isa, temperature and humidity conditions at the surface are sometimes very high. When more heat and humidity are added by diesel exhaust gases conditioned by water scrubbers, conditions in working places may, under these unusual circumstances, exceed those permitted under the Mines Inspection Acts and regulations; at least without a reduction in working hours. At Mt. Isa consideration is being given to the replacement of water scrubbers by catalytic exhaust gas conditioners. Although more expensive, the latter have the advantage of not adding to humidity and of requiring servicing at very long intervals. However, experience at Cobar Mines suggests that catalytic conditioners are not without their disadvantages, particularly for service vehicles.

In some cases, obstructions in the ventilation system may have the effect of so reducing the number of diesel powered vehicles in a given area that production is adversely affected thereby. This situation is more common in Tasmania where a minimum flow of 100 c.f.m. per horsepower is required compared with 50 c.f.m. elsewhere. The mining method at Renison is more vulnerable to this kind of difficulty because the large diesel engines of the load and carry machines and trucks are often operating in the stope at the same time.

Long drawpoints, as at Mt. Isa, require connections to special ventilation drives if the flow requirements of the regulations are to be met without recourse to fans and ventilation piping. The drives are located either above or below the haulage level.

(l) Pillar Mining. The flexibility of layout possible with rubber tyred diesel equipment has led to a number of interesting applications in pillar mining at Mt. Isa. The use of small load and carry machines is particularly noteworthy. At New Broken Hill Consolidated Ltd. the question of providing for the mining of rib as well as crown pillars has posed some problems in the choice between accepting substantial cycle delays while building conventional finger post pillar barricades and the addition of cement to hydraulic fill used round pillars. This latter change may adversely affect flotation recoveries in the mill, due to the presence of cement in decanted filling water and in the top layer of fill which is picked up as dilution in loading broken ore.

(m) Working Time. Cobar, Cleveland and Mt. Isa work a three shift five day week, with some overtime at Mt. Isa on production. Mt. Charlotte, New Broken Hill Consolidated and Renison work two shifts per day on ore production, the third shift being restricted to development, filling, etc. Effective time at Cobar is beginning to be affected by the substantial distances to be travelled up into the cut and fill stopes as they rise above the main haulage levels which are spaced at 600 foot intervals. The time actually available for productive work in the stope averages slightly over six hours per shift for all cases described.

(n) Tramming Speeds. The highest average speeds appear to be sustained at Mt. Charlotte where averages as high as 10.8 m.p.h. have been observed. It is interesting to note that this mine appears to have encountered proportionately more trouble with axle failures than any other. Estimated maxima of 8-10 m.p.h. have been reported from Cobar. Most mines have found that underground operating conditions are such that load and carry machines load in first gear and tram in second. It is not unusual for gearboxes to be adjusted so that first and second gears only are available to drivers. Average trip speeds including dump point manoeuvering are usually around 6 m.p.h. At Renison, a system of block signals, operated by vehicle lights, limits vehicle speeds on the access decline to about 6 m.p.h.

(o) Transfer Points. Because of its bottom dumping characteristic, special provision must be made at passes where Transloaders are to be used. This is done either by placing a grid over the pass, as at Mt. Charlotte, or by cutting a slot with an inclined bottom in the floor at the edge of the pass, as at Cobar. With the introduction of the Scooptram type machine, Transloaders have been withdrawn from stope loading at Cobar and are operated only on main level transfers from stope orepasses to main orepasses.

In cut and fill stopes, circular steel plate chutes within the fill have been passed over in favour of rock passes, initially accessible directly in the walls of stopes, but more recently a further trend to passes entirely outside the stopes has been in evidence. At Broken Hill, chutes are built up from interchangeable all steel, all timber and composite joggles which provide flexibility in construction. Chutes can be tailored to meet expected wear-patterns and tonnages to be passed from various horizons. They are intended to pass up to 250,000 tons without major repair. Large chute fronts, with openings 6 feet by 5 feet or greater have been developed at Mt. Isa and Broken Hill. They are used to load large rail trucks on 3ft 6in. & 3ft gauge track. Elsewhere load and carry machines tip over stop logs; often the openings are further protected by reflective signs and streamers.

AVAILABILITY AND UTILIZATION.

There is no general concensus in definition of these statistics and it is not proper to compare the bald percentage figures obtained on the varying bases. Some mines who operate three shifts per day count only seven or seven and a half hours as the theoretical maximum figure per shift. Others count eight hours. In the case of some other mines where two shifts only are worked per day, the third shift is a maintenance shift with the result that availability is very high - of the order of 80-90%.

The cumulative effect of operational delays on availability is noteworthy; substantial reductions in actual operating time per shift can result when one is superimposed on the other.

Regardless of the definitions used in arriving at the actual figures, availability varies with the size of the fleet in relation to the extent to which vehicles are used and are essential to production.

Availability figures are used in one mine in the calculation of bonus payments to the maintenance crew.

OPERATOR TRAINING.

Operators of load and carry machines usually come from one of two backgrounds - conventional mining or surface construction plant operation.

Most State Mines Inspection Acts make provision for the driving of diesel machines to be restricted to those authorized to drive by the Mine Manager. Training is usually carried out on the job, either by supervisors or other operators. The exception here is Mt. Isa where the large number of machines justifies three diesel instructors in the Training Section. They use vehicles made available by mine foremen in charge of particular areas to train employees controlled by the mine foreman concerned. Certificates are issued which specify the particular machines which the holders are competent to drive.

MAINTENANCE.

Practice in this field varies, depending on such factors as whether equipment is captive in stopes, as in loader cut and fill at Broken Hill and MICAF at Mt. Isa or whether equipment can be driven to surface shops either directly via a decline, as at Renison, or via a very large cage, as in the K57 shaft at Mt. Isa.

Generally speaking, the more restricted the machines are the more difficult and expensive it is to get spares, supplies and maintenance equipment (such as welders) to them. Maintenance labour is less effective in these circumstances too.

A number of modifications have been made since the first introduction of the load and carry machines.

In the case of Transloaders, these modifications have been to increase engine power, to increase the size of the dump door opening and to change the driving position from "straight ahead" to "side on". Although these modifications have been effective in making Transloaders more suitable for the Australian applications, there is a universal operator preference for the four wheel drive machine where both are available.

Modification to the "Scooptram" type machine, whether manufactured by Wagner or Eimco, have been concerned with heavy axle loadings resulting from use in heavy ore on rough inclined roadways. Axle capacities have been increased, bucket sizes decreased and chassis members strengthened to reduce maintenance on these machines.

At several mines, reference was made to the adverse effect of full-ahead, full-astern operation of load and carry machines. At Mt. Isa new machines are supplied with an air operated directional control valve to cope with this practice.

Electrical systems have provided trouble in many instances, and a number of mines are replacing electric starter motors by compressed air operated ones, apparently with favourable results as some new machines are being supplied with compressed air starters.

The interval at which major overhaul of load and carry machines is undertaken seems to have been well established by experience in a number of mines at between 2000 and 3000 operating hours. Electric and hydraulic engine hour meters are in use on many machines; in other cases, shiftbosses' estimates of operating time are used in lieu of meters. Where there are long periods when engines are allowed to run while machines are not actually operating, the engine hour meter can give a false impression of the operating hours for components such as tyres, buckets etc.

Maintenance experience at Cobar and Mt. Isa has been well documented, both because of the relatively large numbers of machines in use and also because of the availability of engineering staff to do this. For a detailed description of practice and modifications, refer to the section of this Record covering the individual mines,

Incentive schemes operate at Mt. Isa and Cobar. That at Mt. Isa is based on the total tonnage handled by Scooptrams during a given cost period. The tonnage includes any "double-handling" that may be required for operational purposes.

At Cobar, the incentive is based on percentage availability of all machines in the fleet for a given fortnightly period. In cases where repair of a machine is held up for lack of spare parts, the machine is counted as having the availability of the group average after the first 4 days.

SUPERVISION, MANAGEMENT, PLANNING.

Only a limited proportion of the foreman and shiftbosses supervising operations in which rubber tyred diesel equipment is used have themselves used this kind of equipment during their days of practical mining. As time goes on, of course, the proportion will rise above the present 30-40% particularly in mines where all operations use this equipment.

In most of the larger mines, supervision is on an area basis, with first line supervisors covering development, production or services. In a few cases there are specialist teams for long hole stope drilling, hydraulic filling, raise boring etc. which have their own specialist supervisors.

In small operations, planning is either carried out by the operators themselves, or technical staffs are so small that there are no difficulties in arranging discussions between planners and operators.

In larger operations, more formal arrangements are necessary, but the end result is the same ie. the formal plans drawn up are only finalized by agreement between the planners and the operators.

Longer term plans over intervals of say 5 years, are normally revised at yearly intervals. Shorter term plans call for quarterly or even monthly revision. Weekly and in some cases daily meetings provide the very short term control. Such meetings can be the means of sustaining a steady production from underground in terms of tonnage and grade. This is of great assistance in achieving good performance from concentrating mills.

With the increasing use of inclines and declines for access to working faces where rubber tyred diesel equipment is in use, the problem of suitable vehicles for supervisor transport assumes wider significance. Particularly where level intervals are great, the problem can also affect the actual working time available in callings where men do not ride to and from the job on their own vehicle. Standard diesel engined Landrovers appear to have been used almost universally for this purpose so far, but in practically all cases, experience indicates that something more robust could be used to advantage.

The installation of telephones underground is a substantial help in meeting the problems of supervision. At Mt. Isa, the telephone system is the heart of a Mine Control System which provides for the relaying of information and requests for services as in the case of machanical breakdown. Allied with this system are the Equipment Inspectors who, having responsibilities neither to the production nor to the maintenance sides of management, can report in an unbiassed way on operation malpractices, equipment faults, etc.

Another noteworthy facet of management brought out in the course of the review was the increasing use of technicians such as the Stope Control Officer at Cobar Mines Pty. Ltd. This officer is of foreman status and background. He designs the rows of holes required in stopes to bring out ore to limits set by geologists, physically makes spot checks of holes drilled for depth and angle and designs stope firings in conjunction with the Production Engineer.

SUMMARY AND CONCLUSION.

The use of rubber tyred diesel equipment is a firmly established practice in Australian metal mines. Its use is being extended on established mining operations and rates highly for selection by new underground operations.

Modification of vehicles and operating techniques during these first years of operation have established satisfactory routines for maintenance and operating parameters in Australian mines. However, there does seem room for further experiment and discussion in determining the most economical overall balance between development of more robust and therefore costly equipment and the development and maintenance of high standard operating surfaces both in access roadways and stopes. Possibly the time is ripe for one of the branches of the Australasian Institute of Mining and Metallurgy to arrange a Symposium at which planners, operators, maintenance engineers and equipment suppliers could freely exchange experience in this field.

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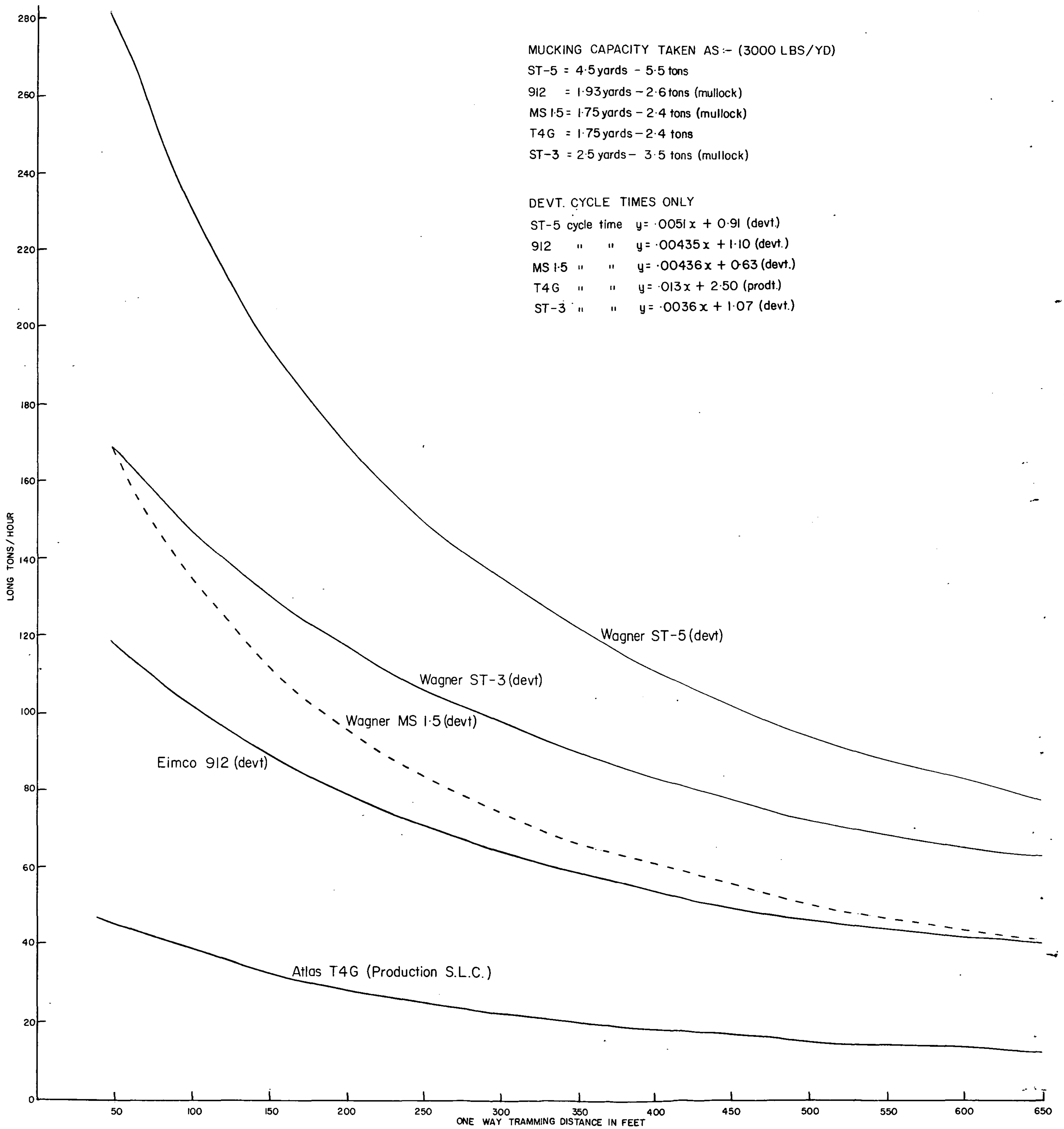
FIGURE I MT. ISA MINES LTD

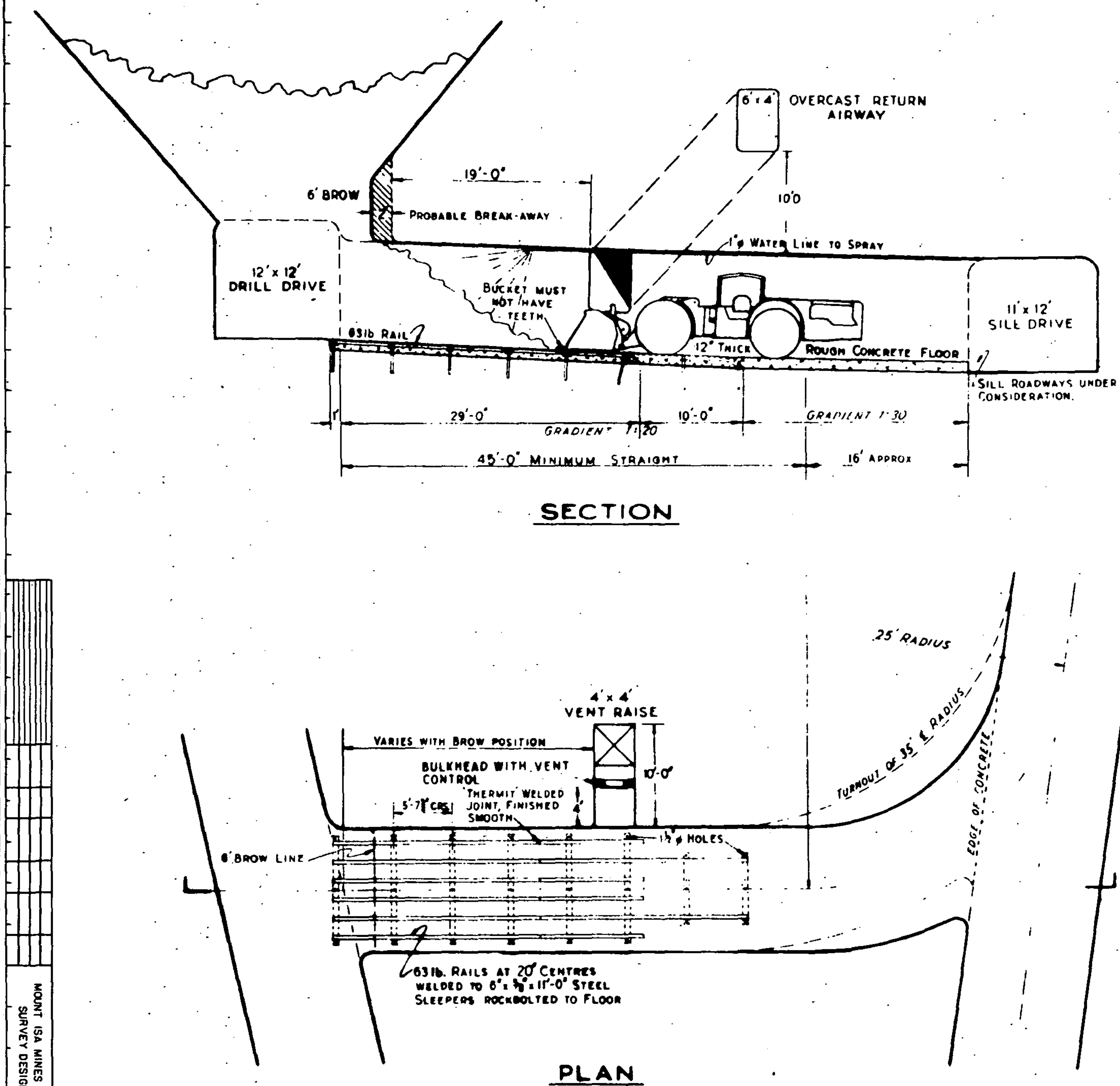
COMPARISON OF LOAD AND CARRY MACHINE PERFORMANCE



To accompany Record 1970/5

M(G) 136

FIGURE 2

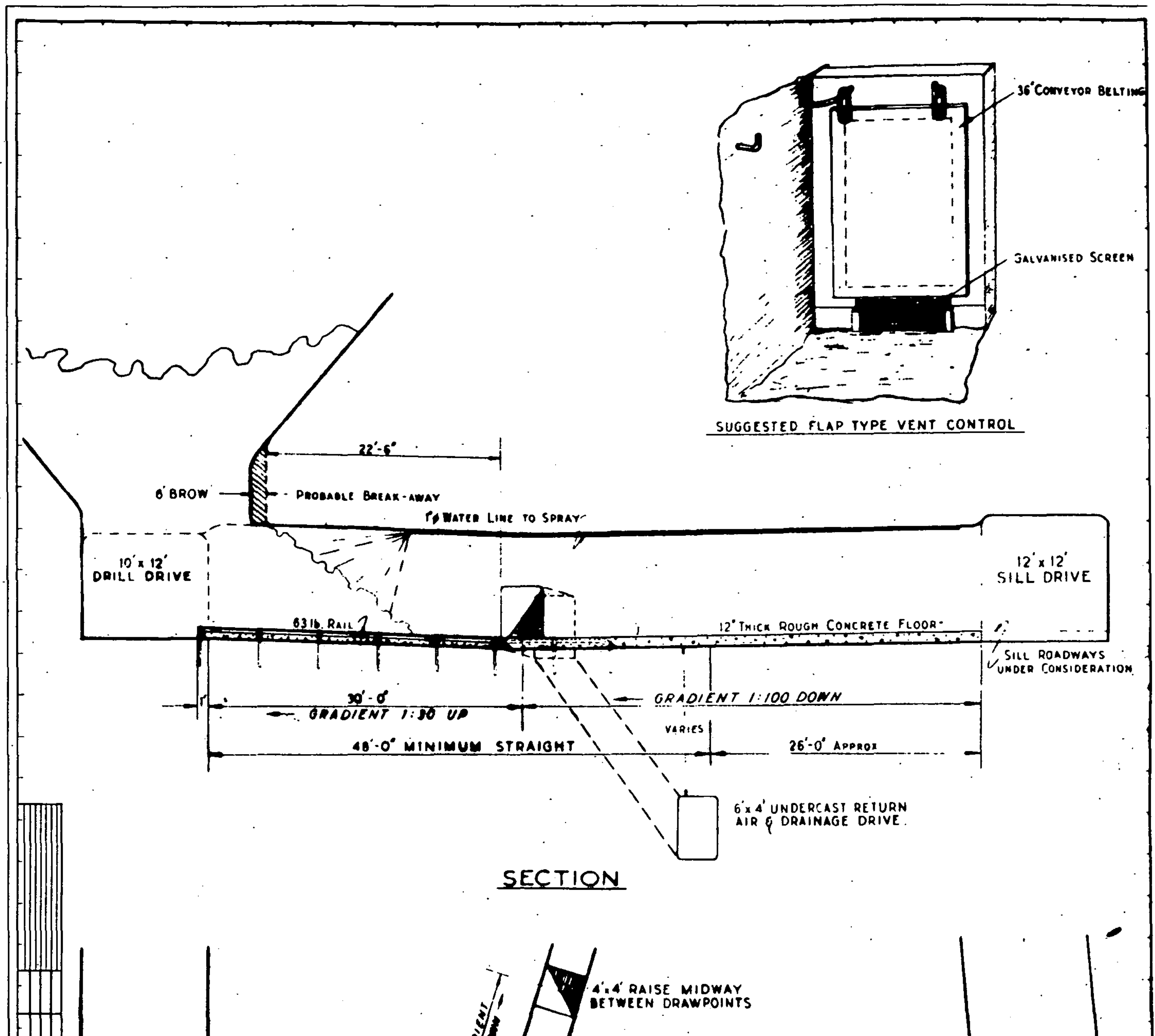


MOUNT ISA MINES LTD. SURVEY DESIGN

TYPICAL DRAWPOINT WITH OVERCAST RETURN AIRWAY

MOUNT ISA MINES LIMITED STANDARD DRAWING	SCALE	APPROVED	DATE
TYPICAL DRAWPOINT WITH OVERCAST RETURN AIRWAY	DRAWN		
	TRACED		

FIGURE 3

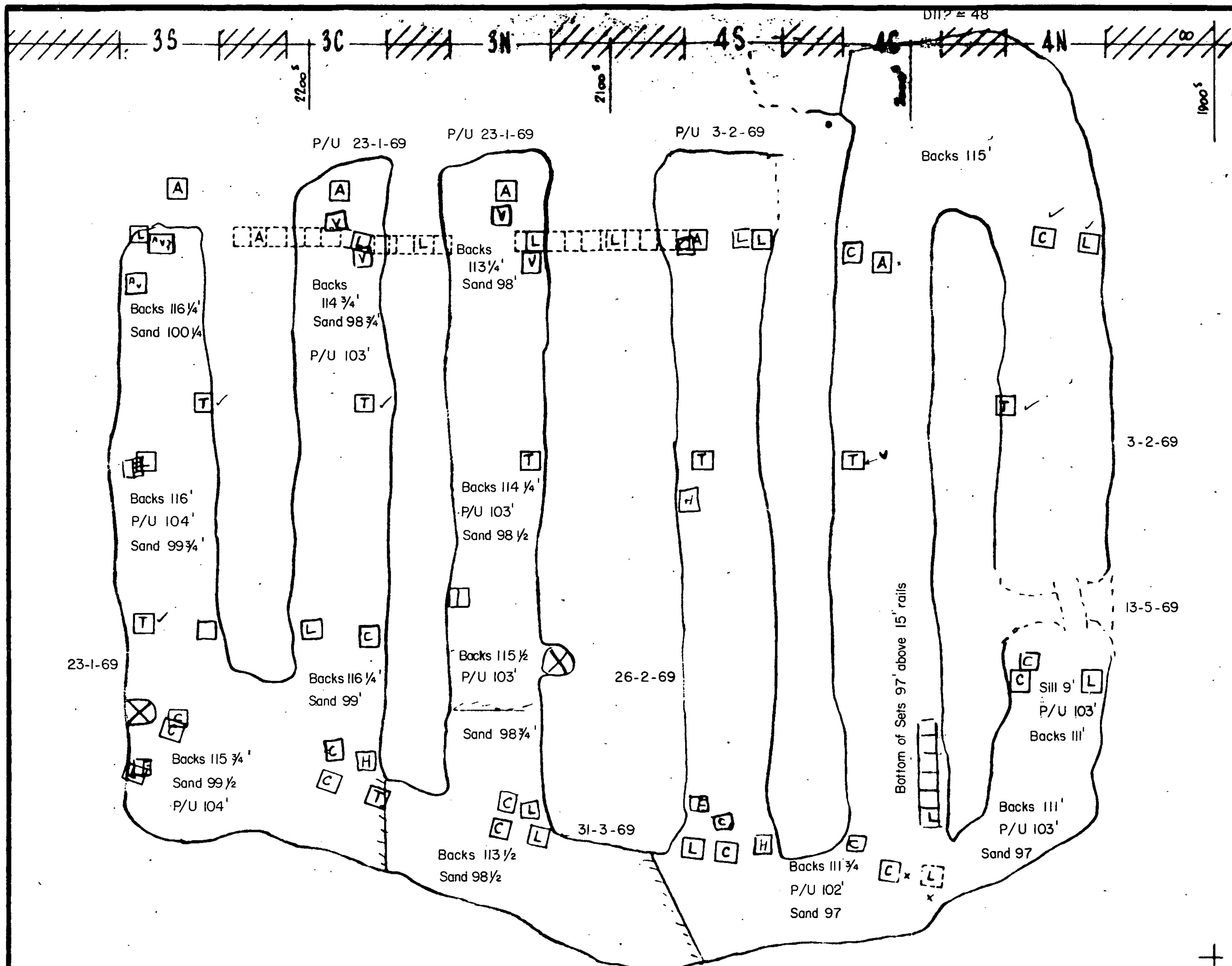


To accompany Record 1970/5

M(G) 138

FIGURE 4

M.I.A. Airflow Requirements: ST-5 = 10,000 cfm, PT-10 = 5,000 cfm; ST-5 & PT-10 together = 12,500 cfm.
Diesel Horsepower: ST-5 = 200 BHP, PT-10 = 60 BHP. L - from LHS manifold (bucket at front)



EXHAUST TESTS		ST-5 Nº				PT-10 Nº		
M.A.C. (ppm)	GAS	Max. Revs.		Idling Revs.		Max. Revs.	Idling Revs.	
		L	R	L	R			
1500	CO							
1000	NO + NO₂							

Operating Time Clock Rdg				
Prog. Operating Hours				
Airflow over Unit (cfm)				
cfm per BHP				
% of M.I.A. Reqmts.				
Upstream Temps. (°F)				
Downstream Temps. (°F)				

ATMOS. TESTS	GAS → MAC (ppm) location ↓	CO	NO+NO₂	CO₂	H₂S	SO₂	O₂	
		50	5	5000	20	5	≮ 20 %	
ST-5 Nº								
PT-10 Nº								

Please return the original transparency to the Ventilation Office.

Observation No	1	2	3	4	5	6	7
Time hrs							
PROCESS							
Quantity kcfm							
Temps °F	/	/	/	/	/	/	/
Velocity fpm							
Dust ppcc							
Notes							

FOR VENT OFFICE USE	Date	By
Test Results on Prog. Records		
Original Copy to Vent Records		
" " " NBHC "		
Final Copy to Vent Records		

~~Z C Ltd~~ NBHC Ltd

VENTILATION REPORT

Nº 15 LEVEL PANEL 3-4 'C

AIRFLOW SURVEY & DIESEL GAS TESTS

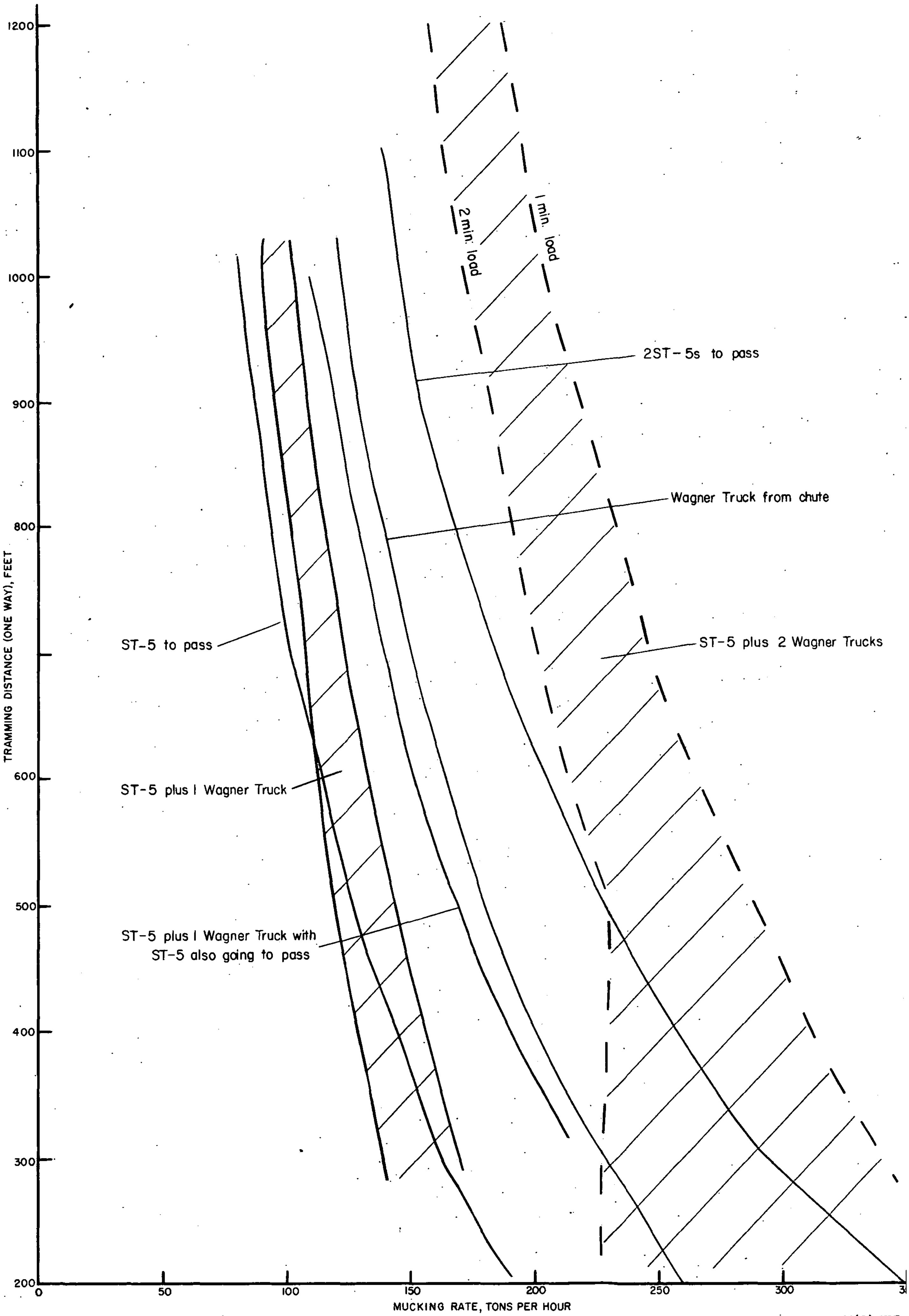
SCALE	1" = 40'	Circulation :	Initials	Date
Date of Survey		UG Mgr.		
Survey by		A.UG M.		
Dwg. Nº	N - -	Foreman		

To accompany Record 1970/5

M(M) 88

FIGURE 5 COBAR MINES PTY LTD

MUCKING RATES FOR VARIOUS COMBINATIONS OF RUBBER TYRED DIESEL EQUIPMENT



APPENDIX 1

QUESTIONNAIRE ON RUBBER TYRED DIESEL EQUIPMENT AND PRACTICE IN METAL MINES.

1. Is this equipment used throughout the mine?

If not give details of the separate areas of the mine in which this kind of equipment is in use for:

(a) development
(b) preparation of areas for stoping
(c) stoping itself

2. What is the annual production from the various areas and types of operation?

3. On an annual basis (say 1967/68) what proportion of the mine stoping ore tonnage is produced using this kind of equipment? What proportion of development footage is produced by this kind of equipment?

4. Give details of the numbers, make model and main size specifications of equipment in use in each area. Include details of rock drilling equipment mounted on rubber tyred jumbos, etc. What are the total numbers of the different types of equipment on the mine?

5. Please give a brief description of the ore and rock types encountered and mining methods used in the various areas where mobile diesel equipment operates. Refer to earlier publications where appropriate. Give details of any rock mechanics measurements. Give in situ and loose figures for density of ore where available. How does this vary with grade - is it affected by the variation in minerals such as pyrite not normally included in statements on grade?

6. What transport arrangements are provided for getting equipment from the surface to operating areas? Indicate minimum sizes of cages, shafts, drives etc and maximum weights for individual sections lowered in shafts, in stopes, etc. Indicate the extent to which equipment must be dis-assembled for transport and whether any special rail trucks or attachments to cages, skips ect have been developed for this purpose. Please give details of any such special equipment.

7. Give details (including changes in practice with experience) of chutes, ore passes etc. into which mobile haulage equipment discharges and of points from which loading takes place where transfer operations are undertaken.

8. Indicate the provisions made for routine servicing of equipment including tyre inflation, refuelling, lubrication.

9. Please give details of the operations in the different areas:

(a) Preparation for stoping, particularly the extent of work carried out with conventional equipment and hence not covered by 1(b) above.

(b) Drilling performance in the different areas, giving separate data for differing hole diameters, rockdrill types etc.

(i) Hole diameter - inches
(ii) Average hole depth - feet
(iii) Tons of ore per-foot drilled
(iv) Shank life - feet
(v) Bit life - feet per sharpening
Bit life - total
(vi) Penetration rate - feet per minute
(vii) Drilling rate (including delays) feet per manshift
(viii) Drilling rate (excluding delays) feet per manshift
(ix) Average air pressure - day shift
" " " afternoon shift
" " " night shift
(x) Average working time available per shift - minutes
(xi) Give such details as are available for drilling delays

(c) Give details of blasting practice for the various operations and hole sizes along the following lines:

(i) Hole diameter - inches
(ii) Average quantity of ore broken per firing; pattern of holes and tonnage broken.
(iii) Type of explosive used
(iv) Type of initiation used
(v) Explosives factor - pounds per ton
(vi) Charging density - pounds per foot of hole
(vii) Charging rate (including delays) feet per manshift
(viii) Charging rate (excluding delays) feet per manshift
(ix) Average working time available per shift
(x) Factors limiting size of boulder handled; extent of secondary breaking required.
(xi) Explosive or equipment used for secondary breaking

(d) Loading and hauling performance for the various situations and machines:

(i) Mucking rate, (including delays) tons per machine shift, tons per manshift, tons per maintenance manshift.
(ii) Mucking rate (excluding delays) tons per machine shift, tons per manshift, tons per maintenance man shift.
(iii) Average and range in lead distance (one way) - feet
(iv) Average working time available per shift
(v) What methods are used for control of floor height and fill dilution in cut and fill operations?
(vi) Is selective mining practised - is waste left in the stope or handled to a different location to ore - how is ore and waste distinguished?
(vii) Is information available to plot a performance graph of tons/operating hour against one way tramming distance in specific situations?
(viii) Provide data on tyre performance along the following lines:

Machine	Service	Tyre Size	Condition	Life	Cost/hr

(e) Preparation of stopes and filling:

(i) Note any special features relevant to or caused by the use of mobile diesel equipment.
(ii) Refer to any drainage features associated with the pouring of large blocks of fill at one time.
(iii) Manshifts required per cubic yead of fill for stope preparation.
(iv) Rate of filling - cyd per hour and cyd/manshift
(v) Average size of pour - cyd
(vi) Filling crew required - no. of men
(vii) Rate of additions (eg. cement) per cyd
(viii) Cost and/or quantities of materials for stope preparation - per cyd of fill

(f) Labour requirements and efficiencies for the various stoping and development units - what are the figures used for planning and budgeting purposes - tons per period per stope crew and what does such a crew consist of?

(g) Securing ground - give details of barring down equipment, platforms, rockbolts, mesh, gunite etc. used in areas where mobile diesel equipment operates. If rockbolting of stope backs is a regular practice, at what stage are the rockbolts recovered and how?

(h) Is any special action taken to provide a suitable floor for the mobile diesel equipment to operate on either:

(i) By additions to stope fill - see also (e) above
(ii) By pouring concrete, adding fine top dressing etc on haul roads for development or transfer operations

(i) What dilution takes place in the use of mobile diesel equipment - how is this reduced?

If available give dilution factors due to

(i) Overbreak
(ii) Pickup of top layers of fill

(j) To what extent are load and haul machines used for purposes other than filling ore during the operating cycle? What operations are carried out by this type of machine and what proportion of machine operating time does it represent?

10. Availability and utilization of load and haul equipment particularly is difficult to express in universal terms where different mining shift sequences are adopted, and depends also on the number of machines available to the maintenance section. The following information would be useful:

(a) How is availability normally expressed and what figures are obtained?
(b) Give figures for "in stope down time" and "idle time" where these are relevant.
(c) Are there figures available to show the relationship between maintenance and tramming distance - either in terms of material cost manhours or both?

(d) Express utilization and availability in terms of a 7 day 24 hour week and then express scheduled operating time as a proportion of 7 day 24 hour operation. There may be scope here for two scheduled times, one including those periods when the machine is not available for maintenance work due to shift changing etc.

(e) Give data on material costs in relation to both maintenance man hours, machine operational hours etc. Give data on age of machines and extent of rebuilding that has been carried out in this connection.

11. Operator training - what background do machine operators have, what training do they receive and what are the statutory requirements of the relevant Mines Inspection Act and Regulations or its equivalent? Please quote the relevant reference.

12. Ventilation - describe the ventilation system for the working places in which mobile equipment is used. What are the statutory requirements for quantity and quality of air to be circulated? Please quote the relevant reference to the Mines Inspection Act and Regulations or its equivalent. If possible quote a figure for the various mining methods - cfm per ton mined or other appropriate basis.

13. Describe pillar mining arrangements or proposals if pillar mining is not yet being carried out. Is there a place for mobile diesel equipment in the pillar mining method proposed? What preparation is made for pillar mining during the initial mining and to what extent does it affect these operations?

14. For other than routine servicing covered by 8 above, give details of major sources of trouble and remedies adopted in the maintenance of the various types of equipment. Give details of intervals for and work undertaken at major overhauls. How is the time interval between servicing measured - are engine hour meters or operators' or supervisors' records used for this purpose?

15. Describe equipment modifications not covered in 14 above, including hard-facing of bucket lips, changes in bucket size and shape, axle capacity etc.

16. Are machine operators and others paid on a contract or wages basis? Where the latter method is used give details of base rates and margins for the various types of machine. Where payment is by contract what rates apply, what quantities are measured, when and by whom? What are the average and range a contractors rates and earnings? If there is a bonus, rather than contract scheme of payment, describe it.

17. What is the background from which maintenance crews are drawn? How are they trained and paid? Do they participate in a bonus scheme? If so please give details. How are the maintenance men organized into crews and supervised?

18. Give details of the numbers and grades of supervisors engaged in controlling the mobile diesel equipment operations. What is their background, how do their pay rates compare with the machine operators?

19. Outline the planning and scheduling carried out on a long term, yearly and short term basis to control the operations described. Who does the planning at these various intervals - what objectives are given them and by whom are they given? How is the planning at these various levels co-ordinated? See item 9(f) for details of productivities used in this kind of planning.

20. What provision is there for communication between the surface and the areas in which mobile diesel equipment is used? Describe any special equipment or techniques used in this aspect of the operation.

21. What transport (if any) is provided for the supervisors? Is this satisfactory and what would be ideal?

22. Please provide any readily available photos which illustrate particular items of equipment or features of practice.

23. Please give details of hours per shift and shifts per week operated by machines and their drivers.

APPENDIX 2

MT. ISA MINES LTD - REQUIRED AIR FLOWS

DIESEL TYPE	H.P.	M.R.A. MINIMUM C.F.M.	AUXILIARY VENT LINES REQUIRED IF THERE IS NO THROUGH FLOW
20 Ton Loco	210	10,500	2 x 24"
ST5	175	8,750	• Long Headings - 2 x 24" • Short Headings - 2 x 20"
12 Ton Loco	135	6,750)	1 x 24" or 2 x 20"
ST4	135	6,750)	
ST3	135	6,750)	
Transloader	130	6,500)	
CAT922	80	5,000)	1 x 20"
ST2	78	5,000)	
MS1.5	78	5,000)	
MTP-F10	78	5,000)	
MTP-F12	78	5,000)	
Eimco 912	78	5,000)	
Traxcavator	60	5,000)	
Chamberlain Tractor	62	5,000)	
PT10	52	5,000)	
G.D. Jumbo	52	5,000)	
A.B. Tractor	43	5,000)	
International Tractor	40	5,000)	
Jeep	31	5,000)	
Drill Platform	27	5,000)	

APPENDIX 3

MT. ISA MINES LTD - VENTILATION FORMS

DIESEL GAS ANALYSIS M.I.M. 95 (F) 1/67		Date / /
Fast Idle ☐ Working ☐ Lugging ☐	Machine No. Machine Type	Period Level

REMARKS: (Location, etc.)

....
....
....
....

Drive Size	Air Veloc. - f.p.m.	Est.Volume-c.f.m.

	ENGINE		AMBIENT		
	Drager	Lab.	Drager	Lab.	Act.
CO					50 ppm
CO^2					0.5%
NO^2					5 ppm
O^2					19%
SO^2					-
H^2S					20 ppm
Ald.					-

MINES REGULATION ACT CONTRAVENTION M.I.M. 1059 4/65	
Time	Date / /
Place	
VENTILATION OFFICER'S REPORT: Temperatures Gas Diesel: Gas " Air Flow	
NOTES: (Equipment, men, etc.) .... Ventilation Officer	

MINES REGULATION ACT CONTRAVENTION M.I.M. 1059 4/65	
Time	Date / /
Place	
TO OPERATOR: Ventilation conditions contravene regulations: O Temperature - regulation 6 (2) O Gas - regulation 6 (1) O Diesel Operation - regulation 146- Gas and/or airflow PRESENT WORK IS TO STOP UNTIL CONDITIONS ARE CORRECTED. REPORT WITH THIS NOTE TO YOUR SUPERVISOR. A recommendation is not made/made (See over). .... For Registered Mine Manager	

APPENDIX 4

N.B.H.C. LTD. MAINTENANCE SCHEDULES

WAGNER ST-5 UNIT NO. DATE / SHIFT

DAILY MAINTENANCE SCHEDULE

	1. Check operators report	/
	2. Check report of previous shifts fitter	/
ENGINE	Lubricating System:	
	3. Check oil level, B.P. - DD20W	/
	4. Check leaks and correct	/
	5. Record oil pressure ________	/
	Fuel System:	
	6. Check leaks and correct	/
	Drive Belts:	
	7. Check all belts	/
	Induction and Exhaust:	
	8. Check air connections	/
	9. Check scrubbers and connections for leaks and correct	/
	10. Check float valves	/
	11. Drain and flush scrubbers	/
	12. Check exhaust connections and Pipes	/
POWER TRAIN	Torque Converter:	
	13. Check operating temperature and note ________	/
	Transmission:	
	14. Check oil level-engine idling, oil 180-200°F B.P.-A.T.F.-A	/
	15. Check clutch pressure and note ________	/
	Drive Axles:	
	16. Check wheel nuts	/
	17. Check axle mounting bolts	/
	Tyres:	
	18. Check tyre condition and note damage	/
	19. Check tyre pressures, front and rear 45 psi	/
BRAKES	20. Check brake air pressure and note ________	/
	21. Check lines for leaks and damage and correct	/
	22. Test brakes	/

DAILY MAINTENANCE SCHEDULE CONTINUED

STEERING	23.	Check steering hoses from leaks and damage and correct	/
	24.	Check steering valve operation	/
	25.	Check steering cylinders	/
HYDRAULICS	26.	Check oil level, B.P. ATF-A	/
	27.	Check hoses for leaks and damage and correct	/
	28.	Check cylinders	/
	29.	Check operation of hydraulics	/
BUCKET &	30.	Check for weld cracking	/
ARMS	31.	Check bucket teeth - replace worn caps	/
CHASSIS	32.	Check swivel hinge and bearings	/
ELECTRICAL	33.	Check lights, switches and wiring	/
	34.	Check alternator charge rate	/
INSTRUMENTS	35.	Check for correct operation	/
	36.	Note engine operating hours ___________	/

REMARKS

WAGNER ST-5 | UNIT NO. | DATE/SHIFT

WEEKLY MAINTENANCE SCHEDULE

	1.	Complete Daily Maintenance Schedule	/
ENGINE		Fuel System:	
	2.	Drain fuel tank sludge reservoir	/
	3.	Drain fuel filter sediment	/
	4.	Clean pre-cleaner on fuel lift pump	/
	5.	Check injection pump and governor oil levels B.P. DD20W	/
POWER TRAIN		Drive Axles:	
	6.	Tighten wheel nuts 470 lb.ft.	/
		" back nuts ¾" 180 lb.ft.	/
		" " " 1-1/8" 470 lb.ft.	/
	7.	Check differential oil, front and rear for metal particles	/
	8.	Check differential oil levels, B.P. SCL90	/
BRAKES	9.	Drain air reservoirs (2)	/
	10.	Test safety actuators	/
CHASSIS	11.	Grease all points	/
ELECTRICAL	12.	Check battery electrolyte level (2)	/

REMARKS

WAGNER ST-5	UNIT NO.	DATE/SHIFT

THREE WEEKLY MAINTENANCE SCHEDULE

	1. Complete Daily Maintenance Schedule	/
ENGINE	2. Tighten mounting bolts	/
	Lubricating System:	
	3. Drain edge filter housing	/
	4. Change oil in sump and oil cooler B.P. DD20W	/
	5. Change by-pass filter element, F272 or F500	/
	Valves:	
	6. Check clearance, .004" - .006" with engine cold	/
	Fuel System:	
	7. Clean fuel pump breather	/
	8. Clean pre-cleaner on fuel lift pump	/
	9. Drain fuel filter sediment	/
	10. Check injection pump and governor oil levels B.P. DD20W	/
	11. Drain fuel tank sludge reservoir	/
	12. Change secondary fuel filter element Pt. No. 0120-10, Bin No. 263560	/
	Cooling System:	
	13. Check air ducting and deflectors	/
	14. Clean blower and cooling fins	/
	15. Check blower bearings and rotor	/
	Induction and Exhaust:	
	16. Clean air pre-cleaners (2)	/
	17. Change air cleaner oil (2)	/
	18. Check air connections	/
	19. Tighten manifold nuts	/
POWER TRAIN	Torque Converter:	
	20. Change filter elements every 6 weeks and at 500 hrs. PF 157 Pt. No. 5577124; Bin No. 263574	/
	Transmission:	
	21. Clean and oil transmission breather filter	/
	Drive Axles:	
	22. Tighten wheel nuts 470 lb.ft.	/
	" back nuts ¾" 180 lb.ft.	/
	" " " 1-1/8" 470 lb.ft.	/
	23. Tighten axle mounting bolts, 1" 500 lb.ft.	/
	¾" 240 lb.ft.	/

THREE WEEKLY MAINTENANCE SCHEDULE CONTINUED

POWER TRAIN CONT.	24.	Check differential oil, front and rear, for metal particles	/
	25.	Check differential oil levels B.P. SCL90	/
	26.	Check planetary hub oil levels B.P. SCL90	/
	27.	Clean axle breathers	/
BRAKES	28.	Drain air reservoirs (2)	/
	29.	Check compressor head bolts	/
	30.	Check compressor mounting bolts and alignment	/
	31.	Adjust brakes	/
	32.	Test safety actuators	/
STEERING	33.	Replace filter element, No. 1 only Pt. No. 228468, Bin No. 263582	/
HYDRAULICS	34.	Replace oil filter elements - No. 1 Pt. No. 228468, Bin No. 263582, Nos. 2 & 3, Pt. No. 1567, Bin No. 263588	/
BUCKET & ARMS	35.	Check condition of all arm bearings	/
CHASSIS	36.	Grease all points	/
ELECTRICAL	37.	Check battery electrolyte level (2)	/

REMARKS

WAGNER ST-5	UNIT NO.	DATE/SHIFT

500 HOUR MAINTENANCE SCHEDULE

	1.	Complete Daily Maintenance Schedule	/
	2.	Complete Three Weekly Maintenance Schedule	/
<u>ENGINE</u>	3.	Drain and clean edge filter	/
	4.	Test injectors and fuel injection pump insitu with "Injectester"	/
	5.	Clean wire gauze insert in engine vent pipe	/
	6.	Change secondary fuel filter element Pt. No. 0120-10 Bin No. 263560	/
	7.	Clean engine	/
	8.	Blow dust from alternator and starter	/
	9.	Check valve rotation	/
<u>POWER TRAIN</u>		<u>Torque Converter and Transmission</u>:	
	10.	Change oil: drain when hot only B.P. ATF-A	/
	11.	Remove Transmission sump, clean filter and pan	/
	12.	Replace oil filter elements No. 1 Pt. No. 228468, Bin No. 263582, Nos. 2 & 3 Pt. No. 1567, Bin No. 263588	/
<u>BRAKES</u>	13.	Inspect brake diaphragms, replace if necessary	/
	14.	Inspect brake linings and re-adjust brakes	/

<u>REMARKS</u>

APPENDIX 5

COBAR MINES PTY. LTD.

VENTILATION FORMS

VENTILATION REPORT

CMPL 337

Monthly Test of Diesel Engine Exhaust Gas

Vehicle Tested	Meter Hours	Test Conditions	Noxious Gas Concentrations in Exhaust		Date	Remarks
			(a) Carbon Monoxide (CO)	(b) Nitrogen Oxides (as NO2)		

COBAR MINES PROPRIETARY LIMITED

MEMORANDUM

CMPL 318

FROM: Ventilation Engineer

TO: Operating Engineer

Following the ventilation survey of the stopes airflow accommodation for production units is tabulated below:

STOPE	FLOW (CFM)	PRODUCTION UNIT ACCOMMODATION	COMMENTS
12CZ2			
12CWS			
12CWN			
12CES			
& 12CZI			
12CEN			
18CAN			
18CAS			
18CB			
18CE			

K. A. McLeod,
VENTILATION OFFICER.

COBAR MINES PROPRIETARY LIMITED

CMPL 379

MEMORANDUM

FROM: VENTILATION ENGINEER

TO: SCHEDULING ENGINEER - GENERAL MINE FOREMAN - LEVEL FOREMEN

TABULATED BELOW IS INFORMATION RECORDED
DURING THE VENTILATION SURVEY OF
SHOWING REASONS FOR ANY ADVERSE CONDITIONS

Location	Temperature		Gas Tests			Normal Air Flow	Airflow at Time of Survey	Remarks and Work Required	Foremans Signature
	W.B.	D.B.	Gas	Conc.	Perm.				

VENTILATION OFFICER

VENTILATION REPORT

CMPL 333

Date and Time	Location	Operation	Airflow c.f.m.	Gas Tests			Dust Count p.p.c.c.	Temperatures			Remarks
				Gas.	Conc.	Perm.		W.B. Deg.F	D.B. Deg.F	S.H. gr/lb.	

APPENDIX 6

COBAR MINES PTY. LTD.- CUMULATIVE EFFECT OF OPERATIONAL DELAYS ON AVAILABILITY

OPERATIONAL DELAYS/SHIFT			0	10%	20%	30%	25%	40%	50%	60%
HOURS VEHICLE CAN MUCK			6.33	5.75	5.10	4.45	4.1	3.84	3.2	2.55
Hours vehicle available for mucking per shift.	8	Hours vehicle actually mucks per shift.	6.33	5.75	5.10	4.45	4.1	3.84	3.2	2.55
	7		5.5	5.0	4.5	3.9	3.5	3.35	2.8	2.22
	6		4.75	4.3	3.85	3.33	3.1	2.86	2.4	1.92
	5		4.00	3.6	3.2	2.8	2.57	2.4	2.0	1.6
	4		3.15	2.86	2.55	2.22	2.05	1.92	1.6	1.27
	3		2.40	2.15	1.92	1.57	1.84	1.44	1.2	0.96
	2		1.59	1.44	1.27	1.12	1.02	0.96	0.8	0.64

APPENDIX 7

COBAR MINES PTY.LTD.

LOCATION OF TELEPHONES UNDERGROUND.

1200 Level

East Incline	1100 level
Fill Distribution	E(2) and 1400 level
Plat No. 1 Shaft	
Plat No. 2 Shaft	
Store	
Supervisors	
West Incline	
Workshops	

1800 Level

Crusher Station
Crusher Tip
East Incline
Loading Station No. 2 Shaft
Plat
Pump Station
Rock Box M2 Conveyor
Store and Substation
Supervisors
West Incline
Workshops

APPENDIX 8

GOLD MINES OF KALGOORLIE (AUST.) PTY.LTD.

EXTRACT FROM DESCRIPTION OF OPERATIONS.

MOUNT CHARLOTTE:

5.1. GENERAL AND GEOLOGY.

The Mount Charlotte orebody was first mined in 1893 and was worked, to a depth of approximately 50 feet, by open cut methods. Narrow, east-west quartz veins, in the walls of, and under the open cut, were selectively mined by narrow shrink stopes. From Mines Department records, it appears that spasmodic mining operations were carried out by various prospectors, companies and tributers, until 1957 when investigations were well advanced towards proving the existence of a large low-grade orebody below the open cut.

The deposit was tested by diamond drilling from the surface to a depth of 700 feet, by a drilling pattern of 25 feet by 100 feet, and the holes were directed to intersect surfaces of changing gold values at right angles.

The average economic dimensions have proved to be of the order of 600 ft long x 150 ft wide and the productivity varies from between approximately 4,000 tons per vertical foot at the surface and 9,000 tons per vertical foot at the 900 ft horizon.

The ore body is lozenge shaped with its longer axis striking north-south and its attitude generally vertical. To the north-west and south-east it abutts against two major faults, the Charlotte and Reward faults respectively. The long axis of the ore body is in the direction of tension associated with movement along the faults.

The Charlotte Fault strikes N 40°E and dips 70° west. It is a well defined fault zone; about 10 ft wide, and is composed of soft chlorite schist. Minor shears diverge from the main fault zone at an acute angle.

The Reward Fault consists of a number of sub-parallel shears with intervening lenses of massive greenstone. This zone of weak ground strikes N.N.E., dips west at 30-90°, and has a maximum width of 40 ft.

The host rock is generally massive, medium grained dolerite, typically dark green, and carries megascopic grains of ilmenite.

Two types of altered rock are associated with the ore body and these are:-

(1) Bleached but dominantly ilmenite rock containing little or no pyrite and usually very little gold.

(2) Bleach rock with ilmenite replaced by leucoxene strongly pyritised, and containing most of the gold.

These altered rocks enclose a network of quartz veins which range in thickness from approximately one foot to a fraction of an inch. Pyrite mineralization is strongest near the quartz veins but is apparently related to the frequency of the veins rather than to their thickness.

Free gold is most commonly seen in the quartz veins and generally on, or very close to, their margin.

5.2 MINING

"A" Block (500 ft to Surface)

Between the 500 ft level and the floor of the open cut, the ore body is being mined by a completely mechanized cut and fill method, leaving 30 ft wide rib pillars between 50 ft wide stopes. The fill used is dry tailings from surface dumps. Underground, both ore and fill are transported by diesel load-haul-dump units.

Broken ore gravitates to a 42 in. x 30 in. jaw crusher below 5 level via two 6 ft diameter steel passes which are raised up with the fill. Crushed ore is transported, on a 30 in. conveyor, up a 16° incline, to the 5 level. The skip loading pocket is on the 650 level.

At June 30th, 1968, the back of the cut and fill stope was within 120 feet of the open cut floor. It is intended to take a further two lifts off the stope, at which time only 30-50 feet of ore will remain beneath varying depths of fill previously placed in the open cut. To ensure a fill passage for lower work, this ore will be caved on a retreat system, with an anticipated 40% recovery. Final retreat from the stope will be through a footwall drive planned to reach the Man and Supply Shaft.

"B" Block (900 ft to 500 ft)

This block contains 2,103,000 tons of ore and is being mined as a series of longitudinally, ring blasted stopes. Production commenced on February 6th, 1968, and by June 30th the total mine production reached the planned target of 45,000 tons per period. Production at the rate of 50,000 tons per period is planned to commence on July 1st, 1969.

Three primary open stopes have been laid out, each the width of the ore body and 100-120 ft long. They are separated by 30 ft wide rib pillars, and an 80 ft deep crown pillar is left below the cut and fill stope sill. Ring drilling is done from sublevels on each side of the ore body at the 800 ft, 700 ft and 580 ft horizons.

Ore is blasted to an initial 12 ft wide cut-off slot and drawn through millholes on 9 level using diesel loaders. Three full rings, from 900-580 ft levels, representing a full month's production, are fired together.

After extraction of the primary ore, the rib and crown pillars will be blasted in sequence, and the broken ore will be drawn, beneath fill, through draw points, on the 900 ft, 860 ft and 800 ft levels.

Broken ore is transported, by diesel equipment, to a bar-grizzly protected pass above a 60 in. x 48 in. Vickers Ruwolt, deep frame, double toggle crusher, driven by a 250 h.p. motor. The crusher is situated just above 10 level, has a capacity of 450 tons per hour, on a closed-side setting of 6 in; and is fed by a Jaques Nico apron feeder, 65 in. wide x 15 ft long. Crushed ore is conveyed on a

42 in. wide, steel cord conveyor belt, 604 feet in length, up a 10° inclined drive to two skip loading station passes at 9 level. Both ore and mullock can be stored separately in these passes of 1,000 tons and 500 tons respective capacities.

Ventilation for "B" Block is provided by a 100 in. fan located on the surface, exhausting through an 11 ft diameter ventilation shaft which was raised from 9 level. Currently 108,000 c.f.m. are exhausted, but this can be stepped up to 200,000 c.f.m. for future work.

To service the drilling, hauling and crusher levels, a Man and Supply Shaft was raised, and equipped with a 10 ft x 10 ft service cage and counterweight. Ore and mullock are hoisted in Reward Shaft on a continuous three shift five day per week cycle.

HOISTING

General specifications of the hoisting installations at Mt. Charlotte are set out below:

	Reward Shaft	Man & Supply Shaft
Shaft Depth - ft	1270 ft	1000 ft
Compartment Size	4 ft 10 in. x 5 ft 3 in.	10 ft x 10 ft
Winder Drum Size	7 ft 6 in. x 2 ft 2 in.	6 ft x 3 ft
Motor - h.p.	300 (450)	150
r.p.m.	360 (480)	585
Rope Speed - ft/min.	912 (1230)	500
Rope Circumference - inches	3 1/8 (3)	2¾ (3)
Rope Breaking Strain - tons	47.6 (35.6)	28.0 (35.2)
Conveyance Weight - lb	5,400 (4200)	4,968 (Cage) (5,293)
Conveyance Capacity	2.70 (2.85) tons	10 men (18 men)
Conveyance Discharge	Bottom (Bottom)	-

In October a new motor, new skips and new ropes were fitted to improve hoisting capacity. Figures for the new equipment are shown in brackets. Cycle time has been reduced from 83.3 seconds/skip to about 69.5 seconds/skip. Also, a new rope has been installed on the Man and Supply winder and the capacity increased from 10 to 18 men.

APPENDIX 9

GOLD MINES OF KALGOORLIE (AUST.) PTY. LTD.-

INVESTIGATION OF MILL HOLE MUCKING AT MT. CHARLOTTE

A separate investigation was undertaken to check the quantity of ore that can be "mucked"/machine from each mill hole and the characteristic of each driver's loading tendencies. It was noticed that 1 driver consistently loaded the bucket to its struck capacity whereas two others consistently loaded the bucket to within 1 ft. of the struck capacity. This makes a difference of approximately 1.8 ton/bucket. The struck capacity is 4.88 cubic yards or 5.9 tons.

Drivers are instructed generally to attempt full loading conditions in the minimum number of "passes" - recognising the effect of excessive increased wear and tear going back to top up an almost full bucket. It is in this feature that the good driver can fill his bucket in the first "pass".

The loading, dumping and tramming times were checked for some of the mill holes on the 900 level. Those checked were 3, 11, 12, 13, and 14. Eimco No. 5 doing 3 and 11 and Eimco No. 4 doing 12, 13 and 14.

These were checked for periods in excess of 1½ hours/mill hole if possible and from this it was possible to get an estimate of the average number of loads possible per mill hole under normal conditions. These include delays because of other machines using the tip, shift bosses talking to the drivers, allowing for dust to clear from the mill holes and shifting large rocks from the mill hole into a place where they can be popped.

The average loading time varied depending on the size of the mill hole dirt. For fine material such as in M/H 3 the loading time is approximately 15-20 seconds; for rough mill hole dirt up to 90 seconds; for average mill hole dirt the loading time is 45 seconds.

The speeds the Eimcos were tramming at were measured but when comparing with different tramming distances the speeds appeared to be inconsistent and depended on the manoeuvering required at the corners near the tip. The following is a table summarising the performance of the two Eimcos when mucking from some of the mill holes.

	M/H No.	Loads/Hr.	Tons/Hr.	Total Haul Dist.	Average Speed.
Eimco 4	14	28	162	1,105 ft	8.4 m.p.h.
	13	26	150	740 ft	10.8 m.p.h.
	12	30	174	940 ft	19.15 m.p.h.
Eimco 5	11	26	108	660 ft	7.5 m.p.h.
	3	40	164	420 ft	9.6 m.p.h.

Based on the above figures an average of the loads/hour could be estimated for each machine. This would be 28/hour for E4 and whereas E5 had an availability of 65.6% or 3.9 hours/shift. This gives the production rates of 420 tons and 530 tons for E4 and E5 respectively or approximately 1900 tons/day.

The two transloaders would be required to muck 850 tons per day to meet the required production capacity of 2,750 ton/day. A transloader cleaning out a development end in the East Haulage Drive on the 900 level was timed and it was found that it could average approximately 14 loads/hour when having a tramming distance of 1,140 ft. The average size of load would be approximately 5 ton therefore the production rate of the transloader is 70 ton/hour. It is important to note however that this rate can only be reached when the material being mucked is relatively fine mill hole material, or development material.

APPENDIX 10

CLEVELAND TIN N.L. - OPERATORS REPORT SHEETS

AND MAINTENANCE SCHEDULES

CLEVELAND TIN N.L.

MTT-423 TRUCK OPERATOR'S REPORT

OPERATOR .... PTY. No. ....

DATE .... SHIFT .... UNIT No. ....

START OF SHIFT

Hour Meter Reading ....

Check and list below. Report any defects and give details in REMARKS below.

1. Oil leaks on ground .... 8. Exhaust leaks ....
2. Flush scrubber .... 9. Lights ....
3. Fill water supply .... 10. Horn ....
4. Fuel Supply .... 11. Park brake ....
5. Engine Oil .... 12. Foot brake ....
6. Transmission oil ....
7. Tyre pressure ....

HAULAGE

From .... No. of Loads .... Hours ....

....

....

DELAYS

Reason ....

....

TYRES

FUEL ....gallons

FINISH OF SHIFT

Hour Meter Reading ....

Eng. Temp. .... Eng. Press .... Trans.Temp. ....

Covn. Temp. .... Conv. Press ....

REMARKS ....

....

Operator ....

Maintenance .... Supervisor ....

CLEVELAND TIN N.L.

S.T.-5A OPERATOR'S REPORT

OPERATOR: .... PTY. NO.:.............
DATE: .... SHIFT: .... UNIT No.: ....

START OF SHIFT

Hour Meter Reading: ....

Check and list below. Report any defects and give details in Remarks below.

1.	Oil leaks on ground	....	7.	Lights	....
2.	Flush scrubber	....	8.	Horn	....
3.	Fill water supply	....	9.	Park brake	....
4.	Fuel supply	....	10.	Foot brake	....
5.	Exhaust leaks	....		....	....
6.	Tyre pressure	....		....	....

DEVELOPMENT

Place: .... No. of Loads: .... Hours: ....
....

STOPING

Place: .... No. of Loads: .... Hours: ....
....
....
Hours: ....

DELAYS

Reason: ....
....

TYRES

FUEL .... gallons

FINISH OF SHIFT

Hour Meter Reading: ....

Eng. Temp. .... Eng. Press. .... Trans.Temp........
Conv. Temp. .... Conv. Press ....

REMARKS:-

Operator: ....

Maintenance: .... Supervisor: ....

CLEVELAND TIN N.L.

WAGNER SCOOPTRAM MODEL ST5A

Date Unit No. Hours

DAILY CHECK LIST

Mark ✓ if O.K.		Consult service manual for job procedures. Carry tools to make necessary adjustments. Observe safety rules at all times.
o if worked on		
x if further work required		

	Remarks
Engine	
Check engine oil level (Delvac 1130)	
Check and clean pre-cleaners & oil bath air cleaners (2)	
Check engine mounting bolts	
Check blower is working efficiently	
Check engine oil pressure .... p.s.i.	
Check exhaust is smoke free	
Check scrubber float valves (2)	
Flush scrubber & fill scrubber water tank	
Transmission	
Check torgue converter oil level at idle revs.	
(Mobil Fluid 200 ATF Automatic Transmission Fluid A)	
Check clutch pressure	
Check converter temperature	
Brakes	
Check brake air pressure	
Test operation of safety brake	
Test brakes	
Drain moisture from air receivers	
Check for air leaks	
Steering	
Check steering hoses for leaks and drainage	
Test steering	
Other	
Check hydraulic oil level (Delvac 1110)	
Check for hydraulic leaks	
Grease all grease points - 36 points (Mobilgrease MP)	
Check tyre condition for wear	
L.H.F. ______________ R.H.F. ______________	
L.H.R. ______________ R.H.R. ______________	

DAILY CHECK LIST
(Cont.)

Other (Cont.)	Remarks
Check tyre pressures (front 80 psi rear 80 psi)	
Fill Fuel tank ________ gallons	
Check bucket for operation	
Check operators report	

Remarks : ______________________________

____

____

FITTER ______________

CLEVELAND TIN N.L.

WAGNER SCOOPTRAM MODEL ST5A

Date Unit No. Hours

WEEKLY CHECK LIST

Mark ✓ if O.K. o if worked on x if further work required	Consult service manual for job procedure. Carry tools to make necessary adjustments. Observe safety rules at all times.

	Remarks
Engine	
Change engine oil (Delvac 1130)	
Check valve clearances (.004"-.006" cold)	
Tighten manifold nuts	
Clean cooling fans	
Clean pre-cleaner on fuel lift pumps	
Check oil level in injection pump governor (Dlevac 1130)	
Clean fuel course filter	
Check compressor belt tension	
Check cylinder head breather plugs	
Change oil in air cleaners (2)	
Check exhaust connections and pipes	
Check air inlet connections	
Transmission	
Check oil level front differential (Mobilube HD90)	
Check oil level rear differential (Mobilube HD90)	
Check oil level in front planetary hubs (Mobilube HD90)	
Check oil level in rear planetary hubs (Mobilube)	
Check transmission filter	
Clean and oil transmission breather filter	
Check axle mounting bolts	
Clean axle breather holes	
Tighten wheel units (360 ft-lbs)	
Brakes	
Check compressor head & mounting bolts	
Adjust brakes if necessary	
Other	
Check bucket condition repair or hardface if necessary.	

WAGNER SCOOPTRAM MODEL ST5A

WEEKLY CHECK LIST (Cont.)

Other (Cont.)	Remarks
Check condition of all hinge bearings	
Check & lubricate controls	
Check electrolyte level in battery	
Complete daily check list.	

Remarks: ______________________________

____

____

FITTER ....

CLEVELAND TIN N.L.

WAGNER SCOOPTRAM MODEL ST5A

Date Unit No. Hours

150, 600 & 1,200 Hour Check List

Mark ✓ if O.K.
o if worked on
x if further work required

Consult service manual for job procedure.
Carry tools to make necessary adjustments.
Observe safety rules at all times.

	150	600	1200
Engine			
Change engine oil (Delvac 1130)	x		x
Check valve clearances (.004-.006" Cold)	x		x
Tighten manifold nuts	x		x
Clean cooling fans	x		x
Clean pre cleaner on fuel lift pumps			x
Check oil level in injection pump governor (Delvac 1130)	x		
Clean fuel course filter	x	x	x
Check Compressor belt tension	x	x	x
Check cylinder head breather plugs	x	x	x
Change oil in air cleaners (2)	x	x	x
Check exhaust connection & pipes	x	x	x
Check air inlet connections	x	x	x
Check fan bearings & rotor & fan belt	x	x	x
Clean filter cup on engine blower	x	x	x
Fit new fine filter element to oil fine filter	x	x	x
Change secondary filter element lubrication	x	x	x
Change oil in injection pump governor (Delvac 1130)		x	x
Clean knife edge filter		x	x
Replace fuel filter element		x	x
Change injectors			x
Transmission			
Check oil level front differential (Mobilube HD90)	x		
Check oil level rear differential (Mobilube HD90)	x		

150, 600 & 1,200 Hour Check List
(Cont.)

	150	600	1200
Transmission (cont)			
Check oil level in front planetary hubs (Mobilube HD90)	x		
Check oil level in rear planetary hubs (Mobilube HD90)	x	x	
Replace converter & transmission filter element (PF-157)	x	x	x
Clean & oil transmission breather filter	x	x	x
Check axle mounting bolts	x	x	x
Clean axle breather holes	x	x	x
Tighten wheel nuts	x	x	x
Change oil torgue converter (Mobilfluid (200 ATF)		x	x
Change oil transmission		x	x
Remove sump & clean oil screen torgue converter		x	x
Repack hub bearings			x
Change front differential oil (Mobilube HD90-52 pints)			x
Change rear differential oil (Mobilube HD90-24 pints)			x
Change front planetary hub oils (Mobilube HD90-16 pints)			x
Change rear planetary hub oils (Mobilube HD90-16 pints)			x
Brakes			
Check compressor head & mounting bolts	x	x	x
Adjust brakes if necessary	x	x	x
Inspect brake diaphragm		x	x
Inspect brake lingings		x	x
Hydraulics			
Check hydraulic oil level	x	x	
Replace hydraulic filter element (P.No.1567)	x	x	x
Check hoses for leaks & damage	x	x	x
Check bucket lift & tilt cylinders	x	x	x
Change oil (Delvac 1110-90 gallons)			x

	150	600	1200
Bucket & Arms			
Check condition of all hinge bearings	x	x	x
Check bucket for operation	x	x	x
Check bucket & bucket lip condition	x	x	x
Repair of hard face if necessary			
Electrical			
Check electrolyte level in battery	x	x	x
Clean battery	x	x	x
Check lights, switches & cables	x	x	x
Check alternator belt tension	x	x	x
Check alternator charging rato	x	x	x
Inspect & lubricate alternator & starter			x
Other	x	x	x
Check all instruments for correct operation			
Investigate all leaks & correct			

CLEVELAND TIN N.L.

WAGNER TRUCK MTT - 423

Date Unit No. Hours

DAILY CHECK LIST

Mark ✓ if O.K.
o if worked on
x if further work required

- Consult service manual for job procedures,
- Carry tools to make necessary adjustments,
- Observe safety rules at all times.

Engine	Remarks
Check engine oil level (Delvac 1120 or 1130)	
Check and clean pre-cleaners and oil bath air cleaners	
Check engine mounting bolts	
Check blower is working efficiently	
Check engine oil pressure ________ p.s.i.	
Check exhaust is smoke free	
Check scrubber float valves	
Flush scrubber and fill tank	
Transmission	
Check torque converter oil level at idle revs	
Mobilfluid 200 ATF Automatic Transmission (Fluid A)	
Check clutch pressure	
Check converter temperature	
Check drive chain lubricator and top up (Delvac 1130 or 1120)	
Check wheel nuts (360 ft. lbs.)	
Brakes	
Check brake air pressure	
Test operation of safety brake	
Test brakes	
Drain moisture from air receivers	
Check for air leaks	
Steering	
Check steering hoses for damage	
Test steering	

DAILY CHECK LIST
(Cont.)

	Remarks
Other	
Check hydraulic oil level (Delvac 1110)	
Check for hydraulic leaks	
Grease all hinge points - 3 shots Mobilgrease MP	
Check tyre condition for wear	
L.H.F. ____________ R.H.F. ______________	
L.H.R. ____________ R.H.R. ______________	
Check tyre pressures front rear	
Check all implements function correctly	
Check lights	
Check fire extinguisher	

REMARKS: ____

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FITTER ___________________________

CLEVELAND TIN N.L. MTT2

WAGNER TRUCK MTT -423

Date Unit No. Hours

75 HOUR CHECK LIST

Mark ✓ if O.K.
o if worked on
x if further work required

Consult service manual for job procedure.
Carry tools to make necessary adjustments.
Observe safety rules at all times.

	REMARKS
Engine	
Change engine oil (Delvac 1120 or 1130)	
Check valve clearances (.004-.006 cold)	
Tighten manifold nuts	
Clean cooling fins	
Clean pre-cleaner on fuel left pump	
Check oil level in injection pump governor	
Clean fuel coarse filter	
Check compressor belt tension	
Check & clean cylinder head breather plugs	
Change oil in air cleaners (2)	
Check exhaust connections & pipes for leaks	
Check air inlet connections	
Transmission	
Check oil level front & rear differential (Mobilube HD90)	
Check oil level in front & rear planetary hubs (Mobilube HD90)	
Check transmission filter	
Clean & oil transmission breather filter	
Check axle mounting bolts	
Clean axle breather holes	
Tighten wheel nuts (360 ft. -lbs.)	
Check chain adjustment	
Grease drive shafts	
Brakes	
Check compressor head & mounting bolts	
Drain out air reservoirs	
Adjust brakes	
Grease brake cams on drive axles 3 shots - Mobilgrease MP	

75 HOUR CHECK LIST
(Cont.)

	REMARKS
Other	
Clean entire vehicle	
Check hydraulic oil tank breather	
Check condition of all hinge bearings	
Grease drive lines - 3 shots Mobilgrease MP	
Check & lubricate controls	
Check scrubber & float valves	
Complete daily check list	

REMARKS: ____________________

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FITTER ____________________

CLEVELAND TIN N.L. MTT3

WAGNER TRUCK MTT - 423

Date Unit No. Hours

150, 600 & 1,200 Hour Check List

Mark ✓ if O.K.
o if worked on
x if further work required

Consult service manual for job procedure.
Carry tools to make necessary adjustments.
Observe safety rules at all times.

	150	600	1200
Engine			
Change engine oil (Delvac 1120 or 1130)	x	x	x
Check valve clearances (.004"-.006" Cold)	x	x	x
Tighten manifold nuts	x	x	x
Clean Cooling fins	x	x	x
Clean pre cleaner on fuel lift pumps	x	x	x
Check oil level in injection pump governor (Delvac 1120 or 1130)	x	x	x
Clean fuel course filter	x	x	x
Check compressor belt tension	x	x	x
Check exhaust connection & pipes	x	x	x
Check air inlet connections	x	x	x
Check fan bearings & rotor & fan belt	x	x	x
Clean filter cup on engine blower			
Fit new fine filter element to oil fine filter	x	x	x
Change secondary filter element	x	x	x
Change oil in injection pump governor		x	x
Clean knife edge filter		x	x
Replace fuel filter element		x	x
Change injectors			x
Transmission			
Check oil level in front & rear differentials (Mobilube HD90)	x	x	
Check oil level in front & rear planetary hubs (Mobilube HD90)	x	x	
Clean & oil transmission breather filter	x	x	x
Check axle mounting bolts	x	x	x
Clean axle breather holes	x	x	x

Transmission (Cont.)		150	600	1200
	Change oil torque converter (Mobilfluid 200 ATF)		x	x
	Change transmission oil		x	x
	Remove sump & clean oil screen-torque converter		x	x
	Repack hub bearings			x
	Change front & rear differential oils (Mobilube HD90)			x
	Change front & rear planetary hub oils (Mobilube HD90)			x
Brakes				
	Check compressor head & mounting bolts	x	x	x
	Check & adjust brakes	x	x	x
	Inspect brake diaphragm		x	x
	Inspect brake linings		x	x
Hydraulics				
	Check hydraulic oil level	x	x	
	Check hoses for leaks & damage	x	x	x
	Check all hydraulic operations	x	x	x
	Change hydraulic oil (Delvac 1110)			x
Electrical				
	Check electrolyte level in battery	x	x	x
	Clean battery	x	x	x
	Check lights switches & cables	x	x	x
	Check alternator belt tension	x	x	x
	Check alternator charging rate	x	x	x
	Inspect & lubricate alternator & starter	x	x	x
Other	Complete 75 hour check list	x	x	x
	Check all instruments for correct operation	x	x	x

REMARKS ______________________________

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FITTER ______________

CLEVELAND TIN N.L.

Date .... Unit .... Hours ....
Miles

REPAIR SHEET

Describe the extent of repairs and list
spare parts issued

Fitter ______________________________

SPARE PARTS USED

Part No.	Description	No. Off	Part No.	Description	No. Off	

APPENDIX 11

RENISON LIMITED - LOADER STUDY

By: D. Wakefield

Date: January, 1969

Subject: Loader study on ST5 and CAT 950

OBJECT

1. To obtain a mucking cycle formula for the ST5's and CAT 950 loader.

2. To estimate the capacity (in tons/hour) of the two types of loaders for various tramming distances.

3. To obtain a breakdown of the working time of the loaders including an estimate of the percentage of time taken up by delays.

INTRODUCTION

Time studies were conducted over a period of about four weeks from 16.12.68 to 13.1.69. Only one observer (the author) was used and was stationed at the working face. Eleven studies involving 145 scoop cycles were conducted in order to find the mucking cycle formula, and ten availability and utilisation studies were also conducted.

The time study was restricted to day shift but included most working faces in the Renison mine as well as the stockpile and Battery Mine.

RESULTS AND DISCUSSION

1. Tramming distances (muckpile to carrier) ranging from 40 ft to 500 ft were plotted against the corresponding tramming times. Unfortunately no tramming distances between 200 and 400 were obtained, which left a large gap in the graph. However, two straight line trends were distinguishable corresponding to tramming full and tramming empty for the ST5's.

   The CAT 950 operating on the surface rarely varied its tramming distance so that a mucking cycle formula could not be obtained for direct comparison with the ST5. However, from the two points plotted for the CAT 950 it is obvious that the CAT has a much faster tramming speed than the ST5. The CAT also has a very fast dumping rate and is ideally suited to work on the surface. However, if taken underground reversing in the restricted area of the tunnel may cut down its tramming speed.

   The varying slopes in the mine appeared to have little effect on the tramming full time (except possibly Dreadnought where the tramming full is downhill - however, no study was done here). The tramming empty times did appear to be affected by the slope of the tramming surface since the points were rather scattered.

The formula obtained for tramming full for the ST5 was:

$$Y = 0.0027x + 0.06$$

where x = tramming distance (in feet)

Y = tramming time (in minutes)

A meaningful formula for the entire bogging cycle could not be obtained due to the large difference in the tramming empty and tramming full times and also because of the large variations in bogging times, depending on the relative difficulty of bogging in various places.

The average bogging and dumping times for the ST5 were:

Bogging (per scoop full) = 0.83 min
Dumping (" " ") = 0.31 "

The dumping time generally included a short delay while the carrier moved into position. It should be noted also that the bogging and dumping times varied sometimes quite considerably with different operators.

2. Assuming a bucket capacity of 6 tons for the ST5 and 3 tons for the CAT 950, the capacities of these loaders (in tons per hour) were estimated for various tramming distances in various parts of the mine. These capacity calculations involved making an estimate of the average amount of time in each hour occupied by delays.

   The values for the estimated capacities of the loaders are given on the attached sheets headed "Work Study Observations". These values range from 83 tons/hour in the Battery up to 228 tons/hour on the stockpile (using the CAT 950). The values in brackets directly below the ones mentioned above give theorectical maximum capacities, i.e. if there were no delays.

   A plot of estimated capacity of loader versus tramming distances was rather scattered. This scattering was probably due to the difference in difficulty of bogging in various places in the mine. A linear tendency was however noticeable with the capacity decreasing as the tramming distance increased.

3. A total of ten availability and utilisation studies were conducted on the ST5 and CAT 950 loaders. Unfortunately these studies were not taken over the entire shift time and so the results are of limited value. The part of the bogging cycle (bogging, tramming full, dumping, tramming empty or delay) that the loader was undertaking was recorded at ¼ minute intervals on the attached sheets. The reasons for delays are also given on these sheets.

Area	Machine	Bogging	Tramming Full	Dumping	Tramming Empty	% of Total Time Spent in Delays
		% of Actual Working Time Spent :				
Renison Decline	ST5	42%	33%	10%	15%	2% plus 13% cleaning up face at end of job
Dreadnought	ST5	37%	25%	10%	28%	1% plus 31% cleaning up
Stockpile (dumping straight into crusher bin	CAT950	28%	35%	7%	30%	42% (waiting for MTT's and trucks)
Stockpile (using MTT's to dump)	CAT950	36%	25%	16%	23%	8%
Stebbins	ST5	50%	15.5%	19%	15.5%	58% delays